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

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

Toronto, Ontario
August 22-26, 1983
du 22 au 26 août 1983

Minutes and members' reports

Procès-verbaux et rapports des membres

Catalogue No. Fo 18-1/1983-1E
ISSN 0705-4858
ISBN 0-662-13465-6

PROCEEDINGS

OF THE

NINETEENTH MEETING

OF THE

CANADIAN TREE IMPROVEMENT ASSOCIATION

PART 1:

MINUTES AND MEMBERS' REPORTS

HELD IN
TORONTO, ONTARIO
AUGUST 22-26, 1983

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, KOJ 1JO

Part 2. Clonal Forestry: Its Impact on Tree Improvement and our Future Forests

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

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

Produced by
Canadian Forestry Service,
Environment Canada,
for the
Canadian Tree Improvement Association,
Ottawa, 1984

COMPTES RENDUS

DE LA

DIX-NEUVIÈME CONFÉRENCE

DE

L'ASSOCIATION CANADIENNE POUR L'AMÉLIORATION DES ARBRES

1RE PARTIE

PROCÈS-VERBAUX ET RAPPORTS DES MEMBRES

TENUE Á
TORONTO, ONTARIO
DU 22 AU 26 AOÛT 1983

RÉDACTEUR C.W. YEATMAN

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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 1JO

2e partie. La foresterie clonale: Son rôle dans l'amélioration de notre forêt et de celles de l'avenir.

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Publié par
le Service canadien des forêts
Environnement Canada,
pour
l'Association canadienne pour l'amélioration des arbres,
Ottawa, 1984

PROCEEDINGS OF THE NINETEENTH 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 Twentieth Meeting of the Association will be held in Quebec, Quebec, August 19-23, 1985. Speakers will be invited to address the topic of "Accelerated Genetic Gains through New Technologies". Canadian and foreign visitors are welcome. Further information will be distributed in the winter 1984 to all members and to others on request. Enquiries concerning the 20th Meeting should be addressed to: Dr. Armand Corriveau, Centre de Recherches forestières du Laurentides, C.P. 3800, Sainte-Foy, Quebec. G1V 4C7.

To: *Dr. C.W. Yeatman, Editor, C.T.I.A./A.C.A.A.*
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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, Fredéricton, N.B. E3B 5X4.

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La vingtième conférence de l'Association aura lieu à Québec, Québec, du 19 au 23 Août 1985. Des orateurs seront invités à s'adresser au sujet de "augmentation génétique accéléré à couse de nouvelle technologie". 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 vingtème réunion devrons être adressées à: M. Armand Corriveau, Ph.D., Centre de Recherches forestières des Laurentides, C.P. 3800, Sainte Foy, Québec. G1V 4C7.

À: *Dr. C.W. Yeatman, éditeur, A.C.A.A./C.T.I.A.*
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Signé . . . . . .

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July 1983

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Alan J. Carmichael

Following graduation from the Faculty of Forestry, University of Toronto in 1947, Alan joined the Ontario Department of Lands and Forests where he remained throughout his forestry career. He was posted to the Ontario Tree Seed Plant at Angus, Ontario where he immediately became involved in a number of seed improvement projects.

Alan's first concern was to improve seed quality in order to increase the yield and quality of nursery stock. Extensive research was undertaken to investigate extraction procedures and kilns were constructed to determine the effects of temperature on seed yield and seed quality. In addition, the influence of dewing techniques on seed coat damage was studied. This research was used in modifying the existing extraction machinery and when the main plant was destroyed by fire in 1959, the replacement extractor incorporated much of Alan's research and innovations.

By the mid 1950's, Alan became heavily involved in initiating a tree improvement program for the Province. He travelled throughout the Province examining candidate plus trees selected by field foresters. At Angus, he developed the techniques for grafting scions sent in by field staff from his selections.

By 1960, orchards were established for white and red pine and yellow birch in central Ontario, and for black and white spruce in the north. In the interim, before the orchards became productive, stands and plantations were selected as seed production areas. A research program was initiated to study the population structure of native and exotic pine species.

To further his work, Alan joined the Ontario Forest Research Centre to study factors of wood quality. In conjuction with the Ontario Research Foundation, Alan worked on plus tree wood criteria to further increase the value of Ontario's future forest. Unfortunately, before this work was completed, he contracted Multiple Sclerosis which increasingly limited his physical abilities but did not, in any way, diminish his determination and dedication to his work. Alan retired from the Department in February, 1972 when his handicap became too severe for him to carry on.

Alan was a bachelor who enjoyed cooking and tolerated comfortably the remainder of the constellation of household chores. He was an accomplished alpine skier who, long before the advent of modern downhill equipment, made parallel fall-line skiing look deceptively effortless and simple. He exhibited the same drive and dedication to his personal pursuits as he did to his work. This, plus his strong Christian faith, carried him forward with optimism through 11 years of struggle until his death in 1983.

Both the Province and the scientific community have benefitted considerably in the foundation of knowledge resulting from Alan's studies. He will be remembered not only for what he was as a person, but or what he accomplished for the advancement of the science of forestry in Ontario.

Mark Johannes Holst

Mark died in hospital on Monday, 14th November, 1983. Mark will be remembered by all who knew him for his energy and imagination, good humour and great humanity. These talents he brought to his work in creating the broad and varied foundation of source-identified trees that remains the basis for breeding research programs at the Petawawa National Forestry Institute and elsewhere in central and eastern Canada. He distributed seed and plants far and wide in Canada, northern United States and indeed around the world, all the while making lasting friendships and alerting foresters at all levels to the potential for genetic improvement in silviculture. The results of Mark's provenance experiments have directly influenced rules for seed collection and seed transfer form the prairies to the Atlantic. Progeny tests and clonal breeding orchards continue to demonstrate genetic traits of individual trees and provide pedigreed materials for controlled breeding. Mark was a true pioneer, afraid of no man, a visionary who had a great respect and love for the forests and the natural world. He will be remembered fondly by all who know him and worked with him. His plantations and breeding materials are a fitting and lasting tribute and a continuing contribution to the cause of good forestry in Mark's adopted country,. Canada.

BUSINESS MEETING - MINUTES

Ms. R.M. Rauter chaired the 19th Business Meeting of the CTIA/ACAA held in the Medical Sciences Building, University of Toronto, on Tuesday, August 23, 1983.

217. MINUTES OF THE LAST MEETING

Motion: That the minutes of the 18th business meeting be approved as publishd.

Moved by D.P. Fowler, seconded by J. Hood. Carried

218. MEMBERSHIP

a) The names of new sponsoring members are as follows:

R.F. Weary	President, Bowater Mersey Paper Co., Liverpool, N.S.
V. Clarke	Woodlands Manager, Scott Maritimes Ltd., New Glasgow, N.S.
A. Thor	Woodlands Manager, Nova Scotia Forest Industries, Port Hawkesbury, N.S.
D.L. Eldridge	Deputy Minister, Nova Scotia Dept. Lands and Forests, Halifax, N.S.
J.A. Kayll	Director, School of Forestry, Lakehead University, Thunder Bay, Ontario.

Motion: That the new sponsoring members be elected.

Moved by J. Begin, seconded by F. Yeh. Carried

(Editor's note: Sponsoring members are recorded in the membership list by position only to ensure continuity of information exchange).

G. Vallee inquired if active members must submit biennial reports and if sponsoring members received all correspondence. The Editor, C.W. Yeatman, responded in the affirmative on both points.

b) The names of nominated new active members were presented as follows:

W.D. Baker	OMNR, Kenora, Ontario
M.B. Barkhouse	Bowater Mersey Paper Co., Liverpool, N.S.
B.A. Barkley	OMNR, Chesterville, Ontario
J. Beaulieu	CRFL, CFS, Québec, P.Q.
H. Bitto	NBIP Ltd., Dalhousie, N.B.
M. Butler	PEI, Dept. Energy & Forestry, Charlottetown, PEI
M. Carlson	BCFS, Vernon, B.C.
G. Caron	Fac. For., UNB, Fredericton, N.B.
G. Crook	CIP Inc., Calumet, P.Q.
G. D'Aoûst	CRFL, CFS, Québec, P.Q.

A. Dion	CIP Inc., La Tuque, P.Q.
R.E. Farmer	Fac. For., Lakehead Univ., Thunder Bay, Ont.
L.Z. Florence	Dept. For. Sci., Univ. of Alberta, Edmonton, Alta.
H.M. Frame	N.S. Dept. L & F, Debert, N.S.
W.M. Glen	P.E.I. Dept. Energy & For., Charlottetown, PEI
C.M. Harrison	Nfld. Dept. For. Res. & L., St. John's, Nfld.
P. Janas	PNFI, CFS, Chalk River, Ontario
M. Pandila	Sask. For. Div., Prince Albert, Saskatchewan
W. Raitanen	OMNR, Timmins, Ontario
H.O. Schooley	PNFI, CFS, Chalk River, Ontario
Mrs. A. Wood	BCFS, Mesachie Lake, B.C.
J.H. Woods	BCFS, Mesachie Lake, B.C.
B. Yuill	Scott Paper Co., New Glasgow, N.S.

Motion: That the nominated new active members be duly elected.

Moved by T. Mullin, seconded by D. Fowler. Carried

219. FINANCIAL STATEMENT

The financial statement prepared by Treasurer C.W. Yeatman was tabled for membership information and acceptance. (see attachment #1). The statement shows a balance of $5,125.58 in the association's account as of August 17, 1983.

Motion: That the financial statement as presented be accepted.

Moved by B.S.P. Wang, seconded by E.K. Morgenstern. Carried

C.W. Yeatman stated that because of invited speaker expenses the present meeting would need at least 125 attendees to break even and that that number has been exceeded.

O. Sziklai congratulated the CTIA Executive and Education Committee for their initiative in supporting a student from each forestry faculty to attend this meeting.

220. FINANCIAL CONTRIBUTORS FOR THE SYMPOSIUM

Ms. Rauter explained that the following organizations had contributed to this symposium:

- Ontario Ministry of Natural Resources supplied mail, printing, copying, banquet assistance, organization personnel, field meeting with lunch, etc....
- University of Toronto provided the meeting rooms, coffee and icebreaker.
- Ontario Forest Industries - cash contribution of $2,000.

Motion: That the CTIA/ACAA express our sincere appreciation to the contributors.

Moved by C.W. Yeatman, seconded by E.K. Morgenstern. Carried

221. EDITOR'S REPORT

C.W. Yeatman presented the Editor's report (see attachment #2). The Editor recommended that the membership list be updated, published and distributed and that the Constitution and Bylaws be reprinted at a total cost not to exceed $1,500.00. The Editor mentioned the continuing and appreciated support of the CFS in publishing the Proceedings, parts 1 and 2.

Motion: That the Editor's Report be accepted as read.

Moved by C.W. Yeatman, seconded by J.I. Klein. Carried

222. BUSINESS ARISING FROM PREVIOUS MEETINGS

a) EDUCATION COMMITTEE (E.C.)

Ms. Rauter explained that the E.C. (composed of B. Devitt, A. Fortin, R.M. Rauter, C.W. Yeatman, F. Yeh) had not been active since the '81 meeting when the Proposed Terms of Reference for a Scholarship Fund and unsuccessful solicitations for joint sponsorship were discussed. The executive, including members of the E.C., felt the need to continue support of forest genetics students (see item 212a) and as such provided funding to a student from each forestry faculty to attend the current meeting. (see attachment #3).

Led By O. Sziklai, the membership supported an active E.C. and the suggestion was made to revise the membership of the committee. F. Yeh agreed to remain to provide continuity while G. Murray, M. Pandila, J. Begin and E.K. Morgenstern were suggested as new members. All accepted the challenge. The new E.C. was reminded that CTIA/ACAA would cover mailing costs and that discussions concerning funding should begin with the new executive.

Motion: That the E.C. pursue the establishment of Forest Genetics Scholarships at Canadian universities and lobby for inclusion of a Forest Genetics course in the undergraduate program at Canadian universities.

Moved by J.I. Klein, seconded by C. Harrison. Defeated

After considerable discussion the motion was defeated and the suggestion made that the E.C. meet the following day to discuss a mandate.

b) FOREST TREE SEED REGULATIONS COMMITTEE

G. Buchert led the discussion. A critical review of an early draft of proposed seed regulations was prepared by the Committee. Apparently drafts number 3 and 4 have been published but have not been forwarded to the CTIA/ACAA for perusal. The committee will obtain these drafts for review and comment.

223. FUTURE MEETINGS

a) LOCATION OF 1985 MEETING

Ms. Rauter called attention to the resolution passed by the 18th meeting (item 213c) which stated that the 20th meeting be held in Quebec in 1985. G. Vallee confirmed that Quebec would host the meeting and that the new executive would determine a theme.

b) LOCATION OF 1987 MEETING

An invitation was received from the Nova Scotia Dept. of Lands and Forests to host the 21st meeting in that province.

Motion: That the Nova Scotia Dept. of Lands and Forests invitation to host the 21st meeting of the CTIA/ACAA in Nova Scotia be accepted.

Moved by G. Buchert and seconded by G. Powell. Carried

c) LOCATION OF 1989 MEETING

Suggestions were requested and tentatively received from both Alberta and Saskatchewan.

224. ELECTION OF OFFICERS

The nominating committee of G. Buchert and G. Murray proposed the following slate of officers for election:

Chairman	A.G. Corriveau
Vice-chairman (Symposium)	G. Vallée
Vice-chairman (Local arrangements)	L. Parrot
Executive Secretary	J.F. Coles
Editor/Treasurer	C.W. Yeatman

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

Motion: That the slate of officers proposed be elected.

Moved by G. Buchert, seconded by G. Murray. Carried

225. NEW BUSINESS

a) TREE SEED WORKING GROUP

Motion: That the Tree Seed Working Group should organize a workshop at the forthcoming 20th CTIA/ACAA meeting in Quebec City in 1985.

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

Motion: That the Tree Seed Working Group become an ad hoc committee of CTIA/ACAA.

Moved by C.W. Yeatman, seconded by R.E. Farmer. After some discussion the motion was withdrawn.

Motion: That the CTIA/ACAA endorse the research priorities of the Tree Seed Working Group and recommend further work in these areas by the appropriate organizations.

Moved by B.S.P. Wang, seconded by G. Powell. Defeated

Motion: That the CTIA/ACAA establish a Working Group on seed research.

Moved by R.E. Farmer, seconded by J. Hood. Carried

Motion: That B.S.P. Wang be interim chairman of a Tree Seed Working Group and establish terms of reference and a mandate.

Moved by R.E. Farmer, seconded by A. Gordon. Carried

b) GENE CONSERVATION

C.W. Yeatman led a discussion of gene conservation centred around the resolution recently adopted by the Western Forest Genetics Association. Dave Harry provided the background for the WFGA resolution.

Motion: That CTIA/ACAA endorse the principles of gene conservation with respect to management of our forests.

Moved by C.W. Yeatman, seconded by B.S.P. Wang. Carried

c) POSITION OPENING

At the Pacific Forest Research Centre - the position of Forest Geneticist to study disease resistance in white pine.

d) Motion: That the members of CTIA/ACAA thank the executive committee for an inspiring and well organized meeting.

Moved by G. Vallee, seconded by E.K. Morgenstern. Carried

226. ADJOURNMENT

Motion: That the 19th business meeting of the CTIA/ACAA be adjourned.

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

James F. Coles
Executive Secretary

Attachment #1

FINANCIAL STATEMENT

August 17, 1983

Balance 29 July, 1981	$2,411.56
Income	5,024.83
Expenses	2,310.81
Balance (17th August 1983)	$5,125.58

C.W. Yeatman
Treasurer, CTIA/ACAA

Attachment #2

EDITOR'S REPORT
July 1983

The Proceedings, Parts 1 and 2, of the 18th Meeting of the Canadian Tree Improvement Association were published in 1982 with the financial and material support of the Canadian Forestry Service. The Membership and Proceedings Distribution List, July 1982, was prepared for printing at the Petawawa National Forestry Institute and the cost of printing was borne by the Canadian Tree Improvement Association.

Both parts of the proceedings and the Association list were sent to all Canadian addressees. Part 2 of the Proceedings, Symposium on

Seed Orchards and Strategies for Tree Improvement, was distributed to all foreign addressees. Mailing was undertaken by the Publications Distribution Centre of the Department of the Environment, Hull, Quebec.

The List of Members and Addressees is maintained on the computer at Petawawa National Forestry Institute. Currently it includes the following numbers by category.

Honorary Members	3
Sponsoring Members	27
Active Members	72
Prospective Active Members	23
Corresponding Members	325
Canadian institutions and libraries	134
Total Canadian	484
U.S. addressees	216
Other foreign addressees (66 countries)	269
Total addressees	1069

There have been 160 additions,
20 deletions,
and 120 changes of address

in the two year period between meetings of the Association.

I recommend that the updated List again be printed and distributed to all Canadian addressees in 1984.

I also recommend that the Constitution and Bylaws be reprinted for distribution to new members as required.

I therefore request authority for expenditure of funds not to exceed $1,500.00 for printing 700 copies of the Membership and Mailing List and 300 copies of the Constitution and Bylaws.

Members are again urged to assist the Editor by notifying him promptly of changes of address, names of new prospective Active and Corresponding members, changes of responsibility that directly affect members' status in the Association, retirements and deaths.

C.W. Yeatman
Editor, CTIA/ACAA

Attachment #3

STUDENTS SPONSORED BY CTIA/ACAA
TO ATTEND 18TH MEETING, 1983

STUDENT	AFFILIATION
Sally Aitken	University of B.C.
Nora Kopjar	University of Alberta
Sylvie La Liberte	Laval University
Om Rajora	University of Toronto
Mike Stoehr	Lakehead University
Kathleen Tosh	University of N.B.

POSTER SESSION

Authors and Titles[1/]

Ahuja, M.R. Federal Research Center for Forestry and Forest Products, Institute of Forest Genetics and Forest Tree Breeding, Sieker Landstrasse 2, D-2070 Grosshansdorf, Federal Republic of Germany.

Biotechnological Approaches to Clonal Forestry: The Aspen System.

Baker, W.D. Ontario Ministry of Natural Resources, Northwestern Region. Kenora, Ontario. P9N 3X9.

Tree Improvement Program in Ontario's Northwestern Region.

Caron, G.E. Department of Forest Resources, University of New Brunswick, Bag Service, No. 44555, Fredericton, N.B. E3B 6C2.

Occurrence of Sporangiate-Vegetative Structures and bisexual strobili in Young Plantations of Black Spruce.

Cheliak, W.M. Canadian Forestry Service, Petawawa National Forestry Institute, Chalk River, Ontario. K0J 1J0.

Certification of Controlled Matings Using Isoenzymes.

Falusi, K. Faculty of Forestry, University of Toronto, Toronto, Ontario. M5S 1A1.

Genetic Variation in Populus balsamifera L.

Florence, L.Z. and J.R. Kenny. Department of Forest Science, University of Alberta, Edmonton, Alberta.

Genetic Analysis of Forest Trees Using Recombinant DNA Molecules: Experiments with Lodgepole Pine.

Gordon, Alan G. Ontario Tree Improvement and Forest Biomass Institute, Ministry of Natural Resources, P.O. Box 490, Sault Ste. Marie, Ontario. P6A 5M7.

Spruce Improvement Through Intra- and Inter-specific Breeding.

[1/] For further information, please contact authors.

Graham, B.J. Forest Resources Branch, Ontario Ministry of Natural Resources, Parliament Buildings, Toronto, Ontario. M7A 1W3.

TSINOW: Ontario's Computerized Tree Seed Inventory.

Graham, Celia. Forest Resources Branch, Ontario Ministry of Natural Resources, Parliament Buildings, Toronto, Ontario. M7A 1W3.

Reproduction Cycle of Jack Pine.

Harry, D.E. University of California, Department of Genetics, Berkeley, California, U.S.A. 94720

Genetic Structure of Incense-cedar Populations: Allozyme and seedling Growth Variation.

Ho, R.H. Ministry of Natural Resources, Ontario Tree Improvement and Forest Biomass Institute, Maple, Ontario. L0J 1E0.

Enhancement of Cone Production by Gibberellic Acid Application, Girdling and Root Pruning in spruce.

Ho, R.H. and Y.A. Raj. Ontario Tree Improvement and Forest Biomass Institute, Ontario Ministry of Natural Resources, Maple, Ontairo. L0J 1E0.

Haploid Plant Induction Through Anther Culture in Poplar.

Hyun, J.O. Ontario Tree Improvement and Forest Biomass Institute, Ontario Ministry of Natural Resources, Maple, Ontario. L0J 1E0.

Genetic Variation in Populus tremuloides Michx.

Knowles, P. and T. Krickl. Lakehead University, Thunder Bay, Ontario. P7B 5E1.

Isozyme Comparison of Natural and Artificially Regenerated Jack Pine.

Maynard, C., D. Tricoli and A. Drew. State University of New York, College of Environmental Science and Forestry, Syracuse Campus, Syracuse, New York. 13210.

Prunus serotina in Vitro Propagation.

Morgenstern, E.K. and A.J. Pottinger. Department of Forest Resources, University of New Brunswick, Bag No. 44555, Fredericton, N.B. E3B 5A3.

Propagation of Tamarack by Stem Cuttings.

Morse, S.H. and D.L. Rogers. Ontario Ministry of Natural Resources, P.O. Box 605, Oxford Ave., Brockville, Ontario. K6V 5V8.

Clonal Forestry and Fast Growing Hardwoods in Ontario: Diversity with a Difference.

Mosseler, A. Ontario Tree Improvement and Forest Biomass Institute, Ontario Ministry of Natural Resources, Maple, Ontario. L0J 1E0.

Willow Hybridization for Biomass Energy Production.

Muhs, H.J. Federal Research Centre of Forestry and Forest Products, Institute of Forest Genetics and Forest Tree Breeding, Sieker Landstr. 2, D-2070, Grosshansdorf, West Germany.

How do Lawmakers Meet the Risks Connected with Clonal Forestry?

Muhs, H.J. and G.J. Wühlisch. Federal Research Centre of Forestry and Forest Products, Institute of Forest Genetics and Forest Tree Breeding, Sieker Landstr. 2, D-2070, Grosshansdorf, West Germany.

How Strong is the Influence of Topophysis in Cuttings of Picea Abies (L.) Karst.?

Murray, G. Petawawa National Forestry Institute, Chalk River, Ontario. K0J 1J0.

White Spruce Breeding Strategy - An Example in the Upper Ottawa Valley.

Niebling, C.R. and H.D. Gerhold. Pennsylvania State University, Forestry Research Lab., University Park, Pennsylvania. 16802 U.S.A.

Linkage of Genes in Scotch Pine: An Electrophoretic Analysis.

Powell, G.R. Department of Forest Resources, University of New Brunswick, Bag Service No. 44555, Fredericton, N.B. E3B 6C2.

Strobilus and Foliage Colour in a Natural Population of Abies Balsamea.

Raj, A. Yesoda. Ontario Tree Improvement and Forest Biomass Institute, Ontario Ministry of Natural Resources, Maple, Ontario. LOJ 1EO.

Rapid Multiplication of Poplars Through In vitro Propagation.

Rajora, O.P. Ontario Tree Improvement and Forest Biomass Institute, Ontario Ministry of Natural Resources, Maple, Ontario. LOJ 1EO.

Isozymes as Gene Markers for Populus L. Species and their Inter-specific Hybrids.

Roddy, D.M. Prince Albert Pulpwood, P.O. Box 1720, Prince Albert, Saskatchewan. S6V 5T3.

Jack Pine Wood Density.

Sziklai, O. University of British Columbia, Dept. of Forest Sciences, Faculty of Forestry, MacMillan Building, Vancouver, B.C. V6T 1W5.

Research Programs Related to Tree Improvement at University of British Columbia.

Yeatman, C.W. Canadian Forestry Service, Petawawa National Forestry Institute, Chalk River, Ontario. KOJ 1JO.

Response in Canada of Jack Pine Provenances to Gremmeniella Abietina.

Zsuffa, L. Ontario Tree Improvement and Forest Biomass Institute, Ontario Ministry of Natural Resources, Maple, Ontario. LOJ 1EO.

White Pine Breeding for Resistance to Blister Rust.

FIELD TOURS

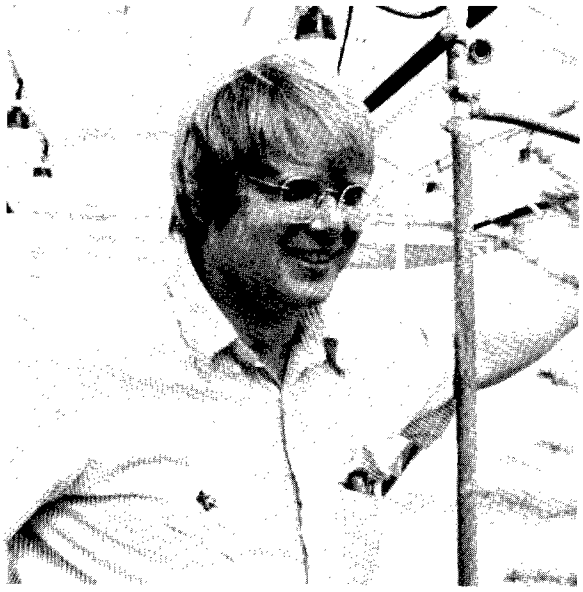
AUGUST 1983

C.T.I.A./A.C.A.A. FIELD TRIPS - 1983

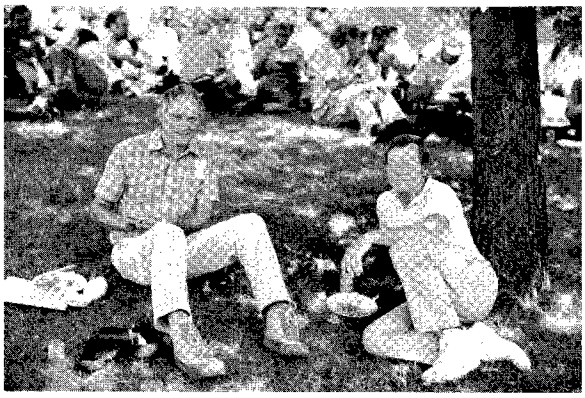
ONTARIO TREE IMPROVEMENT AND FOREST BIOMASS INSTITUTE

"Tour guide" George Buchert at O.T.I.F.B.I.

Happiness is a C.T.I.A. tour of O.T.I.F.B.I. with Louis Zsuffa and Marie Rauter.

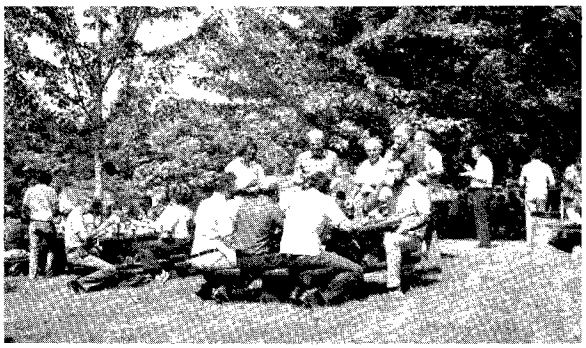


O.T.I.F.B.I. General Manager D. Drysdale greets guest speakers J. Bonga, K. Ohba, J. Kleinschmit, A. Franclet and W. Libby.



Al Gordon and D. Fowler relax at O.T.I.F.B.I.

"Love this Ontario hospitality" Hans Roulund and Carl Heimburger look for a shady spot for lunch.

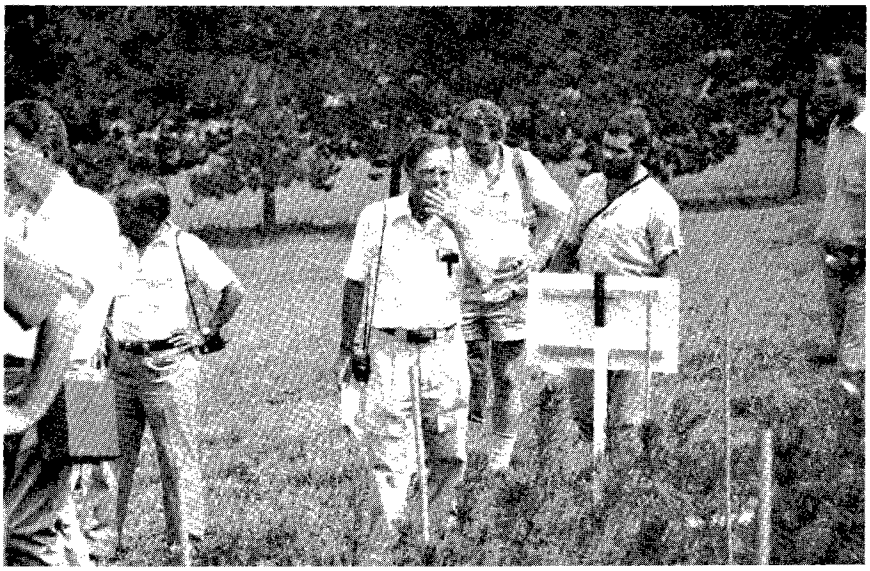


Under the maples at Maple. Don Boufford enjoys the refreshing taste of ..... watched by Mrs. M. Roulund, Hans Roulund, Carl Heimburger, Jerry Klein and Jochen Kleinschmit.

ORONO NURSERY

PETAWAWA NATIONAL FORESTRY INSTITUTE

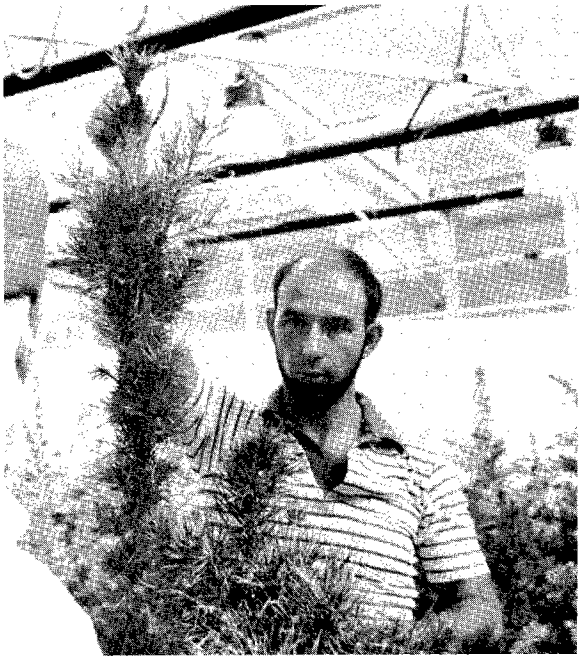
Tony Richmond, Tim Boyle and Yesoda Raj watch while Zdenek Zdrazil and Kit Yeatman get to the root of the matter at P.N.F.I.

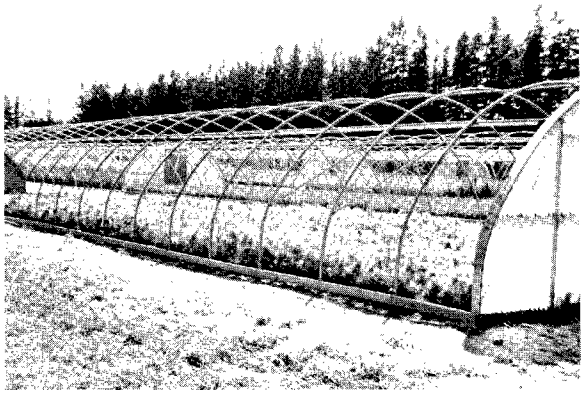


"What did Kit Yeatman say about those jack pine?" Kris Morgenstern, Zack Florence, John Dojack and Willard Fogal at P.N.F.I.

Bill Bunting explains the art of propagation at Orono.

Bernie Phillion demonstrates the effect of benzylaminopurine treatment of jack pine at Orono.





Rootstock for Orono's 1984 grafting program will spend winter under plastic in this cold frame.

PRE-MEETING TOURS

1. Fast Growing Hardwoods Program, Ontario Ministry of Natural Resources, August 19.

An inquisitive assembly of C.T.I.A. members left Ottawa at 8:00 a.m. on August 19 for a fast-paced tour of some of the work of the Fast Growing Hardwoods Program. This Program is concerned with developing and transferring to potential users the technology required to establish and maintain fast growing hardwood plantations. The major focus so far has been on poplar species, with willow, alder and birch also receiving some attention more recently.

A small (3.5 ha) plantation of hybrid poplar was the first tour stop. The importance of proper site preparation, weed control and matching clones to site was emphasized. Four clones were planted over this area in 1980 at a 3m x 3m spacing. The stocking of this rising-4 plantation was over 90%, with the average height, by clone, ranging from 5.9 to 7.9 meters.

The G. Howard Ferguson Nursery at Kemptville plays a major supportive role in the Program. This year, over one million poplar cuttings will be produced in the clonal stoolbeds for production plantations and field trials. Genetic material from all test clones and all plus tree selections is preserved here. Progeny from both open and controlled pollinations are germinated and prepared for outplanting in progeny trials. Seed of poplar and other fast growing species received from international sources is germinated here.

Travelling south, enroute to technology development trials, the group stopped briefly to admire a plus tree selection. Since 1979, superior native poplar trees have been selected in eastern Ontario for inclusion in the tree improvement program. Selected trees are involved in the program in three ways: seeds resulting from open-pollination are collected; branch material is collected for controlled pollinations; and root material is taken for clonal propagation of the parent tree. Over 1400 selections have been made to date.

At the Edwardsburg Land Assembly, an 1800 hectare land bank available for poplar technology development, the group saw a variety of field trials, each designed to address practical concerns of intensive forest management. Spacing trials, clone-site trials, herbicide trials, and exotic seedlot trials were some of the field trials visited. Topics discussed included trial design and establishment, quality control, and data collection and analysis.

A 46 hectare production plantation in Cornwall District, owned by Domtar Inc. was the next stop. Planted in 1981 to smaller monoclonal blocks of 23 poplar clones, this plantation provided an excellent basis for a discussion of allocation - the decision-making process by which clones are matched with site on the basis of information about clone and site characteristics, and availability of planting stock.

The final stop of the day was fittingly a production plantation which was established in 1975 and scheduled for harvesting later in the fall of 1983. This prompted a discussion on harvesting techniques, yield estimates and coppice management. This particular plantation was not representative of the quality expected today in a hybrid poplar plantation. Productivity of hybrid poplar plantations can be expected to continue to increase for some time as a result of the introduction of new and superior clones, better tending practices, and the availability of more information on favourable mixtures of clones and optimum sizes of clonal blocks.

2. Royal Botanical Gardens and Niagara Peninsula, August 21.

Thirty-three people took advantage of the beautiful late summer weather to view some sites in Southern Ontario. Participants included Europeans and people from all parts of North America. The first stop on this "non-technical" tour, conducted by Congress Canada, was the world famous Royal Botanical Gardens in Hamilton. By special arrangement, we were given a tour of the facilities that included an explanation of some of their genetic improvement work on roses and a viewing of the arboretum.

The group had lunch at the Ohba Inn in historic Niagara-on-the-Lake, one of the oldest settlements in Ontario. The tour culminated with a voyage on the Maid of the Mist and a drenching from Niagara Falls. Although we were a little late returning to Toronto, the day was a great success for all involved.

FIELD TRIPS

1. Ontario Tree Improvement and Forest Biomass Institute, August 24.

The Ontario Forest Research Centre was renamed the Ontario Tree Improvement and Forest Biomass Institute in October, 1982 with a much expanded mandate and with supplemental funding provided by the Board of Industrial Leadership and Development (BILD).

CTIA participants boarded buses at New College, University of Toronto and headed north to the Ontario Ministry of Natural Resources' research facilities at Maple.

Doug Drysdale, General Manager, gave a brief welcoming address. The visitors were then split into smaller groups for tours of individual research projects. Geoff Pierpoint gave a synopsis of the work underway in the Forest Ecology and Silviculture Section, including his own Forest Ecosystem Classification project. Hardwood silviculture, minirotation plantations and biomass yields were the topics of discussion in Harvey Anderson's lab. Participants squeezed into Rong Ho's small lab to witness the interesting products of the tissue culture work. Although Al Gordon's lab is located in Sault Ste. Marie, and not Maple, the visitors got to hear of Al's work on spruce hybridization as he enter-

tained in Jim Hood's lab. George Buchert described his isoenzyme, seed respiration, and pitch pine cold hardiness research while Louis Zsuffa and Ken Bennett talked about the famous poplar program amid their prized stool beds.

Following this very rushed and brief exposure to research at Maple, tour participants were given time to recover during a picnic lunch on the front lawn. After lunch the tour moved on to Orono.

2. Orono Tree Nursery, August 24.

The Ontario Ministry of Natural Resources tree nursery is located on the outskirts of the community of Orono, four miles north of Highway 401. It was founded in 1922 in the midst of an agricultural area where today corn, tobacco, apple, vegetable, and dairy farms abound. The tree nursery consists of 837 hectares of which 248 are suited to tree nursery stock production. White spruce, red pine, white pine, Norway spruce and white cedar comprise most of the nursery's 8 million annual seedling production. Hardwood species such as maple, oak, birch, poplar, and basswood are also grown. Seedling and transplant stock as well as greenhouse transplants, ornamentals, grafted stock, and juvenile cuttings are raised.

The August 24, 1983 tour of the Orono facilities included a slide presentation describing the juvenile cutting production cycle, viewing the modern facilities used to propagate black spruce cuttings, seeing the grafted stock in the cold frames, and a look at how clonal and growth records are stored with the Apple computer. The session also provided an opportunity to view seedbeds, transplant beds, a white pine seed orchard, a white spruce seed production area, and a spruce stool area on the nursery.

Following the tour, refreshments were served. Barbequed steak and corn on the cob were then enjoyed by all. The day was capped by W.R. Bunting's presentation on his recent nursery research activities.

POST-MEETING TOUR

Petawawa National Forestry Institute, Canadian Forestry Service, August 26-29.

More than 30 people joined the post-meeting field tour to Petawawa National Forestry Institute. On the way to P.N.F.I. the group stopped to examine experimental plantations of hybrid poplars and conifers established near Kempenfeldt Bay by the Ontario Ministry of Natural Resources. The second stop included lunch and a tour of the O.M.N.R. Tree Seed Plant at Angus.

The next two and one half action-packed days were spent at P.N.F.I. inspecting and discussing research being done by the Tree Genetics and Breeding Project, the National Tree Seed Centre, and other

projects within the Intensive Forest Management Program. The tour at P.N.F.I. included visits to field tests of jack pine, Scots pine, white spruce, Norway spruce and larch which were used as examples to demonstrate some basic genetic principles and to demonstrate and compare methods used to implement different strategies for the genetic improvement of forest trees.

In addition to its scientific and technical content the tour offered a range of other experiences. For example, no one who visited Algonquin Park to see a practical demonstration of genetic management of jack pine could forget the early morning encounter with the field artillery of the Canadian Armed Forces, or the lakeside barbeque and soccer game.

According to comments made by those who took this tour it was a success and has helped to further the objectives of the Canadian Tree Improvement Association. The hospitality provided by the Canadian Forestry Service and the Ontario Ministry of Natural Resources, and the work of all who made the tour possible is gratefully acknowledged.

TREE IMPROVEMENT IN NEWFOUNDLAND AND LABRADOR A FUTURE OUTLOOK

C. Harrison

Forest Geneticist
Department of Forest Resources and Lands
Bldg. 810, Pleasantville
St. John's, Newfoundland
A1A 1P9

Keywords: Seed-production areas, plus-tree selection, seed orchards, exotics, provenance trial, hybrids

Prior to 1979, all tree improvement work in this province was under the auspices of the Canadian Forestry Service. In that year, the Newfoundland and Labrador Tree Improvement Working Group was formed, bringing the Provincial Government into the picture. For the next three years, Provincial activities were co-ordinated by Forester, Woodrow Burry. Considerable progress was made during those years, especally in the location of plus-tree candidates and seed-production areas, but tree improvement was only one of Burry's responsibilities. The Province made a further commitment of tree improvement in 1982 by hiring the author as a full-time Forest Geneticist. This paper discusses the various approaches to tree improvement that will be followed in this province for the next few years.

EUGENIC SILVICULTURE

The most elementary approach will be Eugenic Silviculture. Whenever a stand is harvested, if possible, it is desirable to replace it by planting with the best available stock. Unfortunately, it will not be feasible to do this on every hectare cut in the foreseeable future. Where natural regeneration is despended upon, it is still possible to take genetics into consideration. Unfortunately, traditional seed-tree and shelterwood harvests are generally inadviseable in Newfoundland because the high winds and heavy rains create such a blowdown problem. However, it might be possible to remove definitely inferior trees from the stand two or three years before the harvest. In any case, dysgenic practices, such as highgrading, must be halted immediately.

SEED PRODUCTION AREAS

Immediate genetic gain in this province will primarily come from seed production areas. A number of superior stands have been selected in black spruce and white spruce, and we are looking for them in larch. Clearing, rogueing, and cultural treatments are beginning this summer. For this year's seed collection, steps are being taken to ensure that only seed from above-average trees is collected.

PLUS-TREE SELECTION

The backbone of our long-range tree-improvement programme, as with most others, will be plus-tree selection and breeding. In addition to Departmental and CFS efforts in this area, a programme of public participation in plus-tree selection is now being tested in Central Newfoundland. A $50.00 reward is offered for the reporting of a tree which is actually selected for inclusion in our breeding programme. A pamphlet has been published and distributed which gives detailed information on the recognition and reporting of potential plus trees, including instructions for marking these trees and mapping their locations.

About 200 plus-tree candidates of black spruce and white spruce had been located prior to this season. Final evaluations and decisions on these trees are now being made. Selection of larch plus trees has also begun.

Half-sib progeny tests will begin with seed collection in 1984 and planting out in 1985. Scions will be collected from each plus tree as soon as a final decision is made regarding it's inclusion in the breeding programme. This will be to preserve the genotype in case the tree is lost as well as for the establishment of clonal orchards.

PROVENANCE TRIALS

Provenance trials have already been established in Newfoundland. The black spruce trials, about 15 years old, were established in seven locations. In all but one, a Newfoundland source did best, but at least one source from outside Newfoundland did best in all but two locations. Since about 3/4 of the provenances were Newfoundland sources, this indicates that there may well be valuable genotypes outside Newfoundland which we should bring here if possible.

White spruce provenance trials have been underway in Newfoundland for decades. Out-of-province sources, espically western Quebec and eastern Ontario, have consistantly outperformed Newfoundland sources. There seems to be some question as to whether enough Newfoundland sources were included to justify any generalizations re local vs. exotic provenances. Such results are not illogical, though, because Newfoundland populations of white spruce are generally small and isolated, which is conducive to inbreeding. Provenance trials involving Newfoundland sources out-of-province sources, and crosses between widely separated Newfoundland sources will be started in the next year of so. Nevertheless, the results of the former trials do constitute sufficient evidence of Mainland superiority to justify going ahead with reforestation with some of the best Mainland provenances.

So far, no larch provenance trials have been established here. The performances of several Nova Scotia seed lots indicate that larch improvement in this province may need to draw heavily on gene pools outside Newfoundland. Larch provenance trials will begin in Newfoundland within the next two years.

Of the other native species, balsam fir and white pine are such problem species that no provenance trials are foreseen in either species. Red pine is so genetically uniform that the minimal gain would not justify the expense of provenance trials. The lack of demand for native birch or any birch for that matter, must of necessity relegate that genus to a low priority. With the possible exception of poplars and willows, no other provenance trials of native species are foreseen at this time.

EXOTICS

A major component of Newfoundland's tree improvement programme will be the introduction of exotics. A number of exotics have already been tried in Newfoundland. Based upon data on these past plantings supplied by Peter Hall, of the Canadian Forestry Service, a rating system was devised based upon survival 10 years after planting and height growth after 15 years. Hall's data also included control plots of a few native species, but even they were, in most cases, from seed sources outside Newfoundland.

These species were rated along with the exotics. The top ten species according to this rating were four species of larch, jack, lodgepole and western white pines, red and white spruce, and one exotic birch.

Based upon this and other information, all exotic species will henceforth be assigned to various priority categories ranging from Priority I-A, "Proven Exotics" to Priority IV-X, "Exotics which might actually be harmful if introduced."

Planning, decisions, and action regarding all first priority species will begin immediately, if it has not already begun. Second-priority species will be planted experimentally on an opportunistic basis. Other priorities will be kept in the back of our minds and perhaps experimented with from time to time.

Hybrids will also have a role to play in Newfoundland. Himalayan blue pine, which is planned for introduction as an exotic anyway, is resistant to white pine blister rust and can be crossed with native white pine. Hybrids in Populus, Salix and probably other genera will also be experimented with in the province.

Both the clonal and seedling approaches to seed orchard establishment will be followed. The clonal approach is deemed necessary to preserve the original genotypes of the plus trees, to make them more readily avialable for controlled crosses and to eliminate the danger of inbreeding in seed orchards. There are also advantages to the seedling approach, though, and since half-sib progeny tests are planned anyway, it will not cost much more to later convert these tests to seed orchards.

Another type of orchard that will be established this year is a super-seedling outbreeding orchard. A sufficient number of super seedlings i.e., those which are 3 1/2 standard deviations above the mean in height growth, have already been selected in black spruce, white spruce, and larch from several different provenances. All possible combinations of two provenances will be planted in 49-tree plots in an alternate pattern to maximise crossing between the two provenances involved. When the trees begin to bear seed, test plantings will be made to determine whether certain combinations of provenances consistently produce superior offspring.

GENETIC IMPROVEMENT OF BLACK SPRUCE IN NEWFOUNDLAND

J. Peter Hall

Newfoundland Forest Research Centre
Canadian Forestry Service
St. John's, Newfoundland
A1C 5X8

Keywords: flower stimulation, auxin, selfing, seed set

I. SOME EFFECTS OF GIBBERELLINS ON FLOWERING IN BLACK SPRUCE

Two problems encountered in breeding programs with conifers are the long juvenile period and the variation in levels of flowering from year to year. These problems cause delays and interruptions in research programs so if early and consistent flowering could be assured it would result in increased efficiency of tree breeding research. Flowering levels of conifers have been altered by cultural methods but results have not been consistent or predictable. In the past decade the manipulation of flowering through the application of exogenous growth substances, particularly the Gibberellins, has become more widespread (Pharis 1976).

Selections are being made in natural black spruce (Picea mariana (Mill.) B.S.P.) stands in Newfoundland for eventual inclusion in seed orchards. In order to obtain maximum benefits from these seed orchards, early and consistent flowering is necessary. This study was established to determine:

(a) if flowering could be stimulated by the application of gibberellins,
(b) at what levels the gibberellins were effective,
(c) optimal time of year for application.

Methods

In June 1982, forty 20-year old black spruce trees were selected in a natural stand in central Newfoundland. These trees had not produced any female flowers previously and produced no male or female flowers in 1982.

The following hormonal treatments were used:

Control-distilled water
Gibberellic acid-(GA 4/7) at 200 parts per million (ppm)
" " " 800 ppm

GA 4/7 at 200 ppm + GA_9 at 10 ppm
GA 4/7 at 200 ppm + Naphthalenacetic acid (NAA) at 100 ppm

Results and Discussion

The greatest effect in stimulating male flowering was achieved using GA 4/7 at 800 ppm and the least effect using the same hormone at 200 ppm (Table 1). For female flowering there was no dosage-related response for GA 4/7 and the addition of GA_9 or NAA increased flowering over the controls only slightly. Use of the auxin NAA has had little effect. These results are consistent with previously published data which indicate a positive response to flowering using gibberellins (Pharis 1976). More recently it has been found that the same hormone (GA 4/7) stimulates flowering in young jack pine seedlings (Cecich 1981).

Table 1. Numbers of male and female strobili on treated and untreated black spruce.

Treatment	Numbers of strobili (total for 4 trees per trt.)			
	7 July		4 August	
	Male	Female	Male	Female
Control (water spray)	7	4	7	31
GA 4/7 at 200 ppm	29	111	9	0
GA 4/7 at 800 ppm	473	113	10	1
GA 4/7 at 200 ppm + GA_9 at 10 ppm	90	8	11	0
GA 4/7 at 200 ppm + NAA at 100 ppm	175	32	189	10

These data also indicate an earlier rather than later application of growth hormone to be the more effective. The results also mask a wide variability from tree to tree which is not surprising since flowering is likely to be under fairly strong genetic control. Use of clonal material would reduce the tree to tree variability.

II. PRELIMINARY EFFECTS OF INBREEDING IN BLACK SPRUCE

Studies on the genetic improvement of black spruce in Newfoundland include provenance and progeny trials, selection of plus trees and studies on seed crops and flower induction. Black spruce commonly occurs in even-aged stands many of which develop after wildfire. Because of this type of stand structure there is more chance of an increased degree of relatedness in adjacent trees in a stand compared to that between widely spaced individuals. This increased degree of relatedness means that when these individuals breed, the progeny will also be closely

related. Given a high level of long distance pollen movement, natural inbreeding would be slight. However, under Newfoundland conditions, where black spruce stands are usually broken up by unforested areas or areas of other species, the gene flow is likely to be restricted and the possibility of inbreeding will be increased. Evidence of inbreeding has been found in small isolated black spruce stands in Ontario (Morgenstern 1972). Inbreeding in conifers commonly results in reduced numbers of filled seed and reduced growth rates in the progeny (Franklin 1970).

In natural black spruce stands, competition favours outbred trees and the chances of the inbred slower-growing trees of maturing and contributing to the gene pool are small. If competition is eliminated from artificially established stands which use closely related seedlings then these trees will not be removed by natural mortality and the slower growing trees will result in lowered productivity.

To develop effective breeding strategies for black spruce, knowledge of the genetic structure of the population is essential. This can be studied, in part, by comparing the effects of known matings in a natural population.

Methods

In June 1982, twelve dominant black spruce mother trees were selected in a 20-year old stand of natural origin in central Newfoundland. Pollen was collected from each of the mother trees and a bulk mixture was collected from each of four sources:

Gander Lake	22 000 metres upwind of the mother trees
Mint Pond	4 200 " " " " " "
Camp 5	650 " downwind " " " "
North Pond	within 100 metres of the mother trees.

Each mother tree was selfed and crossed with each of the polymixes.

Results and Discussion

The total number of seed obtained varied little among treatments and the differences were not statistically different (Table 2). The selfed cones yielded slightly more seed than the outcrossed ones. There were large tree to tree differences which indicates some genetic control over the ability of cones to open and release seed.

Seed weights were significantly different for pollen sources but the seed weights from selfing were statistically different only from the source 6 200 metres distant. The tree to tree differences in seed weight were not statistically significant.

Percent full seed per cone was statistically significant for both pollen source and among mother trees. Pollen source accounted for over 70% of the variation but the differences among pollen sources was

Table 2. Seed yield and average height of black spruce seedlings after selfing and outcrossing.

	Inbred selfs	Outbred-distance from mother trees (m)			
		22 000	6 200	650	< 100
Total seeds/cone	30.6	29.7	28.1	27.0	26.3
1000 seed weight (g)	1.06	1.22	1.38	1.29	1.23
Percent full seed	18.8	44.1	56.5	51.7	47.3
Average total ht. (cm) after 20 wks. growth	17.5	19.3	19.1	19.4	18.2

not statistically significant. Seed set in white spruce has also been found to be considerably reduced following selfing (Coles and Fowler 1976, Hall, unpub.).

Differences in height at 20 weeks were small, although the selfs were significantly shorter than all other pollen sources. There was no significant differences in height among the other pollen sources. These differences in height are much less pronounced than reported by Coles and Fowler (1976) in a similar study on white spruce. It is possible that the inbreeding depression in black spruce is less pronounced than in white spruce, however the effects of inbreeding may become more pronounced with age.

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TREE IMPROVEMENT
PRINCE EDWARD ISLAND DEPARTMENT OF ENERGY & FORESTRY

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Keywords: Plus tree selection, seed orchards, clonal orchards, stand selection

The Prince Edward Island Department of Energy and Forestry initiated a tree improvement program in 1975.

The Department is an associated member of the New Brunswick Tree Improvement Council, which, in conjunction with the Maritime Forest Research Centre in Fredericton, supplies breeding material, research and technical guidance.

The province's reforestation program involves the out-planting of 1.25 million seedlings annually in approximately equal quantities of black spruce (Picea mariana (Mill) BSP), white spruce (Picea glauca (Moench) Voss), tamarack (Larix laricina (Du Roi) K. Koch) red pine (Pinus resinosa) Ait) and balsam fir (Abies balsamea Mill).

STAND SELECTION

Beginning in 1976, superior stands of white spruce, red spruce (picea rubens Sarg), black spruce, red pine, tamarack and balsam fir were selected to supply seed of known sources for the Province's current reforestation needs. Many of these stands are currently being managed as seed production areas.

Seed collection is being done by climbing, so as to preserve these seed production areas.

PLUS TREE SELECTION

To date, 243 white spruce, 28 black spruce, 41 red spruce, 15 balsam fir, and 18 tamarack have been selected for seedling orchards. Of these, 56 white spruce, 20 red spruce and 17 tamarack are being used in clonal orchards.

ORCHARD ESTABLISHMENT

To date, 10 hectares of black spruce, 12 hectares of white spruce, and 5 hectares of red spruce seedling orchards have been established.

Five (5) hectares have been reserved for a tamarack clonal orchard, part of which is presently being accelerated in a glass greenhouse.

OTHER PROJECTS

The Department of Energy & Forestry is trying to preserve as many native hardwood species as possible. This is being done by selecting individuals for use in seedling orchards.

In an effort to provide Christmas tree gowers with an immediate supply of balsam fir a project to grow selected fir in a greenhouse was undertaken, with the first seedling being shipped to growers in June of 1982.

The growing of these seedlings proved so successful, balsam fir is now being grown operationally in a greenhouse.

COOPERATIVE TREE IMPROVEMENT IN NOVA SCOTIA -- THE SECOND CHAPTER

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Keywords: government-industry cooperation, selection, seed orchards, improvement strategy, genotype-nitrogen interaction

The Tree Improvement Working Group (TIWG) was formally established in 1977 with representatives from the Provincial and Federal Governments, and the three major pulp companies: Bowater Mersey Paper Company Ltd., Nova Scotia Forest Industries and Scott Paper International Inc. The Group developed an initial 5-year work plan, and set out to put the mechanics of a cooperative breeding program in place. A historical review and a description of progress up to 1981 was reported earlier (Mullin 1982). The present report covers work accomplished since the last CTIA meeting in Duncan, British Columbia. Unless otherwise indicated, figures presented cover the calendar years 1981-82.

OVERVIEW BY SPECIES

Black Spruce

Making up over a third of the total seedling requirement, black spruce (*Picea mariana* (Mill.)B.S.P.) is the most valuable species for pulp production. The trait of prime concern is volume production. Height and diameter growth, and response to plantation management are particularly important. Since the heritability of these traits is low from field selected trees, mass selection is not generally used. Selection is concentrated on family tests which are replicated over several sites.

Two distinct breeding regions are easily identified: the Highland area of Cape Breton Island, and the remainder of eastern Nova Scotia. The Highland area is unique in terms of elevation, and harsh winter conditions. The large open cut-overs left as a result of salvage operations during the recent budworm infestation are particularly prone to winter drying and snow abrasion.

Establishment of seedling seed orchards for each of these breeding regions has begun (Table 1). Currently, each of these orchards and their respective family tests, include about 250 families. Additional plus-trees have been selected, and seed has also been acquired from selections made in New Brunswick and P.E.I. Seedling material for the expansion of these orchards and outplanting of additional family tests will be grown in the greenhouse in '83-84.

Red Spruce

The use of clonal orchards for red spruce (*Picea rubens* Sarg.) is dictated by the late age at which the species begins to produce seed. A comparison tree with grading method of mass selection is used, with both volume production and stem quality considered. Selection efforts have been relatively successful with over 430 candidates identified, out of an initial target of 500 trees.

An attempt will be made to produce over 30,000 grafts over the next 5 years, to establish an additional 38 hectares of seed orchard. Major orchard installations are in progress at the Bowater Mersey and Nova Scotia Forest Industries sites in the Annapolis Valley, and a third is to be established in Colchester County by Scott Paper.

White Spruce

The breeding program for white spruce (*Picea glauca* (Moench)Voss) is based on mass selection with clonal seed orchards and subsequent progeny testing. Heavy insect damage, particularly from spruce budworm and bark beetle, have made plus-tree selection somewhat difficult. Although old field stands are suspected of being inbred to a higher degree than wild stands, it is now almost impossible to find white spruce trees suitable for selection in anything but stands of old field origin. The original target of 500 plus-trees has been reduced to 300, and this number should be attained by the end of the 1983 field season.

Reduction in vigor of many white spruce stands due to insect attack, has also posed problems for graft production. Although large healthy scion material can be grafted with good success on vigorous root-stock, experience has shown that only about 50% of grafts attempted using field collected scion material will make it into the orchards. Better technique and regrafting using hedge material may improve these odds, but production of large numbers of grafts is likely to remain a problem.

After one or two seasons in the orchard, white spruce grafts grow very well indeed. Only one clonal orchard has been established to date, by Scott Paper at East Mines. However, the first grafts will be outplanted at the Lands and Forests orchard at Debert in 1984.

Table 1. Orchard Area Established by TIWG up to 1983

Species	Owner	Location	Area (ha)	Type	Year Est.
black spruce	Scott	East Mines (eastern N.S.)	3.2	Half-sib	1982
	NSFI	Strathlorne (C.B. Highlands)	2.8	Half-sib	1983
red spruce	NSLF	Lawrencetown	1.6	Clonal	1977
	NSFI	Waterville	0.8	Clonal	1981
	Bowater	Melvern Square	0.5	Clonal	1983
white spruce	Scott	East Mines	2.2	Clonal	1981,83
	NSFI	MacQuarrie Lake Road	3.6	Half-sib	1978
Norway spruce	NSLF	Debert	1.1	Clonal	1981,83
white pine	NSLF	Debert	1.3	Clonal	1981,83

Totals	Clonal	-	7.5
	Half-sib	-	9.6
	Grand Total	-	17.1

Other Species

Although the native spruces receive the bulk of attention, there are a few other reforestation species which receive at least some work.

A small Norway spruce (*Picea abies* (L.)Karst.) clonal seed orchard has been established at Debert. Much of the selected material in this orchard has been collected from trees growing in provenance tests, selected in plots originating from Sudetan or Carpathian Mountain sources in Poland. These provenances have been identified as best sources for Nova Scotia conditions, but in recent years seed has been nearly impossible to obtain from Poland. The orchard will if nothing else preserve a valuable seed source.

Interest in planting white pine (*Pinus strobus* L.) has dropped sharply since the breeding program began in the mid '70s. Establishment of a small (3.5 ha) clonal seed orchard is nearing completion, and future work will likely be limited to management of this orchard and some progeny testing of the 50 or so plus-trees selected to date.

An important species for Christmas tree production, balsam fir (*Abies balsamea* (L.)Mill.) has received some attention over the past two years at the request of local growers. Clonal techniques are seen to have great potential for increasing the gain from a Christmas tree breeding program. Trials conducted at the Tree Breeding Centre and by the Maritimes Forest Research Centre in Fredericton indicate that shoots from trees up to 15 years of age may be rooted with reasonable success ($\pm$70%) but that plagiotropic growth after rooting is very common. Over the next two years some work is anticipated to refine a breeding strategy for balsam fir, and to compare costs of genetic gains to those which might be obtained through improved cultural practices.

MISCELLANEOUS

Orchard Site Development

The identification and acquisition of suitable orchard sites has been a major problem for all cooperators. Suitable topography and soil types have been difficult to find. Both Bowater-Mersey and NSFI have purchased farmland in the Annapolis Valley region where climate and soils are considered favourable, despite high land prices. The Department of Lands and Forests and Scott Paper are developing installations on forested sites. On these sites, preparation for planting of grafted stock consists of stand harvesting followed by piling and burning of slash using the Eden Brush Rake. The site then receives up to two treatments with a Rome disc. Although not as clean as conventional field preparation, it does encourage rapid decomposition of stumps, and maintains high soil organic matter.

GE Interactions in Black Spruce

A study of genotype-nitrogen interactions in black spruce was initiated in 1980, using 40 full-sib families from a disconnected diallel mating design, and grown for 25 weeks under 3 levels of nitrogen fertility. Preparation of a thesis based on this experiment is progressing, albeit more slowly than anticipated. As expected, General Combining Ability (GCA) effects were highly significant and accounted for the largest component of genetic variance. The family x nitrogen-level component was also significant, and generally about half as large as the GCA component. Changes in rank among environments were rare, and the interaction was due primarily to the greater responsiveness of the taller families at the lowest nitrogen levels to increases in nitrogen fertility. If this trend continues and holds for other environmental factors, it would suggest that although better families may be identified with testing on a limited number of sites, accurate estimates of genetic gain can only be made if tests are established on truly representative planting sites.

Material from this initial study is being propagated vegetatively for outplanting of a follow-up clonal test on 5 sites in 1984.

Five-year Review

The TIWG was put in place with a 5-year initial program. During the final year, an assessment of progress was made and an evaluation prepared with recommendations for changes (Mullin 1983). In summary, changes in species mix have required adjustments to be made in program emphasis and orchard targets. Direction of the program is to continue with coordination by the Tree Breeding Centre, overseen by a Management Committee made up of representatives from each agency and technical advisors from the Canadian Forestry Service. This Committee will ensure that individual agencies meet their obligations. The expected input from the 3 industrial members totals 60% and is shared equally; the remainder is contributed by the Department of Lands and Forests.

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TREE IMPROVEMENT AT NB DEPARTMENT NATURAL RESOURCES

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Keywords: Stand test, plus tree selection, seed orchards, family tests

The New Brunswick Department of Natural Resources' tree improvement program has continued, concentrating on its four main reforestation species: black spruce, jack pine, white spruce and tamarack. Active participation has also continued within the New Brunswick Tree Improvement Council.

A summary of the Department of Natural Resources' tree improvement effort follows.

STAND TESTING

A number of black spruce (Picea mariana (Mill.) B.S.P.) and jack pine (Pinus banksiana Lamb.) stands have been reserved and tested throughout the Province of New Brunswick. Some effort is now being put into obtaining seed from the better stands. So far, 204 kilograms of black spruce seed and 63 kilograms of jack pine seed have come from reserve stands.

PLUS TREE SELECTION AND BREEDING

To date, 328 black spruce and 444 jack pine have been selected for use in seedling orchards. Also, a total of 50 white spruce (Picea glauca (Moench) Voss) and 42 tamarack (Larix laricina (Du Roi) K. Koch) have been selected for use in clonal orchards.

ORCHARD ESTABLISHMENT AND FAMILY TEST

To date, 18 hectares of black spruce, 16 hectares of jack pine, 8 hectares of Ottawa Valley white spruce and 3 hectares of tamarack seedling orchard have been outplanted. Six-year measurement and assessment of the Ottawa Valley white spruce family tests was carried out in 1982. Five-year family test measurements of the black spruce and jack pine orchards will begin in 1983.

About 2200 tamarack and 2000 white spruce grafts have been done. Outplanting of the tamarack and white spruce clonal orchards will begin in 1984 and 1985 respectively.

TREE BREEDING AT THE MARITIMES FOREST RESEARCH CENTRE 1981 AND 1982

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Keywords: Population studies, provenance tests, species hybridization, applied tree improvement, tissue and organ culture, Picea, Larix.

An opportunity exists to substantially increase forest growth by developing and utilizing genetically superior seeds and seedlings in the expanding reforestation programs of the Maritimes Regions. 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 realistic levels of genetic improvement.

In the fall of 1981, R.F. Smith began work toward a MScF degree at the University of Wisconsin and J.F. Coles was seconded for at least two years to act as coordinator for the New Brunswick Executive Forest Research Committee. Mr. J.D. Simpson came on staff to head-up the applied tree improvement program.

HYBRIDIZATION IN PICEA AND LARIX

Interspecific crossing work was continued in 1981 and 1982. In 1981 white spruce (Picea glauca (Moench) Voss.), black spruce (P. mariana (Mill.) B.S.P.), red spruce (P. rubens Sarg.), Norway spruce (P. abies (L.) Karst.) and blue spruce (P. pungens Engelm.) were used as seed parents for crosses with Sitka spruce (P. sitchensis (Bong.) Carr.), Koyama spruce (P. koyamai Shiras.), Taiwan spruce (P. morrisonicola Hayata), Korea spruce (P. Koraiensis Nakai) and oriental spruce (P. orientalis (L.) Link.). In total, 150 different crosses were attempted. Emphasis in the crossing program was on crosses using Sitka spruce pollen from selected trees in Scotland. All 62 attempted crosses of white and Sitka spruce yielded viable seeds. Crossability based on full seeds, although highly variable on an individual cross basis, averaged 98%. All but one of the 17 crosses attempted between black and Sitka spruce yielded full seeds. However, species crossability was estimated as only 1.6%.

The crosses, Norway x Koyama, Norway x Korea, Norway x Sitka, and blue x Sitka also yielded enough viable seeds to suggest the crosses were successful. The other crosses yielded only a very few seedlings which as yet have not been verified as hybrids.

In 1982, white, black, red, Norway, Engelmann (P. engelmannii (Parry) Engelm.), and Serbian (P. omorika (Pancic) Purkyne x black) were used as seed parents for crosses with Sitka spruce from selected trees from British Columbia. In total, 144 different tree x pollen combinations were attempted. All attempted crosses of white and Sitka spruce were highly successful. In fact, crossability averaged 100% suggesting the absence of genetic barriers to crossing. The cross, Engelmann x Sitka was also highly successful. As in 1981, the cross, black x Sitka consistently yielded a few seeds (14 crosses) although crossability was consistently low (average 0.6%). The other crosses did not yield viable seeds.

Flower production in Larix was so poor in 1981 and 1982 that no crosses were attempted.

Work on selection, rooting, and field testing of selected spruce species and hybrids was continued in 1981 and 1982.

SPECIES AND PROVENANCE TRIALS

This work is part of a long-term and continuing program to improve forest growth in the Maritimes by determining the best adapted and productive species and the best provenances within these species for use in various locations in the region.

Red pine

A paper on the performance of red pine (Pinus resinosa Ait.) in two range-wide provenance trials was published (Park and Fowler 1981). These trials included a total of 39 provenances at 17 and 21 years established in three test locations in the Maritimes. The results indicated that red pine is genetically uniform, and that the differences among provenances resulted from non-genetic as well as genetic factors. Although there are statistically significant differences among provenances for most growth characters, the actual differences are small. For example, height superiority of the best provenance over the plantation average was 5.8 to 6.1% (30 cm) in one trial after 17 years but only 4.7% (60 cm) in the other trial after 21 years. Differences among provenances with respect to survival, porcupine damage, and European pine shoot moth damage were not significant. In general, trees from the central part of the species range in the Lake States and Ontario grew slightly faster (3 - 4%) than trees originating from north of 47°N latitude. Trees of local origin were about average.

Black spruce

The cooperative range-wide provenance test of black spruce which was established in a nursery trial at the Acadia Forest Experiment Station in 1972 and field planted in 10 test locations in the Maritimes in 1975, was remeasured. At each test location, up to 99 provenances were represented in 6 replicates with an 8-tree plot. In 1980, accumulated data up to age 5 from field planting were analyzed (Fowler and Park 1982). A factor analysis based on 38 phenotypic and ecological variables indicated that genetic variation pattern in the species is clinal. Genotype x environment interactions were not important among the provenances represented at all test locations. Black spruce of the Maritime provenance appear to be more stable than those of non-Maritime provenances. Truly local provenances were generally below average in height at age 5 years and only slightly above average in survival, suggesting that black spruce is not particularly well adapted, in an evolutionary sense, to many of the sites that it occupies locally. Recommendations are made concerning choice of black spruce provenances for use in the Maritimes Region according to the seed zones of the Region.

Japanese larch

As part of an international cooperative provenance trial, a Japanese larch provenance test was established in 1961 by Mr. H.G. MacGillivray (retired). The test included 20 Japanese larch (Larix leptolepis (Sieb. et Zucc.) Gord.), 3 European larch (L. decidua Mill.) and 2 native tamarack (L. laricina (Du Roi) K. Koch.). The most recent measurements were obtained in 1980, and the data on 20 characters accumulated for this period were analyzed. The results indicated that genetic variation in Japanese larch is random with no apparent correlations among geographic variables of the provenances and phenotypic variables. Although tamarack had a height advantage over the other species up to age 8, Japanese larch was clearly superior in both height and diameter growth by age 12 and increased its superiority through age 19. Survival of Japanese larch was somewhat poorer than tamarack; however, volume of Japanese larch for the best five provenances averaged 156 m^3/ha and was more than double that of tamarack. It is suggested that Japanese larch of good provenance could be used as a short rotation species for fibre production in eastern Canada.

Red spruce

In 1981 and 1982, seven red spruce provenance test plantations in the Maritimes were remeasured. At each test location, 30 provenances were represented in 10 replicates with a 4-tree plot. Data accumulated during the past 20 years are currently being analyzed.

Norway spruce

Two sets of Norway spruce progeny tests of Czechoslovakian and Bulgarian origin were remeasured in 1980, and were analyzed for early height growth and survival. Progenies from Bulgarian provenances were

genetically more variable than those from Czechoslovakian provenances. For both sets, provenance variation within a limited geographic area was negligible. The heritability estimates for 5- to 6-year height of Czechoslovakian progenies were low (0.04) but for 10-year height were moderate (0.18). Higher heritability estimates were obtained for Bulgarian progenies, 0.45 for height and 0.34 for survival. It is proposed that existing provenance plantations be used as a source of material for selection and breeding.

POPULATION STUDIES

An experiment on population structure of tamarack with special reference to inbreeding and relatedness among neighboring trees was published. The experiment involved four subpopulation disconnected diallel and disconnected factorial crosses. Within each subpopulation, 5 parents were control-pollinated including self-pollinations. The average relationship coefficients among neighbor (average 22 m between trees), distant (59 m) and long-distant (135 m) was 0.167, 0.115, and 0.0, respectively. Self-pollination resulted in a significant reduction in seed set, and the study population carried an average of 10.8 embryonic lethal equivalents. Relatively large specific combining ability variances were also obtained (Park and Fowler 1982).

A clonal progeny test of tamarack was established in three locations in the Region in 1981. Mass production of seedlings through "a juvenile cutting method" was achieved by using an inexpensive modification of an ordinary greenhouse. For this experiment, seedlings were used to produce a total of 24,000 vegetatively propagated seedlings in two cycles within one year.

During 1982, inbreeding studies of both white and black spruces were given priority. A white spruce inbreeding study involving five experiments was measured to obtain current data and was analyzed. The most devastating effect of selfing is embryonic deaths, amounting to an average of 93%. The effect of selfing on height growth was evident as early as age 3 years. The evidence of natural inbreeding and relatedness among neighboring trees was analyzed by comparing the effects of self, neighbor, open, open bag, and mix pollinations. Based on sound seed data, an average coefficient of relationship among neighboring trees was 0.3. Effects of natural inbreeding on height, as expressed by reduced growth was detectable as early as age 1 year from seed; however, it became more evident about age 5 from seed.

The black spruce inbreeding experiment was also remeasured in 1982, and the accumulated data have been analyzed. The results indicate that the study population carries an average genetic load of 4.7 embryonic lethal equivalents per zygote. The total number of lethal equivalents, acting from the time of pollination through age 6 years was about 6. Significant differences among female parents in respect to seed weight, percent germination, and 2- and 6-year heights indicate a substantial

variation due to additive genetic and maternal effects. Relative self-fertility in the species, although generally high, varied widely among the parents. Estimated heritability for 6-year height based on polycross progenies was 0.33, and a moderate genetic gain is expected through selection.

CONE INDUCTION EXPERIMENTS IN BLACK SPRUCE

In New Brunswick, most black spruce seedling seed orchards are established on 'typical' planting sites within each region. Only moderate consideration is given towards site selection from the standpoint of ability to produce regular and abundant cone crops, because, aside from the economic constraints, these plantings serve as 'additional' family tests prior to serving a seed production function. Accordingly, while weed/competition control is practiced, trees are not fertilized. Once these orchards reach flowering age and have been rogued to yield a desired level of genetic improvement (to be determined by each agency) they then will be managed for seed production.

Two experimental areas were established: Glencoe, a New Brunswick Department of Natural Resources plantation and Biggar Ridge, a seed orchard established by J.D. Irving Ltd. The common objective of both studies is to find reliable means of enhancing cone and seed production in young black spruce trees. Some of the questions this study addresses include i) which of two nitrogen fertilizers (urea and ammonium nitrate) if either, will have the greater stimulatory effect on black spruce flowering, at what rate(s), and applied when; ii) do fertilizing and spacing affect male and female flowering similarly; iii) will trees grown under initially heavy competition (Glencoe) and then released, respond differently than those grown under virtually no competition (Biggar Ridge); iv) what effect if any, will fertilizing and spacing have on cone/seed yields; and v) do seed yields differ between trees growing on a 'typical' planting site and those growing on an 'old field' site. Preliminary results are as follows:

1. The greatest variation in flowering was attributable to tree size. Increases in flowering due to fertilization or spacing treatments were masked by the predisposition of larger trees to produce more flowers. More meaningful estimates of the increases in flowering attributable to fertilizing and spacing might have been possible if tree sizes in the experiments were more uniform.

2. Ammonium nitrate increased both the percentage of trees bearing female flowers and the numbers produced. The greatest increase in numbers occurred at the 200 and 300 kg N/ha rates. Rates greater than 300 kg N/ha had no positive effect, and in some instances decreased female flower production.

3. Male flower production was reduced at the higher levels of ammonium nitrate (> 200 kg N/ha). However, this reduction was only

minimal at the 200 and 300 levels, indicating that the rates that stimulated megastrobili would probably not do so at the expense of microstrobilus production.

4. Urea had little effect on either male or female flower production.

5. Trees did not respond to any of the treatments in a 'bad' flowering year, 1981.

6. Flowering increased in response to thinning/release but there has not been sufficient time for crown growth and therefore the flowering increase to be significant.

7. None of the treatments affected the seed characteristics studied. Increasing flower/cone production per tree should not be detrimental to the quality of seed from that tree.

8. Several more years of flower counts will be required to determine whether the increases in flowering realized will justify the use of fertilization as a flower enhancement technique in black spruce seedling seed orchards.

TECHNICAL ASSISTANCE PROGRAM

The Maritimes Forest Research Centre continues to provide technical assistance to the rapidly expanding operational tree improvement programs in the Maritimes Region.

The cooperative program in Nova Scotia and the program in Prince Edward Island will be reported separately.

The New Brunswick Tree Improvement Council, formed in 1976, is continuing to concentrate its efforts on black spruce, jack pine, white spruce, and tamarack. Approximately 575 black spruce trees have been selected and 56 ha of seedling seed orchards planted supplemented by family tests. Good progress has been made in the jack pine program with 495 trees selected and seedlings planted in family tests and 31 ha of seed orchards. Clonal seed orchards of white spruce and tamarack are just beginning to be established. Because of the difficulty that has been experienced in producing sufficient ramets, hedges were established and managed for scion production. During the winter of 1982, the first scion collections were made from these hedges. A total of 190 white spruce and 130 tamarack trees has been selected.

One company, with a hardwood pulp and paper mill, has initiated a hardwood tree improvement program utilizing birch. The principle species is white birch (Betula papyrifera Marsh.) but yellow birch (B. alleghaniensis Britton) and European white birch (B. verrucosa) are also receiving attention. Trees have been selected and scions grafted.

During the autumn of 1982, five-year height measurements were conducted on 24 tests: 6 Ottawa Valley white spruce family tests, 3 black spruce family tests, 6 black spruce stand tests, and 9 jack pine stand tests. These early results are providing information on the variation in family growth between different test locations in the Province and help to identify better stands reserved as seed collection areas.

Most Council members are providing funding for specific gravity determinations of the wood of the selected trees. This background information will be useful when evaluating families for dense wood and estimating heritability of wood density.

TISSUE AND ORGAN CULTURE

The main objective is in vitro cloning of mature conifers. The best results so far have been obtained with Larix decidua. Slices of immature female cones collected in early May, and shoot tips excised from vegetative buds collected in early September have produced adventitious shoots. Many of the adventitious shoots arose from subcultured callus. None of the shoots formed roots.

One of the problems still to be solved is how to obtain elongation of the shoots. Such elongation is an important prerequisite for rooting.

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OCCURRENCE OF SPORANGIATE-VEGETATIVE STRUCTURES AND BISEXUAL STROBILI IN YOUNG PLANTATIONS OF BLACK SPRUCE

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Sporangiate-vegetative structures, both mega and micro, previously considered to be oddities, rare occurrences in response to unusual edaphic climatic conditions, are proposed for black spruce (Picea mariana [Mill.] B.S.P.), as normal physiological developmental intermediates between vegetative shoots and megasporangiate or microsporangiate strobili. In addition, bisexual strobili are proposed as normal occurrences in young strobilus-bearing black spruce trees.

A survey conducted in June 1983 in young plantations established the relevant importance of sporangiate-vegetative structures in black spruce. At least 50 percent of trees bearing reproductive structures bore some sporangiate-vegetative structures. An average of 0.17, 0.90, 1.27, 2.00, 3.48, and 4.80 megasporangiate-vegetative structures per tree, and an average of 0.03, 0.00, 0.03, 0.48, 9.28, and 9.08 microsporangiate-vegetative structures per tree, were tallied within the 9-, 10-, 11-, 13-, 15-, and 17-year-old plantations sampled, respectively. Proportions of megasporangiate-vegetative structures to total megasporangiate structures ranged from 1/5 to 1/43 within individual plantations. Similarly, the proportions for microsporangiate-vegetative structures ranged from 1/17 to 1/67 within various plantations. The sporangiate-vegetative structures were principally located, within each tree, at the mergence of the reproductive zones and the vegetative zone.

The bisexual strobili were all located in a restricted area at the mergence of the megastrobilus and microstrobilus zones. Trees bearing bisexual strobili were generally 10 years old, while a few bore bisexual strobili at ages of 11 and 12 years. No younger or older trees bore bisexual strobili. Bisexual strobili were generally located on trees bearing microstrobili for the first time.

TREE SEED AND GENETIC STUDIES AT THE UNIVERSITY OF NEW BRUNSWICK 1981-1983

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Keywords: morphogenesis, cone production, seed set, genotype-environment interaction, vegetative propagation, breeding strategies.

Since our report to the Eighteenth Meeting (Powell and Morgenstern 1982), teaching and research in the areas of tree seed and forest genetics have been further developed in cooperation with various forestry agencies in eastern Canada. The number of graduate students and government support of research have increased considerably. Brief descriptions of studies under way and results obtained in undergraduate and graduate research projects are given.

UNDERGRADUATE PROJECTS

Cone Production

In cooperation with the Petawawa National Forestry Institute and Kimberly-Clark of Canada Ltd., Middlemiss (1982) examined the annual variation in cone production of black spruce (Picea mariana (Mill.) B.S.P.) and white spruce (Picea glauca (Moench) Voss), for the period 1969 to 1979, in clonal orchards at Longlac, Ontario. Correlation and principal component analyses were made for each species using cone and seed production summaries and meteorological records. He found that during the bud initiation year, temperature during late June and early July, and precipitation in July, are important for flowering in the following year. In the year of flowering, June temperatures were critical. Thus, general trends established in other studies appear to be valid for native species in the Boreal Forest also.

Progeny Tests

In cooperation with the Petawawa National Forestry Institute, LeBlanc (1982) examined trends of rank correlation coefficients calculated from total heights in a black spruce half-sib family test measured at ages 7 to 16 years, to determine at what age selections could be made. High correlations were usually reached when the trees were 10 years old, but the total length of the observation period (16 years) may not have been long enough to draw final conclusions. In addition, other traits (e.g., volume production) may have to be considered, and the test environment is critical.

An analysis of a black spruce half-sib family test established by Fraser Inc. in 3 areas of northwestern New Brunswick was performed by Giberson (1983). At the age of 5 years, overall mean height was 77 cm, survival 93%, and the narrow-sense heritability based on individual trees 18%. The Ottawa-Valley-origin white spruce half-sib family test established by several member organizations of the New Brunswick Tree Improvement Council was analysed by Upshall (1983). At 6 years, overall mean height was 101 cm, survival 96%, and heritability 14%. Although these early heritability estimates must be considered with caution, they lie within the range expected.

Provenance Studies

In another study arranged by the Tree Improvement Council, Moore (1982) evaluated the performance of progeny of 37 New Brunswick black spruce stands reserved for seed production. The study was based on 5-year heights measured at 6 test sites well distributed across the Province. The differences among provenances and sites were statistically significant but the interaction, provenances x sites, was not. The absence of significant interactions was also noted in the Maritimes component of the range-wide black spruce study by Fowler and Park (1982). If this trend continues, provenance selection may be simplified in the years to come.

An examination of 15 Norway spruce (Picea abies (L.) Karst.) provenances grown in unreplicated trials in 9 areas of Nova Scotia was performed by Miller (1983). The study again confirmed the value of Latvian provenances, possibly as a result of greater resistance to the white pine weevil (Pissodes strobi Peck.) as noted by Fogal et al. (1982).

Vegetative Propagation

At the Sussex Nursery of J.D. Irving Ltd., Gillespie (1983) studied the rooting of black spruce cuttings from trees 5 to 15 years old. The effects of time of striking, age, clone, and rooting environment were statistically significant at the 1% level. The best time was the period 28 June to 5 July.

Using tissue-culture techniques, Minchin (1983) induced callus formation on hypocotyl and cotyledon explants of black spruce, and studied external features and some internal cellular characteristics during early callus morphogenesis. Initiation of smooth-surfaced, shiny, dark green areas on the callus appeared to presage nodule formation. Sectioning and staining showed that epidermal layers had been ruptured and that the nodule tissues were comprised of cells of a variety of shapes containing non-starch particles, and large intercellular spaces.

GRADUATE EDUCATION AND RESEARCH

Program Development

The Ph.D. program in the Faculty of Forestry was approved in the fall of 1981 and since that time has grown more rapidly than expected. In

our area of specialization, the number of graduate students has increased from 3 to 10. Fortunately, the Natural Sciences and Engineering Research Council of Canada (NSERCC) and the Canadian Forestry Service have recently provided stronger financial support. Several of the graduate students have now completed their course work, and those registered for the Ph.D. degree have passed their qualifying examinations. A new Honorary Research Associate, Dr. G. Tai, was recently appointed by the University. He is a member of the potato breeding team at the Agriculture Canada Research Station in Fredericton and well known for his research in genotype-environment interactions. An NSERCC-supported Postdoctoral Assistant, Dr. W.R. Remphrey, joined the faculty late in 1982 to work on tree morphogenesis, crown architecture and modelling. His research on development of young tamarack (Larix laricina (Du Roi) K. Koch) is closely allied to our cone and seed production studies.

Cone and Seed Production

Cone and seed production of plantation-grown black spruce from age 6 years to 18 years has been investigated by Ph.D. student, G.E. Caron. Early results were given in our last report (Powell and Morgenstern 1982), and have generally been confirmed from three successive years of cone production. Although cone production (in terms of proportions of trees bearing or of numbers of cones per tree) increased with tree age, the increases of both male and female cone production showed biennial fluctuations. Pollen-cone production at first lagged behind seed-cone production by 1 to 2 years, but then increased at a far greater rate than did seed-cone production. As the trees aged, and as their capacity to produce first seed cones, and then both seed cones and pollen cones increased, the positional patterns of cone placement on individual shoots and branches underwent subtle changes. These are being correlated with changes in morphogenetic patterns of vegetative growth. Pollen production has been assessed from counts of pollen cones and by use of pollen traps set in the plantations. Mature seed cones are being analysed to determine whether seed set is related to pollen quantities. Many features of individual trees have been measured to determine, by multivariate techniques, those which are most correlated with cone production. This will extend the earlier findings of Simpson and Powell (1981).

An M.Sc.F. student, K.J. Tosh, is using a somewhat similar approach to that of Caron to investigate the build-up of reproductive capacity in young tamarack. The study is being conducted in 3 plantations at the New Brunswick Department of Natural Resources Nursery at Kingsclear, N.B., and was started in 1983. Initial field studies on this project and that of Dr. Remphrey led to recognition that, contrary to earlier reports on the species, young tamarack produces the bulk of its strobili laterally on long shoots rather than solely in terminal positions on short shoots. This led to full documentation (Powell et al. 1983) because of its importance to understanding of the place of the genus Larix within the family Pinaceae, and of tamarack within the Larix genus.

An M.F. student from Indonesia, H. Arisman, who is supported by the Canadian International Development Agency in connection with the ASEAN-Canada Forest Tree Seed Centre, is investigating cone maturation and

seed quality of Pinus merkusii Jungh and de Vries. Cones collected by normal practices in Indonesia in 1983 will be classified by various ripeness criteria. The seed will be extracted by normal procedures and transported to Fredericton for analysis. It is anticipated that the results of this investigation will lead to recommendations for upgrading field cone-collection techniques.

Two graduate students enrolled in other forestry disciplines, are investigating aspects related to cone and seed production. In forest entomology, M.Sc.F. student, P. Amirault, supervised by Prof. N.R. Brown, is studying cone and seed insects of tamarack, and is testing some possible control measures. In silviculture/fire science, S. Mellish, an M.Sc.F. student, supervised by Dr. I.R. Methven, is investigating the plausibility of combining thinning to enhance cone production, and prescribed fire to control Conophthorus resinosae Hopkins, to increase seed yields for natural or artificial regeneration of red pine (Pinus resinosa Ait.).

Genotype-Environment Interactions

The experiment on genotype-nitrogen interactions in black spruce undertaken by T.J. Mullin was completed in 1981 and data have been analysed since that time. The M.Sc.F. thesis is now being prepared.

A Ph.D. student, J.M. Wanyancha, initiated a similar greenhouse study of tamarack half-sib families raised under three different nitrogen regimes. Numerous measurements of seedling response were made and the experiment was harvested in June 1983. In cooperation with our soils laboratory (Dr. H.H. Krause), the total absorbed nitrogen is now being determined to calculate utilization efficiency. Another experiment is planned. Eventually genetic parameters among all measured variables will be determined.

In the spring of 1983, Ph.D. student R.M. Ricard made a series of halfdiallel and polymix crosses among and within European larch (Larix decidua Mill.) and Japanese larch (Larix leptolepis (Sieb. and Zucc.) Gord.) with the objective of studying heterosis in relation to genotype-fertilizer interaction. The crosses were made under the guidance of Dr. D.P. Fowler in tests established by the Maritimes Forest Research Centre. A large number of cones is developing.

Breeding Strategies

The development of efficient breeding strategies depends upon biological information and the breeding techniques available. While more and more biological data (such as genetic parameters) are being generated, it is also important to improve breeding techniques. Several examples from our studies and those of graduate students will illustrate this point.

The population structure and mating system of black spruce in central New Brunswick is being investigated by means of electrophoretic techniques to determine isoenzyme (gene) frequencies by Ph.D. student T. Boyle. Seed and foliage samples are analysed in the laboratory to determine selfing and outcrossing rate. After overcoming various biochemical

problems (selection of enzymes, buffer and stains), he now obtains clear patterns in the gels. The aim is to improve black spruce breeding strategy by relating the mating system to the accuracy of estimation of genetic parameters.

Another study dealt with the more immediate problem of plus-tree selection. A simple survey of selection techniques and costs in eastern North America indicated that the comparison-tree technique is most commonly used although it was devised in Sweden more than 30 years ago, has come under criticism, and other techniques are available. Further, the intensity of selection is not always well adapted to the breeding method applied. For example, initial tree selection for family testing and seedling orchards is sometimes as costly as selection for clonal orchards. This problem was discussed in a paper at the last Northeastern Tree Improvement Conference (Morgenstern 1983). Graduate student J. Cornelius is examining these problems from an economic point of view.

Another issue is the development of vegetative propagation techniques. The introduction of clonal testing and selection based on rooted cuttings could lead to greater efficiency and large savings in a breeding program, as has been pointed out by Rauter (1974), Corriveau (1976) and others on various occasions. Research into rooting of tamarack cuttings was initiated in 1981 and the first results were reported last year (Morgenstern and Nicholson 1982). While the effects of age of the ortet, season of rooting, and rooting environment have been relatively well established, the problems of overwintering environment to save greenhouse space and of plagiotropic development remain. Graduate student A. Pottinger is concerned with some of these problems.

Finally, another problem is the development of measurement techniques to assess wood quality. As seedling orchards in eastern Canada approach the productive stage, it would be very helpful if relative wood density could be assessed rapidly in the affiliated family tests so that density could be considered as a selection criterion. In cooperation with Dr. L.P. Sebastian of our wood science laboratory, graduate student M. Villeneuve is investigating the patterns of density variation in juvenile and mature wood of plantation grown trees. Further work will explore the use of the Pilodyn tester and other devices.

ACKNOWLEDGEMENTS

The Tree Improvement Chair at the University of New Brunswick is supported by Acadia Forest Products, Boise Cascade Canada Ltd., CIP Inc., Consolidated-Bathurst Inc., Fraser Inc., Georgia-Pacific Corp., J.D. Irving Ltd., and St. Anne Nackawic Pulp and Paper Co. Ltd. These companies are represented in the N.B. Tree Improvement Council together with the N.B. Department of Natural Resources, the Maritimes Forest Research Centre, and the University of New Brunswick. The excellent cooperation of all of these organizations is acknowledged. In particular, Honorary Research Associates J.M. Bonga, J.F. Coles, D.P. Fowler, and Y.S. Park have contributed greatly to the work described here.

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AMÉLIORATION DES ARBRES FORESTIERS AU SERVICE DE LA RECHERCHE 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.

À la fin de 1982, la collection de clones du Service de la recherche comprenait 1 038 clones dont 633 provenant d'arbres sélectionnés en peuplements naturels et 61 en plantations expérimentales tandis 344 clones ont été introduits.

Durant les deux dernières années, quatre dispositifs du test clonal de 3^{e} génération ont été établis dans le sud du Québec.

L'interprétation des données des dispositifs des tests clonaux de 1re et 2^{e} génération a permis de sélectionner 25 clones et de les recommander pour les reboisements.

L'interprétation des données du test de provenances de l'IUFRO sur P. trichocarpa Torr. et Gray après 5 ans de plantation au populetum de Villeroy (âge total de 8 ans) permet de tirer les principales conclusions suivantes:

a) les provenances de Colombie-Britannique et d'Alaska sont toutes rustiques à l'exception de la provenance n° 220 (Île de Vancouver, ruisseau Haslam) dont moins du tiers des plants ont subit des dégâts de gel;

b) les provenances de l'intérieur des états de l'Orégon et de Washington montrent une bonne rusticité mais ceux de la zone cotière subissent des dégâts de gel;

c) la plupart des provenances ayant des dégâts de gel ont un débourrement tardif et une chute de feuilles tardive par rapport aux provenances qui sont rustiques;

d) au Québec P. trichocarpa est très susceptible au charançon du saule et du peuplier (Cryptorhynchus Lapathi L.) et au chancre Septoria musiva Peck. Cependant cette susceptibilité est très variable selon les provenances et les sujets, d'où la possibilité de sélection de sujets résistants pour le développement de clones;

e) d'après les résultats obtenus, les provenances les plus recommandables sont les n^{os} 28, 106, 212 et 209 de l'IUFRO.

PROJET G 70-3. AMÉLIORATION DU MÉLÈZE (LARIX MILL.)
PAR A. STIPANICIC

Mots-clés: Larix Mill., test de provenances, test de descendances, croisement.

Plantations comparatives

Un test de descendances-provenances de L. laricina a été fait au printemps 1982 dont deux dispositifs ont été établis dans les arboretums de Dablon (région forestière B.1a à la limite de L.7) et de La Patrie (région forestière L.5). Dans le premier cas, le dispositif expérimental est composé de 8 répétitions de 3 plants et contient 30 provenances et 450 descendances et dans l'autre cas, nous avons 7 répétitions de 3 plants représentant 30 provenances et 400 descendances. Les descendances proviennent d'environ 50 peuplements différents à travers le Québec. Malgré certains défauts (échantillons très petits: seulement 24 arbres par famille incluse dans chacun de ces tests), nous espérons par cette expérience obtenir les résultats nécessaires à l'identification des meilleures sources de graines et à une meilleure connaissance du comportement de L. laricina au Québec.

Au printemps 1982, nous avons installé dans l'arobretum de Duchesnay un dispositif de 5 provenances de L. decidua et un autre de 5 provenances de L. leptolepis dans lesquelles deux manières différentes de tailler les branches ainsi que trois catégories différentes de longueurs de plants ont été mises en comparaison. Le but est d'établir à quel point l'ébranchage et la grandeur des plants de mélèze influencent la reprise et l'accroissement. Nous pensons qu'un bon choix de provenance combiné à une bonne hauteur d'arbres et une taille adéquate des branches latérales pourrait augmenter la reprise et diminuer les travaux d'entretien dans les jeunes plantations de mélèzes.

Nos plantations, qui font partie de l'expérience n° 378 de Institut forestier national de Petawawa et dans lesquelles on compare différentes familles de L. x eurolepis avec quelques provenances de L. decidua, L. leptolepis et L. sibirica, ont été mesurées à l'automne 1981. Dans les huit dispositifs

répartis dans différentes régions du Québec, 5 ans après la plantation, quelques familles d'hybride L. × eurolepis montrent un meilleur accroissement en hauteur que toutes les provenances de L. leptolepis et L. decidua utilisées dans le test.

Le gain est de 54 p. 100 si on compare la meilleure famille de L. × eurolepis et la meilleure provenance de L. decidua et de 22 p. 100 si on fait cette comparaison avec la meilleure provenance de L. leptolepis.

Récolte des graines

La fructification chez les mélèzes était meilleure à l'automne 1982 qu'à l'automne 1981 et nous avons récolté 68 descendances de L. laricina réparties en sept provenances. En nous basant sur les résultats de nos premiers tests de provenances, nous avons concentré notre récolte surtout dans la région sud du comté de Bellechasse (canton de Langevin).

Dans notre parc à clones de mélèze, nous avons noté aussi la fructification plus importante ces dernières années. Ainsi prévoyons-nous commencer les expériences concernant la pollinisation dirigée au printemps 1984. L'automne dernier nous avons récolté les graines, issues de pollinisation libre, sur seize clones.

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

Mots-clés: pin gris, test de descendances, test de provenances, sélection, hybridation.

Test de descendances

Un test de 65 descendances a été établi au printemps 1981, dans la région du Nord-Ouest québécois (canton de Duverny), afin de compléter le test de descendances réalisé en 1979 à cet endroit.

Plantation conservatoire

Une plantation conservatoire a été mise en place dans la région du Nord-Ouest (canton de Duverny) en 1982, avec 213 descendances provenant des surplus du test de descendances du canton de Céloron, établi en 1980.

Test de provenances

Il y a quelques années, M. Mark Holst, de la Station forestière expérimentale de Petawawa, confiait à la section de génétique du Centre de

recherche forestière des Laurentides la responsabilité de trois tests de provenances de pin gris établis en 1966 sur les concessions de la C.I.P. Inc. avec sa collaboration. Par la suite, le Service de la recherche a été chargé de suivre ces trois tests.

Ainsi, deux dispositifs d'un essai de 64 provenances, représentatives du domaine de l'espèce, installés à Ferme-Neuve (région forestière L.4b) et à Clova (région forestière B.7) ont été mesurés en 1982.

L'interprétation des données montre que dans chaque plantation, la provenance locale se classe très bien mais que d'autres provenances présentent de bonnes performances en hauteur et en diamètre. Ces dernières peuvent être utilisées avantageusement dans les reboisements immédiats et les vergers à graines de première génération pour chaque région concernée.

D'autre part, on remarque que certaines provenances: Pointe-Taillon (Qc), Lac-Spencer (Maine) et Lac-Downs (Qc) se classent parmi les meilleures provenances dans les deux dispositifs.

Sélection, hybridation

Les meilleurs sujets des provenances énumérées précédemment et de celle de Baskatong seront sélectionnés au cours de l'été 1983, pour réaliser des croisements interprovenances et interspécifiques avec le pin de Murray (Pinus contorta var. latifolia Engelm.). On espère ainsi obtenir des hybrides plus productifs et plus droit que les descendances obtenues par croisement entre les individus les plus intéressants des meilleures provenances de pin gris.

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

PAR R. BEAUDOIN

Mots-clés: pin de Murray, plantations comparatives, sélection.

Plantations comparatives

L'installation de dispositifs expérimentaux a été effectuée dans neuf arboretums de la province en 1980, à partir de 134 lots de graines du test de provenances de l'IUFRO semés en 1977 à la pépinière de Duchesnay.

Les plantations comparatives se sont poursuivies en 1981 avec les mêmes provenances, dans cinq arboretums et un regarni a été réalisé dans les dispositifs de 1980.

De plus des plantations conservatoires ont été réalisées en 1981 dans trois arboretums avec les surplus (80 000 plants) des provenances utilisées dans les plantations comparatives. Les provenances étaient disposées en grandes lignes, perpendiculairement au vent dominant, en alternant les provenances côtières et les provenances de l'intérieur. Cette distribution favorisera l'interpollinisation des provenances valables afin de produire de la semence pour les reboisements.

Au cours de l'hiver 1982-1983, plusieurs provenances côtières plantées en 1980 à l'arboretum de Lotbinière ont été affectées par le gel à cause du manque de neige au sol pendant une bonne partie de cette saison.

Sélection

Le comportement, sur les plans croissance et forme, de trois provenances de Colombie-Britannique (Beaver Creek, Reid Lake, Cariboo), installées en 1972 dans des arboretums de la Gaspésie, est très prometteur. Plusieurs arbres ont commencé à produire des strobiles mâles et femelles.

Une sélection des meilleurs sujets sera réalisée dans ces plantations ainsi que dans quelques autres établies par le ministère de l'Énergie et des Ressources dans d'autres régions du Québec.

PROJET G 79-1. AMÉLIORATION DE L'ÉPINETTE NOIRE (PICEA MARIANA (MILL.) B.S.P.)

PAR A. STIPANICIC

Mots-clés: étude de population, test de descendances.

Nous avons poursuivi les travaux commencés en 1979 concernant l'étude de la variabilité régionale et de la structure génétique de l'épinette noire. Les graines de 149 arbres déjà sélectionnés dans 20 peuplements au nord-ouest du Québec ont été récoltées. Cette collection nous servira pour étudier l'héritabilité de la densité du bois dont on a trouvé des différences très marquées au niveau des peuplements et au niveau individuel.

Nous avons entrepris une étude semblable dans la région de la vallée du Saint-Laurent. La fructification plutôt médiocre de l'année dernière ne nous a permis de récolter sur seulement 64 arbres dans onze peuplements. Des échantillons de bois ont été aussi pris à l'aide de la tarière de Pressler.

Les résultats obtenus dans nos tests de provenances âgés de 10 ans démontrent les performances intéressantes d'une provenance du canton de Provost (partie nord du comté de Berthier, région forestière B.7). Le gain

obtenu par rapport aux cinq autres provenances utilisées était de 13 p. 100 pour la hauteur et 18 p. 100 pour le diamètre. L'automne dernier, nous avons élargi l'échantillonnage dans cette région pour obtenir des graines qui seront incluses dans les nouveaux tests de provenances-descendances. La faible fructification a limité le nombre de descendances récoltées.

Nous participons aussi au programme d'établissement de vergers à graines d'épinette noire mis en marche par le Service des pépinières et reboisements de notre Ministère. Nous sommes chargés d'installer et de suivre les tests de descendances qui vont accompagner chaque verger à graines. Ainsi, un test comprenant 400 familles de la zone 1 de récolte de semences a été semé ce printemps en serre et sera planté au printemps 1984. Un autre test semblable sera semé le printemps prochain pour un verger à graines de la zone 2.

PROJET G 81-1. SÉLECTION D'ESPÈCES ET CULTIVARS POUR LA PRODUCTION DE BIOMASSE, PAR G. VALLÉE

Mots-clés: choix et essai des espèces, races, etc., tests de provenances, tests de descendances, tests clonaux, sélection, hybridation.

But du projet

L'utilisation de la biomasse comme matière première et à des fins énergétiques est un sujet très actuel. La sélection d'espèces et de cultivars pour la biomasse est l'un des premiers volets à développer dans le cadre de recherches sur ce sujet, les principaux points à étudier étant:

- le choix des espèces en fonction des produits et caractéristiques désirés (valeur énergétique, etc.);
- la possibilité d'adaptation à divers modes de plantation et d'aménagement;
- le potentiel de croissance et de production en fonction des contraintes écologiques et des sites de production;
- les exigences culturales pour l'obtention de fortes productions;
- la tolérance aux conditions d'exploitation et aux facteurs adverses (maladies, gelées, etc.);
- la facilité de régénération et d'installation du peuplement;
- les caractéristiques spéciales (potentiel de fixation de l'azote).

Avec ces espèces sélectionnées, adaptées à la production de biomasse, le potentiel de production peut être multiplié par deux ou trois et pourrait atteindre jusqu'à vingt tonnes de matière sèche par hectare et par an.

Sélection d'espèces

Les travaux réalisés dans d'autres projets de génétique forestière au Service ont facilité le choix d'espèces et de cultivars valables pour la production de biomasse. C'est le cas pour les genres Populus L., Salix L., Alnus L. et Larix Mill. Des essais ont été établis avec Acer platanoides L., Acer rubrum L., Acer saccharinum L. (dont un test de 5 provenances a été réalisé), Fraxinus pennsylvanica Marsh. et Tilia cordata Mill.

Alnus L.

Travaux réalisés en 1981 et 1982:

- une comparaison de 4 espèces d'aulnes (Alnus crispa (Ait.) Pursh, Alnus glutinosa Gaertn., Alnus incana var. incana (L.) Moench, Alnus incana var. rugosa (Du Roi) Spreng.) et d'un hybride d'aulne (Alnus glutinosa × Alnus incana var. rugosa) selon 4 espacements, mise en place en collaboration avec le programme ENFOR (Dr. G. Frisque du C.R.F.L.);

- un test de 17 provenances d'Alnus incana var. rugosa;

- un verger à graines pour l'obtention d'hybrides entre Alnus incana var. rugosa et Alnus glutinosa;

- réalisation de 34 croisements Alnus glutinosa × Alnus incana var. incana dont un seul a donné des semis;

- sélection et clonage de 40 arbres dont 8 sont des arbres naturels de l'espèce Alnus incana var. incana introduits à la Pointe du Platon dans le comté de Lotbinière. Certains de ces arbres atteignent plus de 20 m de hauteur;

- semis d'un test de 107 provenances de 4 espèces d'aulne de l'ouest de l'Amérique du Nord.

Salix L.

Une étude de production a été faite sur un test de 11 clones ayant des tiges de 3 ans sur des souches de 4 ans. Le meilleur clone a atteint une production annuelle de 8 tonnes sèches.

Le Service possède maintenant une collection d'une centaine de clones de saule qui seront comparés dans des tests.

Populus L.

Un test de 52 clones de peuplier hybride a été établi sur sol forestier après coupe à blanc étoc, à partir de plançons courts (1,5 m). Le taux de survie et la croissance en 1re et 2e année sont très bons, ce qui laisse présager que ce mode de plantation pour enrichir les taillis naturels pourrait être prometteur.

RECOLTE DE CONES ET AMELIORATION GENETIQUE DES ARBRES FORESTIERS AU QUEBEC

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

Pour réaliser le programme de régénération artificielle prévu pour les prochaines années, environ 10 mille hectolitres de cônes de diverses espèces sont requis annuellement.

Le Service pépinières et reboisement 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 la culture de semis en récipients ou à racines nues.

RECOLTE DE CONES

Au cours de 1981, 10 800 hl de cônes furent cueillis alors qu'en 1982, ce volume a été porté à 16 000 hl. L'année 1982 marque un record pour le volume de cônes récoltés au Québec. Les efforts des deux dernières années ont surtout porté sur l'épinette noire, l'épinette blanche, le pin gris et le pin blanc. La fructification fut particulièrement bonne en 1983 pour toutes les espèces, au nord du St-Laurent.

AMELIORATION DES ARBRES

Peuplements semenciers

Durant les deux dernières années, des travaux ont été réalisés sur une superficie d'environ 200 ha. Les espèces considérées sont surtout l'épinette noire et le pin gris. Les travaux ont surtout consisté à nettoyer les peuplements déjà établis, à dégager les arbres choisis comme semenciers, à tailler quelques flèches terminales, à fertiliser pour augmenter la production de cônes et à arroser certains peuplements contre la tordeuse des bourgeons de l'épinette.

Depuis quelques années, les travaux dans les peuplements semenciers visent surtout à les entretenir et les protéger alors que l'accent porte davantage sur les vergers à graines.

Sélection d'arbres

Au cours des deux dernières années, près de 5 300 arbres, surtout des pins gris, épinettes noires et blanches, ont été sélectionnés, portant ainsi le nombre total à près de 8 000. La récolte de cônes est déjà effectuée sur la presque totalité des pins gris et des épinettes noires alors que la récolte de greffons se fait sur demande selon les possibilités du greffage.

L'extraction s'effectue à Duchesnay. Des données statistiques sont compilées sur les cônes et les semences récoltés sur les arbres. Toutes les semences sont conservées et serviront pour les vergers à graines et divers autres tests.

Vergers à graines

Au cours des deux dernières années, l'entretien des vergers à graines déjà établis s'est poursuivi et aucune superficie n'a été ajoutée aux quelques 100 ha déjà en place. La superficie totale requise pour les vergers de 1re génération est fixée à 450 ha.

Cependant, environ 15 000 greffes d'épinette blanche ont été effectuées au cours des deux dernières années. Elles seront plantées dans les vergers en 1984. Egalement, la production de semis a débuté en 1982 pour l'établissement de trois vergers de semis en 1983.

CFS FOREST GENETICS RESEARCH AND TREE IMPROVEMENT IN QUEBEC: 1981-1983

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Key words: White pine, white spruce, cloning, genetic research.

During the period under review, the CFS conducted in collaboration with the Quebec Ministry of Energy and Resources, research and work on genetics, improvement, and vegetative propagation of white spruce, white pine, and Norway spruce. Natural as well as artificial populations were genetically sampled, genetic tests were conducted in a controlled environment and in a nursery. They were analyzed then replicated in different ecological regions. The selection of superior genotypes was pursued, while breeding arboreta and propagation gardens were established. In addition, research contracts on the genetic variability of wood quality of white spruce and on the in vitro production and selection of frost hardy stocks were made with faculty members at Laval University.

WHITE SPRUCE

Research and work on the genetics and improvement of white spruce were initiated in 1976 by genetic sampling and testing of 50 populations of Quebec origin. The early test, conducted in a plastic greenhouse, included 250 half-sib families. Estimation of the genetic variability and inheritance of growth characteristics were obtained from first and third year observations in the greenhouse and nursery. In the spring of 1979, the experimental material was replicated in three forest environments representative of the Lac St. Jean, Eastern Township, and Lower St. Maurice reforestation areas.

The research in the genetics of white spruce was later enlarged through the exchange of seeds with Canadian collaborators, mainly Dr. Ying of the Petawawa National Forestry Institute. The wide range progeny/population study that included 450 seedlots was conducted in two phases. Phase 1 was started in roctrainers in February 1979 and included 308 half-sib families from 90 different populations. Measurements were taken in the greenhouse and the container grown seedlings were transplanted the following spring in three sites located in the Gaspé Peninsula, Lower St. Lawrence Valley, and the Laurentides regions.

Phase 2 of the study was initiated in March 1980 and included 356 half-sib families from 90 populations. Fifty percent of these populations were also part of phase 1 and served as link between both phases. After measurements of early growth and phenology, the seedlings were taken out to overwinter and were transplanted in the nursery for additional observations and development. Flushing, weekly growth measurements, and dormancy observations were taken during the 1982 growing season. They are the subject of a forestry student's thesis. In June 1983, the experimental material was transplanted, according to complete randomized block designs, in five additional environments, completing the sampling of Quebec areas of high interest for white spruce reforestation.

Meanwhile, a study of the inter and intra-population variability of the moisture content and unextracted wood specific gravity was conducted from a 20 year old white spruce population trial. Statistically significant differences were found between sources for both characteristics and a positive correlation was found between provenance mean wood specific gravity and diameter growth rate. This study was conducted within the frame of a Laval University student's thesis.

In addition, a breeding orchard including superior clones selected in wild stands, provenance trials, and progeny tests was set up at Cap-Tourmente. Multiplication hedges of 200 clones of outstanding Peterborough and Cushing provenances were established at Valcartier Forest Experiment Station. Some 150 additional clones from superior sources were also established for the same purpose. In Beauce, a seedling and a clonal seed orchard were set up in collaboration with the Quebec Department of Energy and Resources.

Finally, a research contract was undertaken by Laval University researchers for the study of inter and intra-population variability of the intrinsic lumber related to white spruce wood characteristics.

WHITE PINE

White pine genetics research and improvement work, conducted taking into consideration the climatic and edaphic conditions of southern Quebec, were initiated in 1976. The study was undertaken following the results of a survey of blister rust incidence demonstrating the possibility of producing white pine in low rust incidence zones with less than 5 and 15% losses by the fungus. Since then, 250 natural populations were genetically sampled, sixty plus-trees were selected for fast growth, good stem and crown form, and absence of rust galls or damage caused by white pine weevil, and propagated by grafting to establish breeding and clonal seed orchards. A first orchard site was prepared and rootstocks were established by the Quebec's Service of Nurseries and Reforestations. Field grafting is scheduled for next spring.

White pine genetic material was exchanged with Canadian and American collaborators. Our seed bank has almost 800 lots. In the

spring of 1982, phase 1 of the genetic study of the species was started in a plastic greenhouse. The early test counted 250 half-sib families from 165 different populations. Germinative capacity, hypocolyl length, and total height at 8 and 17 weeks were measured. These observations were the subject of a B.Sc. thesis. No particular trend in the growth of white pine populations was found. However, family and population differences were statistically significant. Few south-western Quebec and south-eastern Ontario populations grew as well as sources from the southern Appalachian region. Seedlings were transplanted in the nursery where additional observations relative to growth and phenology will be taken before field testing.

Also in 1982, 175 families form 37 populations of four haploxylon pine species; Pinus griffithii, P. koraiensis, P. sibirica, and P. peuce were produced in the greenhouse. Germination percentage was good in most of the lots. Even after a 90 days stratification, seeds of Korean white pine were still germinating one year after sowing. All the lots overwintered successfully. Cold resistant stocks will be used as sources of blister rust resistant genes.

NORWAY SPRUCE

Based on results of trials of more than one hundred provenances conducted within the Great-Lakes - St. Lawrence forest region, the Norway spruce improvement program was initiated in 1981. Fifteen high yield and frost hardy provenances were identified, and nearly one hundred superior phenotypes were selected based on their growth, form, and apparent tolerance to white pine weevil. In 1982, commercial plantations older than 15 years, were surveyed. They were evaluated as potential gene sources for the improvement program. Twenty-five additional plus-trees were selected in the outstanding plantations. Fifty clones were multiplied by grafting to set up breeding orchards for the controlled crosses and multiplication gardens which will produce scions and cuttings required to establish the projected 90 ha clonal orchards.

CLONING

Our cloning work has two objectives: first, the achievement of rapid genetic gains through the multiplication of outstanding genotypes; and second, the improvement of the cloning techniques adapted to forest trees.

Through testing of different substrates and environmental conditions, rooting success of mini-cuttings was increased. We hope by such a practice to compensate for the insufficiency of seeds produced by specific crosses and accelerate genetic tests. Six to eight week old Norway spruce seedlings were rooted with 92% success, while one year old superior white spruce seedlings were rooted with 90% success. Hedging

increased the rootability of 20 year old white spruces; 28% of the cuttings taken from the ortets rooted while 45% rooting success was obtained from hedges made from the same ortets.

A research contract was undertaken by Dr. M. Lalonde of Laval University to produce by tissue culture and to select frost resistant Alnus and Larix genotypes.

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CIP carries out tree improvement activities on its freeholds in Quebec and on both private and crown land in New Brunswick. Its program encompasses native and exotic species susceptible to produce good pulpwood. Native trees are given the highest priority since they are adapted to the climate and fulfill actual pulping technology needs.

CIP'S PROGRAM IN QUEBEC, BY J. BEGIN

Keywords: Picea, Pinus, Larix, plus tree selection, progeny test, seedling seed orchard.

The rising cost of wood fiber at the mill threatens the maintenance of Quebec's position in pulp and paper. The remoteness of its fiber sources together with the long rotations and the decreasing volume per tree, all contribute to reduce industry's cost competitiveness. Reforestation will help improve the situation and help meet the challenge of competitiveness, especially if genetically superior stock is used for planting.

With this in mind, a tree improvement program was initiated by CIP in 1979. The objective is to select the best trees in Company controlled forests and to grow their progenies to produce genetically superior seed. The project was partly prompted by our stimulating two-year experience in cooperative tree improvement with the NBTIC in New Brunswick.

The program, tailored to CIP's needs, encompasses two major pulpwood species, black spruce (Picea mariana (Mill.) BSP) and jack pine (Pinus banksiana Lamb.), and three promising exotics, Japanese larch (Larix leptolepis (Sieb & Zucc) Gord.), European larch (Larix decidua Mill) and Norway spruce (Picea Abies (L.) Karst).

Black Spruce and Jack Pine

Most of our improvement effort bears on native species which have already proved their adaptation to the boreal forest conditions. Young stands on Company lands are examined for plus trees which are selected on an ocular basis. We are planning on five hundred plus trees to form the

genetic basis for each species. Plus trees are felled during the winter to facilitate the collection of cones and clipping of scions.

In the past two years, 392 new trees have been added to the breeding population which now totals 180 black spruce and 330 jack pine. Scions collected from these trees are kept in cold storage until they are grafted to dormant white spruce, or jack pine stock, according to species. CIP personnel have successfully grafted more than 9 000 trees (7 980 in 1982-83) at our Harrington Nature Centre (Quebec).

A seedling seed orchard for these two species is currently being established on farm land near Harrington. This area was selected because of its southerly location, long growing season and good site quality, three conditions that are known to promote abundant flowering and cone production. By the time the orchards reach production stage, testing of the progenies will be completed in the St-Maurice which will provide data required for the roguing operation. In addition, controlled crossing of the best clones will be carried out in the clonal orchard and further selection initiated with the aim of preparing a second generation orchard. Details of the selection procedure will be discussed in another section of this report.

Norway Spruce

A somewhat different approach is used with Norway spruce and exotic species. There is no selection in wild stands all of the genetic material coming from provenance tests established earlier by the Company or by the Laurentide Forest Research Centre (CFS) in Quebec. The aim of the program is to try and reproduce by grafting the best trees of selected progenies as determined by the provenance test. Grafting started in 1980 and has produced 1 290 living ramets to date. Of the 110 plus trees selected, 76 have been cloned and the others will be grafted in 1984. The material will be transplanted to a clone bank to be established on the same farm as the black spruce and jack pine seed orchards.

PROGENY TESTS, BY F.DUMOULIN

Keywords: Jack pine, black spruce, progeny tests, seed production, layout.

In the summer of 1982, the St-Maurice Woodlands Division initiated its progeny tests on the jack pine and black spruce families collected as part of CIP's tree improvement program. The progeny tests have two objectives. The first is to select the best families for each species. The second is to obtain a complementary seed production for the seedling seed orchards, to be installed in the Harrington area as mentioned earlier.

The progeny test no. 1 for each species comprises 13 replications and is located near Lac à l'Epaule (73^{o} 43' W, 48^{o} 36' N) in the boreal (B3)

forest region (Rowe 1972). This site was judged representative of the area where CIP's reforestation effort is concentrated in the St-Maurice Division. Progeny test no. 2 will include four more replications for each species and be located near Lac Minou (73° 54' W, 48° 42' N), some 20 kilometers north west of Lac à l'Epaule. When completed, the two progeny tests will total 17 replications of 1 ha each per species.

A replication has the configuration of a matrix composed of 550 plots containing 4 seedlings of the same plus tree. The distribution of families is identical for all the replications for each species. It has been established using the REPAL computer program (Beaudoin and Desaulniers 1980) and respecting a 15 m minimum spacing between families of the same provenance.

In the field, a replication is made of 50 drills produced with a mechanical disc trencher scarifier. The drills, 99 m long and 2 m apart, are cut in eleven 9 m long segments, or plots. Seedlings are spaced 2 m apart within the plots, with 2 successive plots being separated by a 3 meter stretch.

The replication limits are identified with wood stakes and steel posts. Plots are then positioned in the field and their location is temporarily marked using disposable white plastic spoons planted upside down in the center of the drill. As plantation progresses, spoons are replaced with galvanized steel rods to which are attached aluminum tags engraved with the family number. The use of plastic spoons greatly reduces the establishment cost for the layout since all plots are positioned at one time with only one costly measurement of the whole area.

Last year, work performed consisted of the scarification of the site, the delimitation of replications, the localisation of plots and the plantation of the first batch of seedlings. A total of 117 families of jack pine and 40 of black spruce were planted in 1982. In 1983, 94 jack pine and 49 black spruce families will be planted. Also, the Lac Minou site will be prepared in order to receive its first lot of seedlings in 1984 (progeny test no. 2).

Our plans are to complete the establishment of both progeny tests by 1988.

EXOTIC LARCHES, BY G. CROOK

Keywords: Japanese Larch, European larch, hybrids, provenance tests, seed orchard.

Japanese and European larches and hybrids

The CIP improvement program in these species actually began in 1956 with the establishment of a Japanese larch plantation at the Harrington Nature Centre. This plantation was the subject of articles by Wilson

(1968) and by Paillé and Bitto (1979), both appearing in the Quebec Forestry Association's magazine ''Forêt Conservation''. Of unknown provenance, this plantation has nevertheless demonstrated good frost hardiness and excellent growth over the years.

In 1960, six provenances of European larch were established in a provenance trial in Avoca, near the Harrington Nature Centre. Due in large part to site conditions, the growth of most of the provenances has not been notable. The same provenance test was also established at the Petawawa National Forestry Institute.

In May 1980, scions from selected clones in the three above mentioned plantations were grafted to Japanese larch rootstock, leading to the establishment of a clonal seed orchard of 0,5 ha at Harrington in the spring of 1981. The orchard, containing 600 Japanese and 80 European ramets, is designed in such a way that hybrid seed will be produced and collected from the European larch. More scions are to be planted in order to double the orchard area.

Collaborators on this project were the Petawawa National Forestry Institute (C.F.S.), the Ontario Ministry of Natural Resources and the Quebec Ministry of Energy and Resources.

Japanese larch provenance trial and seed orchard

In May 1980, a Japanese larch provenance trial was established near Trois-Rivières, Quebec. This plantation will be progressively thinned and, depending upon results of the provenance trial, will eventually be converted into a seed orchard.

The trial is composed of 79 seedplots represented by 100 seedlings each, except for one seedlot which is present twice in order to produce a plantation of 8 000 seedlings with 10 repetitions. Seedlots were furnished by the Petawawa National Forestry Institute. Forty-two seedlots originate from the Tokachi Hokkaido collection in Japan, 17 others from various collections in Japan, and the remainder are from collections made in Denmark (9), Scotland (7), Poland (1), East Germany (1), Finland (1) and Quebec (1).

Growth in the first two growing seasons was excellent (average height = 1,9 m; maximum height = 2,7 m), and so was crown development. A first thinning is scheduled in September 1983 and will remove 50% of the stems per seedlot in each block. Selection criteria are frost hardiness, growth, and stem and crown form. Eventually, only one stem will be preserved for each seedlot, with a total of 800 trees in the orchard.

This project was initiated and established with the close collaboration of the Petawawa National Forestry (C.F.S.), the Ontario Ministry of Natural Resources and the Quebec Ministry of Energy and Resources.

NBIP'S EFFORT IN NBTIC COOPERATIVE PROGRAM, BY H. BITTO

Keywords: Seed orchard, family test, plus tree selection, black spruce, white spruce, jack pine.

NBIP is an active member of the New Brunswick Tree Improvement Council (NBTIC). The Council was established to coordinate the tree improvement efforts of individual agencies and to facilitate the free exchange of genetic material and information. Each agency is free to pursue individual programs but all will benefit from combining selected material and test results (Anon. 1982). The Council was formed in 1976 and includes all the major N.B. forest companies as well as the Canadian Forestry Service, the N.B. Department of Natural Resources and Department of Forest Resources, University of New Brunswick.

Seed orchard

In 1982, NBIP added 1.5 ha of new orchard to the black spruce seedling seed orchard on freehold near Dalhousie, N.B. Seed for this orchard was provided by NBTIC from selections made by NBIP and other Council members.

This orchard was started in 1979 on cut-over forest land. It now covers more than 8.5 ha.

Orchard maintenance includes weeding and fill planting. Both chemical and mechanical weeding have been employed. Weeding releases the planted seedlings and encourages rapid height growth. Fill planting was used to replace losses from rabbit browsing and winter drying. Lack of adequate snow cover the past two winters, as well as the peaking of the rabbit population had combined to create some winter losses.

Test plantations

As a Council member NBIP establishes, maintains, and measures test plantations on its crown license. In 1982, 1.3 ha of jack pine family test was planted, in 1983 1.7 ha of jack pine and 0.8 ha of black spruce family tests were planted. To date total areas by species are: black spruce (12.3 ha = 5 tests), jack pine (5.5 ha = 3 tests), and white spruce (1.5 ha = 1 test).

Regular inspections are made on these tests and maintenance activities are carried out as needed. Measurements at age five were done on three tests in 1982 and will be done on one test this fall.

Plus trees

During the past two years NBIP has selected five white spruce, six black spruce and two jack pine as plus tree candidates. This brings NBIP's contribution to NBTIC since 1977 to 94 black spruce, 24 white spruce and 14 jack pine.

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TREE IMPROVEMENT PROGRAM IN ONTARIO'S NORTHWESTERN REGION

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Keywords: Seed orchards, family tests, black spruce, white spruce

Tree improvement in the Northwestern Administrative Region of Ontario has been underway for many years, but starting in 1979 the program accelerated in terms of funding, staffing and commitment. Current emphasis is on plus tree selection, and the establishment of seed orchards and family tests. This work has centered on black spruce (Picea mariana (Mill.) B.S.P.) and white spruce (Picea glauca (Moench) Voss), with a jack pine (Pinus banksiana Lamb.) program scheduled to begin in the fall of 1983.

The operational aspect of the program rests with the region's six administrative districts (Dryden, Fort Frances, Ignace, Kenora, Red Lake, Sioux Lookout) who are responsible for the selection, establishment and maintenance of their own seed orchard and test program. In 1982 the Northwestern Region hired W. D. Baker as Regional Tree Improvement Specialist to co-ordinate and assist district staff in the effective implementation of the various tree improvement strategies.

BLACK SPRUCE

Assembly of Breeding Stock

A first generation, half-sib black spruce tree improvement program was initiated in 1976. Eleven breeding zones were defined using Ontario's site regions (Hills 1960) within administrative district's criteria. Each of the 11 programs were based on 320 half-sib family selections. Extensive selections were undertaken from 1976 to 1982 using a rapid ocular procedure. The trees were measured for various attributes, felled, open-pollinated cones were collected from each of the selected parents and seed extracted by individual family (Brown 1979). Some 5,638 trees were selected with 3,520 parents being used in the program. The planting stock was produced at the Dryden and Orono nurseries. Two family tests and one seedling seed orchard were established from this stock for each of the 11 breeding zones during the spring and summer of 1982.

Seed Orchards

Each seedling seed orchard is approximately 5 ha in size and consists of 50 blocks. Each block is composed of one member from each of the 320 families which were grouped in 4 sets of 80. Each set contained the same 80 families throughout the orchard. The 80 trees within a set were randomly planted in 20 clusters of 4 trees each. Clusters were planted at 3.6 m centres with the trees arranged 0.6 m around the cluster centre.

The orchards were established on moderately fertile, deep, well drained soils (i.e. sandy loams, loamy sands) in order to have the capability of inducing stress cone crops. Typical site preparation included root raking, disking and bedding. Upon completion of the mechanical site preparation, further site enhancement was achieved by sowing a cover crop of innoculated Dutch white clover. All orchards have been equipped with a rotary sprinkler irrigation system which employs mobile gasoline or propane powered pumps, 15 cm aluminum mainlines, 10 cm lateral lines and movable, wheel-mounted volume guns. A fertilization program was initiated in 1983 in which 100 kg N/ha in two applications were applied by either a spot or broadcast method.

Family Tests

Family tests were established to determine the breeding value, or genetic worth of the trees in the seed orchard. Two different geographical test sites for each breeding zone were chosen, one within the zone, the second in an adjacent zone of the same site region. The field design consisted of a Randomized Block Design (6 replications, 6 tree row plots) with the 320 families grouped in the same 4 sets of 80 families used in the orchard.

The family tests were established on typical Site Class 1 black spruce sites, usually clay, silty-clay or sandy loams. Site treatment and development of the test sites was fairly intensive and usually consisted of clearing, root raking, disking and bedding. The planting stock for these trials was produced at the same time as the orchard material and outplanted in the spring and summer of 1982. All row plots were staked with the appropriate family number and mapped.

WHITE SPRUCE

The white spruce tree improvement program in Northwestern Region is based upon a first generation, clonal seed orchard strategy. Breeding zones for the white spruce program were delineated using the 4 major site regions (Hills 1960). Using this designation, the programs for site regions 3300 and 3400 are based upon one orchard per site region, while in site regions 4300 and 5300 two separate and unique orchards per site region are being established. Currently, four white spruce clonal orchard sites have been prepared and partially established with the planting being phased in over the next several years. Site preparation for the two other orchards is being initiated during the summer of 1983. A breeding orchard

consisting of five ramets of each clone has been initiated at the Dryden Tree Nursery, Wabigoon, Ontario.

The program to select parent material for orchard use began in the 1960's and is continuing. An intensive selection method based on a site index standard as well as a candidate tree demonstrating good branching and crown development was employed. Scions were collected from the selected trees and vegetatively propogated to produce a sufficient number of grafts for the production and breeding orchards. The Northwestern Region established its own grafting centre at the Dryden Nursery in 1979 with an annual capacity of approximatelv 6,000 grafts.

Each orchard is based upon 216 clones planted in a Randomized Block Design (3 replications, 4 ramets per replicate) with each replicate divided into 6 blocks. The clones within a block are planted in a 'Permutated Neighbourhood Design' (Giertych 1975), in which each ramet is isolated by three rings of different clones and any combination of two adjacent clones do not appear more than once in any specific direction. The use of the permutated neighbourhood design necessitated the staking and numbering of each planting location.

Orchard site development consisted of clearing, root raking and disking, followed by a broadcast application of innoculated Dutch white clover. All white spruce orchards have been equipped with rotary sprinkler irrigation systems.

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CLONAL FORESTS OF *POPULUS* SPECIES IN ONTARIO

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Keywords: *Populus* species, clonal forestry, technology development, tree improvement

The Ontario Ministry of Natural Resources initiated the Farming Fast Growing Hardwoods program in the mid 1970's to develop the technology necessary for the successful establishment of hybrid poplar plantations in eastern Ontario. Since that time, over 1500 hectares of plantations have been established, mainly on previously marginal, idle agricultural lands. Several management systems have been developed, each suitable for specific market opportunities (Raitanen 1980). Potential end uses of hybrid poplar range from biomass for energy, to larger diameter material for pulp, waferboard, and veneer (Barkley 1982a). Technology development has centred on the important stages of plantation establishment. The first step is to conduct an intensive survey of the soils of a candidate site (Evers et al 1983b). Once soil types have been delineated, clones can be objectively matched to the site. The next step is to site prepare the land for the complete elimination of all weed and grass competition prior to planting (Barkley 1982a).

In order to maintain a broad genetic base of the material in plantations, clone-site trials and progeny tests have been established to monitor the growth of hybrids developed from both exotic and native species. Since the initiation of the program, over 3,000 different hybrid clones and progeny have been tested. Of these, approximately 200 have been allocated to production plantations on the basis of growth performance, and resistance to insects and diseases (Morse et al 1983). In addition to the work being done on hybrid poplars, the program has been expanded to investigate other fast growing hardwood genera such as *Alnus*, *Salix* and *Betula*.

TREE IMPROVEMENT

Since 1979, a greater emphasis has been placed on obtaining representation from native poplar species in the region. Therefore, a selection program was begun to identify and preserve the native poplar gene pool (Evers et al 1983a). Once the gene pool has been preserved, it may be enhanced through breeding with other native and exotic poplars.

Native poplars are selected on the basis of superior phenotypic characteristics, such as bole form, crown configuration, vigour, and health (Evers et al 1983a). The selected trees are classed as:

1. Clonal Selections: those trees which may be clonally propagated and put directly into trial plantations.

2. Plus Tree Selections: those trees which exhibit superior phenotypic characteristics.

3. Gene Pool Selections: those trees which are neither clonal nor plus tree selections, but may have value in future breeding efforts. These trees are selected to preserve a broad representation of the gene pool of eastern Ontario.

Both mature and immature indivuduals of Populus balsamifera L., P. deltoides Bartr., P. grandidentata Michx; and P. tremuloides Michx. are identified and selected in each of 110 townships in eastern Ontario. By the end of 1982, 213 P. tremuloides, 299 P. grandidentata, 295 P. balsamifera and 275 P. deltoides had been selected, for a total of 1,102 selections. The target for the program is to have full coverage of the eastern region by the end of 1983.

In the fall and winter after a selection has been made, root material is collected in order to clonally propagate the selection in the greenhouse. The resulting propagules are outplanted in a clonal archive area at the Kemptville Nursery (Barkley 1982b).

Branch material bearing live flower buds is also collected from the plus trees to be used in a breeding program. Through breeding of select individuals, the eastern Ontario gene pool becomes enhanced. The enhanced gene pool is then enriched by crossing the native plus trees with exotic poplar species such as P. nigra and P. maximowiczii. The resulting offspring from these breeding efforts are planted in a number of progeny trials (Evers et al 1983a). The growth of the progeny in these trials is monitored annually. Elite trees (plus trees which exhibit superior genotypic characteristics) are identified based on the relative performance of the offspring. Outstanding individual progeny are then selected and clonally propagated for performance testing in clone site trials. The ten best performing new clones are then allocated to production plantations, while ten poorer performing clones are removed from further testing.

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GENETICS, GENECOLOGY AND TREE IMPROVEMENT OF SPRUCE IN 1981 AND 1982, SAULT STE. MARIE, ONTARIO

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Keywords: interspecific hybridization, crossability, clonal propagation of hybrids

The objectives of these studies are: (1) to determine genetic variation in efficiency, growth and nutrition as related to site regions and productivity systems and to investigate genotype x environment interaction; (2) to create long-term genetic banks for gene pool and population studies, preservation, breeding and selection; (3) through intra and interspecific breeding and assessment of genetic parameters to elucidate the breeding system and structure of the genus Picea; (4) to produce, test and select the best hybrids for propagation; and (5) to develop hybridization techniques for breeding juvenile trees.

HYBRIDIZATION

In 1981, flowering on spruce in Ontario was generally sparse. Controlled crossing was confined to two breeding areas, Sault Ste. Marie and Algonquin Districts. A total of 16 tree x pollen parent combinations were made involving 12 interspecific crosses, five tri-hybrid crosses and utilizing 13 species. One notable success was the repetition of the new cross Picea omorika x P. asperata which was first accomplished in 1980 (Gordon 1982). Emphasis was generally placed on black spruce using selections from Green River, N.B., and from Geraldton and Thunder Bay, Ontario. In previous years selections were also included from Cochrane, Ontario.

There have been a number of interspecific crosses reported in the literature as being successful, which have subsequently been invalidated, the seeds never germinating or the seedlings resulting from contamination. Black spruce is known to cross sparingly with red spruce (Gordon 1976), readily with Serbian spruce (Gordon 1976; Fowler 1980), and with some difficulty with Sitka spruce (cf. Fowler 1983; Gordon 1982). It is possible that only widely separated populations from areas where the ranges of the two species do not overlap appear amenable to low level artificial crossing but thus far the evidence for this is contradictory. This may also be the case with possible black spruce crosses with Engelmann spruce and perhaps with white spruce but the evidence is not strong. Black spruce rarely, if ever, crosses with white spruce although there are two reports (Fowler et al. 1971; Gordon 1980). One of these no longer exists (Fowler

1974, pers. comm.) and the other is still unconfirmed. Despite the foregoing, there is some heterosis in two of the foregoing crosses, notably those with Serbian spruce (Nienstaedt 1975; Fowler 1980; Gordon 1980) and to some extent with Sitka spruce (Fowler 1983; Gordon 1982).

The most startling result of interspecific crossing attempts with black spruce is their consistent failures. In the 1981 crosses pollen parents were: Picea glauca, P. engelmannii, P. sitchensis, P. breweriana, P. chihuahuana, P. asperata, P. likiangensis and P. maximowiczii. In addition, pollen parents in previous years have also included P. schrenkiana, P. polita, P. purpurea, P. koyamai, P. abies and P. pungens. All were failures. As noted in the foregoing, P. sitchensis was previously used successfully as the female parent but crosses with P. mexicana as the female parent were unsuccessful. The increasing knowledge on the extent and particularly the level of interspecific compatibility in black spruce will provide a much better definition of the nature of the breeding base in this species and strategy for breaking incompatibilities.

In 1982, flowering on spruce was moderate and widespread. Breeding areas in three latitudinally separated districts were utilized: Sault Ste. Marie, Algonquin and Simcoe. Two hundred and fourteen tree x pollen parent combinations were attempted involving 63 interspecific crosses, 10 tri-hybrid crosses and 16 species. Some of these attempts were repeat crosses utilizing different parents to obtain measures of reproducibility or to build up stocks of hybrid seedlings. Consistent reproducibility was obtained with P. mexicana x P. rubens, P. glauca and P. engelmannii, the latter of which continued to have very low crossability. All of these have been previously reported (Gordon 1980).

A new cross not previously reported in the literature was P. mexicana x P. omorika. Possible new crosses were P. rubens x P. breweriana; P. omorika x P. breweriana and P. pungens. These, however, are as yet unconfirmed and may represent contamination. Crossability was very low. Black spruce was routinely crossed with nine other species and once again all proved failures.

As tri-hybrid crossing progresses it has been expected that interspecific barriers could be broken down. In fact, the opposite may be true. The crossability of hybrids with a third species, even when all three species are to some extent compatible, has been surprisingly low. Backcrossing has also proved to be much less successful than expected. Most attempts are failures or near failures and more so with one parent backcross than the other. Tri-hybrid crossing has involved P. sitchensis, P. glauca, P. mariana, P. rubens, P. omorika and P. breweriana.

CLONAL PROPAGATION AND TESTING OF INTERSPECIFIC HYBRIDS

Clonal propagation of difficult-to-make hybrids is being undertaken for progeny testing in different site regions. Seedlings and clonal material of the following hybrids are being tested:

P. omorika x P. glauca, P. engelmannii, P. sitchensis, P. chihuahuana,

P. orientalis, P. koyamai, P. asperata, P. maximowiczii and P. likiangensis;

P. glauca x P. pungens, P. sitchensis, P. schrenkiana, P. rubens and P. mariana;

P. mexicana x P. rubens, P. glauca, P. engelmannii, P. likiangensis and P. omorika;

P. sitchensis x P. glauca, P. rubens, P. mariana and P. likiangensis;

P. rubens x P. sitchensis, P. glauca, P. orientalis, P. likiangensis, P. maximowiczii and P. koyamai;

P. abies x P. asperata.

Clonal propagation of our remarkably heterotic hybrid, P. omorika x P. rubens, is underway at the Ministry's Orono Nursery. These hybrids have been progeny tested for 12 years (cf. Gordon 1980). Several thousand clones are being produced from 35 hybrid selections that will be utilized in Ontario's first management outplanting of hybrid spruce.

An information leaflet (Haavisto and Gordon 1982) was produced on the identification, growth behaviour and a method for forced flushing of black and white spruce flowers for pre-season evaluation of potential cone crops, budworm damage, etc. The leaflet, in response to many requests for information on flowering in spruce, was produced jointly with V.F. Haavisto, Canadian Forestry Service, Great Lakes Forest Research Centre.

Other work of this Unit concerns studies of productivity and nutrient cycling in spruce forest ecosystems (Gordon 1981; Gordon in press).

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RESEARCH ON SEED-CONE RECEPTIVITY, CONE INDUCTION AND IN VITRO CULTURE

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Keywords: Picea glauca, Picea mariana, Populus species, pollination technique, gibberellic acid, haploid, vegetative propagation.

The study on effects of pollination techniques and the repeated pollinations upon filled seeds was carried out in black (Picea mariana) and white spruces (P. glauca) in 1981. The objectives were 1) to compare brush and syringe pollinations, and 2) to define the effects of repeated pollinations.

In enhancement of cone production by gibberellic acid 4/7 (GA 4/7) application, girdling, and root pruning, the objectives were 1) to define the effective period of GA 4/7 application, 2) to determine the optimal concentration for spraying, and 3) to establish a suitable mechanical technique.

Research on haploid plant culture was aimed at 1) producing some isogenic pure lines for breeding, and 2) studying the field performance of haploids and diploid pure lines. In in vitro vegetative propagation, rapid multiplication and regeneration of plantlets from tissue or organ of a mature tree were the objectives. Dr. Y. Raj[1] is associated with these studies and the poplar (Populus) material was supplied by Dr. L. Zsuffa[1].

SEED-CONE RECEPTIVITY

Effectiveness of brush and syringe pollinations was compared in black spruce. Three clones and 10 trees per clone were used in the study. Brush pollination resulted in 2.5 to 3 times the production of filled seeds compared to syringe pollination.

Four clones of white spruce were used in the study of the effects of repeated pollinations. Cones were left unpollinated or were pollinated with differently colored pollen, one color on each of three days. The

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results indicated that the ovules without pollen on the nucellus continued to exude pollination drops. The repeated exudation may also have occurred in some of the ovules having pollen on the nucellus. Based on the filled seeds from a single pollination with live pollen, and a combination of pollinations with live and dead pollen, the second pollination had very little effect on production of filled seeds, and pollen from the first pollination was most likely to accomplish fertilization.

CONE INDUCTION

Intravascular Application in Black and White Spruces

Each spruce tree was applied weekly with 100 µg of GA 4/7 in 5 ml of 2% alcohol solution by a cut branch end while controls were treated with 5 ml of 2% alcohol per tree. The application, ranging from 2 to 8 weeks, was started in the first week of May and ended in June. The results are shown in Table 1 (a value of 500 was used in tabulation when a tree produced more than 500 pollen cones). GA 4/7 significantly increased both seed- and pollen-cone production in a good, but not in a poor crop year. The treatments had no effect on pollen viability based on the pollen germination test. However, clones responded differently to GA 4/7 treatment and most variation was attributed to clones.

Spraying in White Spruce

Trees were sprayed biweekly with 10% alcohol solution plus 0.05% Tween 20 for the controls, and 200 mg/l of GA 4/7 in the above solution for the treatments. Twenty trees were sprayed in May, June, and July, and the other 20 in June, July, and August. Branches on the second whorl from the main terminal of another 24 trees were also thoroughly wetted biweekly from May to August with the control solution, and various amounts of GA 4/7 in the above solution for the treatments. The effect of GA 4/7 spraying on cone production was not conclusive after one year's application.

Girdling, Root Pruning or Both in White Spruce

Trees were girdled, root pruned or both, and no treatments were given to the controls. The treatments were carried out in early May for the last 3 years. Root pruning appeared to be effective in enhancing cone production in a good crop year. Girdling and a combination of root pruning and girdling were not effective in both good and poor crop years. The treatments affected clones differently and most variation was attributed to clones.

Table 1: Number of seed and pollen cones by GA 4/7 intravascular application for 3 years. Superscript number indicates the number of trees producing over 500 pollen cones.

Treatments	BLACK SPRUCE Year 81	82	83	Total	WHITE SPRUCE Year 81	82	83	Total
Seed Cones								
Controls	55	192	10	257	47	308	33	388
2 weeks	87	464	0	551	126	353	46	525
4 weeks	57	792	2	851	93	345	18	456
8 weeks	236	605	14	855	282	349	35	666
Pollen Cones								
controls	15	626[1]	94	735	308	632[1]	60	1000
2 weeks	5	707[1]	72	784	584[1]	638[1]	92	1314
4 weeks	32	694[1]	22	748	592[1]	665[1]	131	1388
8 weeks	123	783[1]	80	986	569[1]	783[1]	29	1381

HAPLOID PLANT CULTURE

Poplar anthers were incubated on Murashige and Skoog (MS) (1962) medium supplemented with 2,4-D and kinetin for haploid callus induction when young pollen was at the mononucleate stage. In about two months, a callus emerged from the anther cavity (induction efficiency less than 5%) and was transferred to an organ-inducing medium (MS+BAP+NAA) when the callus was about 5 mm in diameter. Adventitious shoots were regenerated from the callus in about a month and were severed from the callus after reaching 3 cm in height. The shoots were rooted in a rooting medium (MS+NAA) in about 10 days and the plantlets were later transferred and established in soil. Three forms of plantlets were found: 1) normal, 2) rosette, and 3) dwarf, in each hybrid and species.

Young leaves and root tips of the plantlets were used for karyotype analysis and most were found containing 19 chromosomes (ranging from 11 to 38 chromosomes). Haploid plantlets (19 chromosomes) have been produced in *P. balsamifera* x *deltoides* (*P. jackii*), *P. maximowiczii* x *deltoides*, and *P. nigra*. Organogenesis (shoots or roots) has occurred but no plantlets were regenerated in *P. angulata* x *simonii*, *P. deltoides*, and *P.* x *euramericana* cv. *eugenei*.

IN VITRO VEGETATIVE PROPAGATION

Poplar seeds were aseptically incubated on 0.6% agar for germination. When the cotyledons emerged from the seed coat, they were removed from the seedlings and transferred onto the organ-inducing medium. In about a month, many adventitious shoots regenerated from the induced calli. The shoots were rooted in the rooting medium in about 10 days. Plantlets were washed off the agar, and transferred and established in soil. Over 1000 plantlets could be produced from calli induced from a single cotyledon in P. nigra, P. nigra x maximowiczii, and P. tremula in 6 months while a year would be required for P. alba, P. grandidentata, and P. tremuloides.

Plantlets have also been regenerated from calli which were induced from a thin cross section of young stems, pieces of leaves, or buds of mature trees in P. deltoides x nigra, P. trichocarpa x angulata, P. alba x grandidentata, and P. tremula. In production of the plantlets, the processes were the same as in the regeneration of plantlets from cotyledons except the stem sections were first incubated on the callus-inducing medium and the induced calli were later transferred onto the organ-inducing medium.

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TREE IMPROVEMENT PROGRESS IN THE NORTHERN REGION 1981-1983

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Keywords: black spruce, jack pine, plus tree selection, seedling orchards, clonal orchards, progeny testing, wood quality, clonal testing

Considerable progress in the Northern Region tree improvement program has been made over the past two years, a direct result of the renewed enthusiasm and hard work of field staff. Implementation of the regional strategy is under way and on schedule toward the target of providing the entire planting stock seed demand (66 million jack pine, (Pinus banksiana Lamb.), 106 million black spruce (Picea mariana (Mill.) B.S.P.) per year) from rogued, first-generation seed orchards by the year 2000. Additionally, work plans are being developed to produce genetically improved clonal stock, thus taking advantage of juvenile rooting technology developed in Ontario.

PLUS TREE SELECTION

According to the regional tree improvement strategy, 2,000 black spruce and 1,600 jack pine selections will be made over the next several years. For the most part, these trees are destined for use in seedling seed orchards, and therefore were selected with very low intensity. Selection pressure will be exerted upon evaluation of open-pollinated progeny tests. To-date, 750 jack pine plus trees have been selected. During the winter of 1982/83, 70 additional black spruce plus trees were selected for use in a clonal orchard.

SEED ORCHARDS

At the present time, there are four jack pine and three black spruce seed orchards started and in various stages of completion. Ultimately, the regional strategy calls for a total of five jack pine and six black spruce orchards, so the establishment phase is well underway. The various orchards will be planted starting in 1983 and completing in 1988. Commercial seed production is expected from all orchards by 2000.

Jack pine

Two orchard sites have been developed so far in jack pine: A

single orchard near Aidie Creek in Kirkland Lake District and a complex of three orchards in Dalmas Township, Chapleau District. The Aidie Creek orchard is of seedling origin, and first orchard in the region with scheduled completion in 1984. The Dalmas Township complex will consist of one clonal and two seedling orchards, and should be established by 1986. All orchards will be supported by separate clonal breeding orchards.

Black spruce

The Northern Region has been working with black spruce tree improvement for the better part of 20 years, primarily selecting plus trees for use in a grafted orchard in southern Ontario. The results of this effort are mixed, so the decision was made to collect scions from as many existing clones as possible, supplement these clones with new selections from the field, and establish a single clonal orchard in the Northern Region. This orchard will be planted in 1985 and occupy about 12.0 hectares at the Bonner Tree Improvement Centre in Kapuskasing.

Despite the establishment of a clonal black spruce orchard, the wave of the future is definitely toward seedling orchards. Black spruce grafts are characterized by below average survival, slow growth, and often plagiotropic habit. Seedlings, on the other hand are fast growing and vigorous, and can be expected to produce flowers six to eight years after planting under intensive culture. Two seedling seed orchard sites, one at the Bonner Center and one at the Gogama Nursery, are under site preparation and will be established with 400 families each in 1985-86. The remaining seedling orchards will be planted from 1986-88. All orchards will be supported by separate clonal breeding orchards.

PROGENY TESTING

The majority of first generation progeny tests will be open-pollinated trials derived from the original plus trees. This applies to all of the jack pine orchards and to the black spruce seedling orchards. Supplementary tests will also be planted with full-sib families created by controlled mating in the breeding orchards. The black spruce clonal orchard will continue to be tested using juvenile cuttings derived from full-sib seedlings created by controlled crossing.

WOOD QUALITY

One of the selection criteria often carefully examined in tree improvement programs, wood quality (specific gravity, fiber dimensions, extractive content, moisture content, heartwood formation) is receiving considerable scrutiny in the jack pine portion of the regional strategy. Preliminary investigation has suggested considerable variation in these traits, and the examination of breast height disks from the first 200 plus trees confirms large between-tree differences. In this initial sample, weighted specific gravity ranged from 0.369 - 0.474, average tracheid length 2.4 - 3.3 mm, heartwood content 17 - 61%, and moisture content 170 - 226% in the 40-50 year age class. Similar variation was

also observed in other age classes. If these traits are under strong genetic control in jack pine, as they are in most other hard pines, then considerable genetic gain can be realized.

CLONAL TESTING

Ontario has done some pioneering work in large scale production of juvenile cuttings, i.e., cuttings struck from seedlings generally less than two years old. Extending this technology to the realm of tree improvement provides tremendous opportunity for genetic gain. Clonal tests are being planned for the next few years using full-sib families, "super" seedlings, and vigorous young plantation selections as source material. Trials established in the mid - 80's should be producing "certified" clones by the early to mid - 1990's. These proven clones will then be mass produced for regular outplanting.

W.R. BUNTING TREE IMPROVEMENT CENTRE, ONTARIO

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Keywords: Rooted cuttings, grafting, progeny test

A program for the large-scale production of spruce cuttings has been ongoing in Ontario for four years. This work has been based on preliminary studies by Rauter (1974), Armson et al. (1975), Perez de la Garza (1977), and Fung(1978). The program was initiated in 1979 when approximately one-half million rooted cuttings were produced for operational outplanting (Armson et al. 1980). This work was so successful that in 1980, it was decided to build a new greenhouse facility for the production of spruce juvenile cuttings.

OBJECTIVE OF PROGRAM

The purpose of this program is to produce seedling and clonal stock for the Ontario Tree Improvement Program. Ultimately the work performed will increase the yield from Ontario forests by providing genetically improved planting stock. Specifically this program is for:

1) propagation of juvenile coniferous clones by cuttings for progeny and other clonal tests.
2) production of grafted stock for Ontario Tree Seed Orchards.
3) carrying out tests to solve cloning problems with black spruce, white spruce, and tamarack.
4) developing operational techniques for producing large numbers of cuttings from other species such as Scots pine, jack pine, white pine, black walnut, etc...
5) providing trees, surplus to the testing work, for operational field plantings.

GRAFTING

The work program of the last two years involved grafting black spruce, and white pine. The number of grafts completed is approximately 15,000 annually. Grafting success has been high with white pine whereas black spruce successes have been variable. Tests with more juvenile spruce understock (one-year old greenhouse grown) have provided higher grafting successes; this will be pursued further. Late summer grafting in the greenhouse has been good with white pine (92% success) and a failure with black spruce (2% success); this will enable us to increase the capacity of our greenhouses.

CUTTING PROPAGATION

The main impetus of this program has been cloning black and white spruce seedlings of full-sib origin obtained from the controlled crosses in the Glencairn Seed Orchard. Seedlings are grown and cuttings are taken from them and propagated (Phillion, 1982). New cuttings are then taken from the original seedlings and also from the new rooted cuttings. This cycle is repeated until a minimum of 100 and maximum of 140 ramets per clone of one age are produced. At present, the production of 100 to 140 ramets can be accomplished by taking two sets of cuttings from the clone. After rooting the last cuttings are used for progeny outplanting tests. Cuttings for the progeny tests are packed in kraft/poly bags in the fall of the year prior to planting. Approximately 200,000 cuttings per year have been produced.

Black spruce donor plants (cuttings and seedlings) that are surplus to the progeny tests and no longer required at Orono are shipped to Swastika Nursery for their mass cutting propagation program. Approximately 50,000 plants are required at Swastika for this purpose.

Juvenile cuttings from other species such as tamarack, white pine, Scots pine, jack pine, Norway spruce, and European Larch have been successfully rooted.

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RECENT DEVELOPMENTS IN ONTARIO'S PROVINCIAL TREE IMPROVEMENT PROGRAM

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Keywords: staffing, workshops, council, computers, support programs

Tree improvement is advancing rapidly as an accepted operational component of forest management throughout Ontario. It has a high priority in the work planning process and the number of staff directly involved in tree improvement is increasing. Tree improvement strategies for our major regeneration species are in place and implementation is well underway.

This paper highlights recent events and developments in tree improvement in Ontario.

WORKSHOPS

In an endeavour to provide field foresters and technicians with a good basic understanding of tree improvement and its role in forest management, we have conducted workshops over the last two years. Lectures and discussions on genetic principles, tree improvement strategies, and managing for seed production were given by staff from main office, the Ontario Tree Improvement and Forest Biomass Institute (O.T.I.F.B.I.) and the Petawawa National Forestry Institute (P.N.F.I.). The workshops were highly successful and the program is being continued by the University of Toronto as part of their extension services in cooperation with the Ministry of Natural Resources.

In addition to the workshops, the Ministry, along with the Faculty of Forestry from the University of Toronto, sponsored a one day Symposium on Larch. Papers were presented on all aspects of the genus ranging from silviculture and management through to utilization.

STAFFING

Personnel working directly in the area of tree improvement has increased, both in the field and in main office. There are currently five regional tree improvement specialists in the field, of which two are permanent staff. In addition, a new field group was recently established in the Northern Region which includes in its mandate the objective of accelerating the implementation of tree improvement strategies in conjunction with intensive forest management. Main office staff consists of one silviculturist with support from two contract foresters and one part-time clerk. The success of the two-year training position has led to its continuation as part of the main office program.

COUNCIL

In the fall of 1982, representatives from the Ministry and from forest industry convened to discuss the possibility of establishing an Ontario Tree Improvement Council. As a result of these discussions and the recommendations of a joint committee, the council was established in June of 1983 with Mr. Jack Simons, Vice-President of Woodlands, Ontario Paper Company, as its first chairman. The council is currently evaluating proposals from several universities to house the directorship. When a decision is made as to where the council will be quartered then a search will be made for a director. The objective of the council is "To increase the supply of industrial roundwood for the forest industries of Ontario through an accelerated tree improvement program that will shorten rotations, increase yields and improve wood quality".

COMPUTER DATA BASES

Several computerized data bases have been developed which deal with tree seed and tree improvement in Ontario. All systems have been developed in FOCUS, a fourth generation, user friendly language currently available on mainframe IBM machines. The first and latest system TSINOW, an abbreviation of Tree Seed Inventory Now, is an interactive system which maintains all the records with respect to Ontario's primary seed extraction facility at Angus, Ontario. The system parallels the normal sequence of operations that the seed plant undergoes when processing and shipping seed. Data includes volumes of cones/fruit received and processed, seed yields, germination tests and shipment records.

The second system developed, PLUSTREE, is intended to bring together all the information on the location, description and disposition of all plus trees selected throughout the province. This will be followed by and linked to ORCHARDS, a system that will detail the location and description of all seed orchards in the province, including layouts, management and operations.

SUPPORT PROGRAMS

The implementation of short-term support projects to provide answers that are needed in planning and developing our tree improvement programs has continued. A list of some of the current project follows:

1. Identification, selection and breeding of Larix spp. predominantly tamarack (Larix laricina (Du Roi) K. Koch).

2. Identification and evaluation of Norway spruce (Picea abies (L.) Karst.) planted in Ontario

3. Determination of variation in wood quality of tamarack

4. Determination of variation in wood quality of jack pine (Pinus banksiana Lamb.) in both natural stands and in selected plus trees

5. Seed orchard management trials to ascertain the effects of different management prescriptions.

6. Computer modelling for testing and evaluating seed orchard, mating, and progeny test designs

7. Publication of guidelines dealing with various aspects of seed management and tree improvement.

ONTARIO FOREST TREE SEED RESEARCH AND DEVELOPMENT 1981-1983

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Keywords: Provenance, pregermination, mini containers, seed yield and quality, Pinus banksiana, Picea mariana, Picea glauca.

The seed research program at the Ontario Tree Improvement and Forest Biomass Institute (O.T.I.F.B.I.) currently emphasizes maximization of area reforested with genetically improved forest. The highest priority relates to intensive forest management systems using improved quality nursery stock. Studies relate to source of seed, seed production and collection and seed utilization.

SEED SOURCE STUDIES

Older white spruce (Picea glauca (Moench)Voss) cooperative provenance trials in Ontario, planted in 1958 and 1963, are being re-assessed. Important variation in growth between sources noted in previous assessments (Teich et al 1975) appear to have been accentuated. Extreme within source variation points to the need for more detailed population studies. Site variation within replications presents problems in analysis of source variation in these trials.

Older trials of white pine (Pinus strobus L.), red pine (Pinus resinosa Ait.), jack pine (Pinus banksiana, Lamb.) and Scots pine (Pinus sylvestris L.) have been retained on a maintenance basis. Despite limitations, these studies are expected to provide added information to future population genetics studies in these species.

More recent cooperative white spruce regional and all range trials established by O.T.I.F.B.I. and the Petawawa National Forest Institute (P.N.F.I.) respectively have reached the stage of early assessment. Initial planting height and survival data have been measured on 12 experiments across Ontario and 5-year heights and survival on those of the first two series in Northwestern and North Central Ontario. Differences due to source are manifest early and unsuitable sources, such as Birch Island, B.C. which outperformed all other sources in the nursery, have fallen drastically in ranking.

SEED YIELD AND QUALITY

Shortages of white and black spruce (Picea mariana (Mill) B.S.P.) in 1979 and 1980 emphasized the need for seed yield and quality studies. Factors which influence seed production for registered sources from which future seed supplies will come are being studied. Sources of variation in bulk collections from mature stands must be better understood.

Cone yields

In mature white spruce 25 l is more realistic than the 73 l currently used (Anonymous 1977). Maximum yields of 1 Hl have been recorded. From young trees 5-10 l may be expected in a good seed year. For black spruce 2-5 l with a maximum of 10 l from mature trees and 1-2 l per young tree are more reasonable estimates than the 36 l currently in use.

Periodicity influences numbers of cone bearing trees and yield per tree. In a 25-year-old white spruce plantation monitored for 12 years only 26% produced cones in the best year. A few produced cones 7 years out of 12. Most (60%) have produced no cones to date. In Kapuskasing 89% of black spruce in a 25-year-old plantation produced cones in 1982, a minor crop year. Some trees of both species consistently produce larger crops.

Jack pine cone yields are influenced by between tree variability, age, stand density and year of production (Baker 1980). Total yields varied from 3-3000 serotinous cones per tree with an estimated mean of 300. For trees less than 30 years, mean yields were less than 100 cones. In 1977, an average of 32 current cones per tree were collected, with one tree yielding 223 cones, and several bearing none.

Seed yields

Many factors influence yield of seed of the three major Boreal conifers. Numbers of seed per cone in both black and white spruce relate to cone size though the relationship is not as distinct in jack pine. Young black spruce in Nipigon District stands were found to produce 17,000 to 27,000 cones per hectolitre over a four-year period. Trees over 80 years in Sioux Lookout over a three year period produced 38,000 to 51,000 cones per hectolitre and in Geraldton from 35,000 to 44,000. One tree in Hearst yielded the equivalent of 96,000 cones per hectolitre.

Young black spruce tended to produce 10% heavier seed than older trees when cones were comparable in size. Mean seed weights from young trees tend to be 1.1 to 1.2 mg. while older trees produce .8 to .9 mg. seeds. Straight jack pine cones exhibit higher yields than curved cones.

Upland black spruce cone age data supports that of peatland black spruce (Haavisto 1975). Yields and germinability decrease with age of cone but acceptable yields of viable seed have been extracted from cones up to 5 years old. Cone opening varies between trees within stands. Yield differences related to extraction processes are currently being studied.

Seed collection and production

Current seed studies are intended to establish normal yield and quality standards and identify factors influencing them. Such studies are basic to research aimed at improving future seed yield and quality from registered stands, plantations and seed orchards.

In cooperation with the Great Lakes Forest Research Centre at Sault Ste Marie a cone collection tower (Skeates 1982), developed at Maple, was evaluated and found effective in collecting from stands of upland black spruce up to 20 m tall. This would be effective in collecting from older plantations when trees are beyond ladder access.

SEED UTILIZATION

Current seed efficiency varies according to species and stock product. For seedling production of pines and high density seedbed production for transplanting spruce, mean seed efficiency is about 40% for jack pine, 25% for white and red pine and white spruce and 10-15% for black spruce (Skeates and Williamson 1979). For container production, often three or more seeds are sown per cavity to ensure full stocking in the greenhouse. Both situations are unacceptable for genetically improved seed.

Seed research has been concentrated on development of pregermination systems (Skeates 1983) for improved seed efficiency in greenhouse systems, reduction in stock costs and maximum production of improved quality stock in expensive greenhouse systems. Density has been shown as the single most important factor in greenhouse production of stock (Ernst & Whinney, Preliminary guidelines for the development of black spruce accelerated transplant systems 1983, Internal O.M.N.R. report).

Containers

Pre-grown seedlings in cigarette micro containers are recommended for planting into larger containers, the peat-cube being the most adaptive container system. The Dewa block technology has proven highly successful in horticulture and agriculture in Europe and is seen as having similar potential for one-year container systems with spruce species in Ontario. The goal would be high density production in the greenhouse for transplanting into large containers outdoors.

Accelerated transplants

Pregermination of seed has been shown to have a significant affect on growth of black spruce accelerated transplants (Skeates et al 1982). In 1980, paper pots, peat cubes and trays of bare root seedlings, sown with pregerminated seed, all produced two-year transplants in excess of 10 g. The peat cube, among the least costly container systems, is seen as being the easiest to automate. Currently studies are assessing the

potential of Castle and Cook mini-containers, an operational agricultural system in California, for transplanting. The system requires one third the greenhouse space and eliminates one production operation.

Seedlings

The Fluid Drilling system of germinating and sowing seeds with one to two mm. radicles has proven highly successful in agricultural products in Britain. Hagner (1981) has used a similar principle in Sweden. More studies are necessary to evaluate the system.

Direct sowing

Large quantities of seed are required to achieve acceptable stocking standards through direct seeding. To ensure reasonable growth of resultant stands costly thinning will be required. The use of a mini container as a low cost planting alternative would be well worth investigating.

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BREEDING FAST GROWING HARDWOODS AND WHITE PINES AT THE ONTARIO TREE IMPROVEMENT AND FOREST BIOMASS INSTITUTE, MAPLE, ONTARIO DURING 1981 TO 1983

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Keywords: Poplar breeding, white pine breeding, willow breeding, alder breeding, birch breeding.

Poplar and white pine breeding was initiated in the 1940's. Recently, willow, alder, and birch breeding experiments have begun. L. Zsuffa coordinated and supervised these studies, in cooperation with D. Boufford (research assistant), K. Falusi (Ph.D. candidate, research scientist), J.O. Hyun (Postdoctoral fellow, Assistant Professor, College of Agriculture, Seoul National University, Republic of Korea), A. Mosseler (research scientist), and O.P. Rajora (Ph.D. candidate, Faculty of Forestry, University of Toronto).

POPLAR BREEDING

Studies in Native Poplar Species

Studies of genetic variation in native poplar species (Populus tremuloides Michx.) and balsam poplar (Populus balsamifera L.) were launched in 1980. These studies have yielded results in the past period.

Trembling Aspen

Study conducted by J.O. Hyun. Root sections of 200 clones, distributed over stands, in 8 geographic regions, were collected along an east-west, and north-south transect. Root tips were used in an isozyme study and a total of 15 gene loci were resolved from 8 different enzyme systems. Most of the genetic variability resided within the population and only 6.8% of the total genetic variability could be attributed to between population differences.

Balsam Poplar

Study conducted by K. Falusi. Forty female balsam poplar trees were selected in an 80 km wide corridor extending from Lake Erie north to James Bay. Cuttings and open pollinated seed were collected, rooted and germinated, respectively, at Maple.

Twenty-nine half-sib families germinated in leach tubes[1] in July were transferred to the greenhouse in January 1982. The seedlings were grown under a 12 hour and a 24 hour photoperiod until May 1982. Under the 12 hour photoperiod, the tallest seedlings were from southern Ontario (Site region 7E) and averaged 15.7 cm in height. The shortest seedlings were from northern Ontario (Site region 2E)[2] averaging 2.3 cm. Under 24 hour light, the seedlings from both northern and southern Ontario showed no significant difference in growth rate, or final height which averaged 52.7 cm. Observations are continuing in the nursery at Maple.

Poplar Hybridization

Poplar breeding work was conducted by O.P. Rajora. In 1981, again in 1982, the following crosses were made:

	Number of Combinations
P. deltoides x P. deltoides	4
P. deltoides x P. nigra	4
P. deltoides x P. maximowiczii	4

The heritability of taxonomically important leaf characters and height growth of the full-sibs are being studied. Inheritance of 12 isozyme systems was studied and was found to be codominant according to Mendelian patterns.

Twenty-eight pollen mix crosses were made of P. deltoides, P. nigra, and P. maximowiczii in all combinations of two's, using P. deltoides as the female parent. These crosses provided information on the species "preference" in pollination. The use of isozymes as gene markers distinguished the interspecific hybrids produced from these three Populus species.

The full-sibs produced by controlled pollination are planted in the nursery at Maple in a replicated trial. This trial will provide information on heritability of growth parameters, leaf characteristics, and combining ability.

Poplar Trials

Several trials have been established during the 1981-83 seasons.

In northern Ontario nurseries, frost hardiness trials were expanded. At Kapuskasing (northern Ontario), an aspen range test, several progeny trials, and a clonal trial were established. These experiments were replicated in southern Ontario (Midhurst).

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[1] leach tubes (super cell conetainers) Ray Leach Conetainer Nursery, Canby, Oregon.

[2] Hills, G.A. 1966. The ecological basis for land-use planning. Ont. Dept. Lands and Forests. Research Branch. Research Report 46. 204 p.

In southeastern Ontario (Brockville), a series of five clonal trials were established, as well as progeny trials of P. deltoides, and interspecific hybrids.

At several locations across southern Ontario, (Cornwall, Cambridge, Lindsay, Owen Sound, and Maple) clonal trials were established. Finally, at Dryden, in northwestern Ontario, a poplar hybrid progeny trial was established.

BREEDING OF OTHER FAST GROWING HARDWOODS

Programs in willows (Salix L. spp) and birch and alder (Betula L. spp, and Alnus Mill spp) were intensified and expanded. Within the terms of an international project financed by Forestry Energy Agreement of the International Energy Agency, A. Mosseler has conducted willow collections and breeding experiments. Collections of native species and identification of the same have been carried out at Maple to facilitate the basic selection requirements for this species.

During the spring of 1983, a hybridization program was initiated to determine the crossability patterns and characteristics of interspecific hybrids. Of the 50 hybrids produced, the early results indicate successful crosses between Salix exigua x eriocephala, S. petiolaris x eriocephala, S. bebbiana x eriocephala, S. pellita x discolor, S. lucida x exigua, and S. petiolaris x exigua.

K. Falusi continued alder and birch hybridization experiments initiated by Russell and Hoover in 1981 and 1982. The experiments were designed to investigate the ease of producing hybrid seed. The Alnus species used were A. rugosa, A. glutinosa, A. rubra, and A. cordata. The Betula species used were B. papyrifera, B. alleghaniensis, and B. verrucosa.

As of June 1983, catkins have been set in crosses of A. rugosa x rugosa, A. rugosa x glutinosa, A. glutinosa x glutinosa, A. glutinosa x rugosa, A. glutinosa x cordata, and Betula verrucosa x papyrifera.

WHITE PINE BREEDING

White pine breeding continued as outlined in the 1979-81 progress report (Zsuffa, 1981).

Blister Rust Resistance Breeding in Pinus strobus L.

The blister rust resistance of P. strobus is of polygenic nature. Artificially inoculated F_1 progenies succumbed in large numbers and gave no indication of parent trees producing progenies with increased blister rust resistance. Field tests of F_1 progenies indicated higher levels of blister rust tolerance and mother trees with ability to produce blister rust resistant progenies.

Pollination

In 1981 and 1982 the objective of the breeding program was to determine the crossability patterns of the different white pine species and to reproduce some earlier hybrids. In 1983, hybrid white pine which showed resistance to blister rust, were reproduced. An experiment was designed to determine the advantages of a syringe vs. an aspirator in pollen application and conelets formed. The crosses made included P. strobus x griffithii, P. strobus x peuce, and P. strobus x strobus. These crosses were repeated using P. griffithii and P. peuce as the female parent.

Progeny Trials

Five progeny trials have been established during the 1981-83 period. Included were half-sibs of P. strobus plus tree selections, and full-sibs of interspecific hybrids. To alleviate weevil problems in two trials, white pine progenies were interplanted with poplar clonal material.

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BLACK SPRUCE GENETICS, PETAWAWA NATIONAL FORESTRY INSTITUTE, 1981-1982

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Keywords: Picea mariana, progeny, mating system, population structure, isozymes, hybridization

Following the departure of Dr. E.K. Morgenstern, responsibility for this study was taken over by Mr. T.J.B. Boyle who is currently on educational leave at the University of New Brunswick. With no full-time study leader at PNFI the majority of recent work has been concerned with the maintenance and assessment of established tests. However during the summer of 1982 a Project Evaluation exercise was carried out which resulted in recommendations for future work being drawn up. These will be summarized at the end of this report.

PROGENY TESTS

The series of six open-pollinated black spruce (Picea mariana (Mill.) B.S.P.) progeny tests established in Ontario site region 3W (Expt. 353-I) was measured in fall 1981 (nine year height from seed) after five growing seasons in the field. The fall 1982 (nine year) height of the site region 4S series (Expt. 353-J) was recorded early in 1983. The heights were recorded directly into a "Datamyte" recorder and later transferred to disc using an "Osborne" portable terminal. This enabled the information to be collected far more rapidly than had previously been the case.

The series of full-sib progeny tests consisting of a factorial mating design and a 7-tree diallel made in 1970 continue to be assessed. The four tests of the diallel are measured for height and rated for strobilus production every year. The two factorial test plantations are measured for height every second year.

MATING SYSTEM AND POPULATION STRUCTURE

In the fall of 1982 seeds were collected from forty trees in each of six stands in central New Brunswick. Isoenzyme analysis is currently being carried out on this material, using facilities at the University of New Brunswick, in order to obtain estimates of mating

system parameters. If possible an estimate will also be made of the coefficient of relationship between neighbouring trees using the pollination pattern of rare alleles. This information will then be used to assess the efficiency of various tree improvement strategies.

PROJECT REVIEW AND FUTURE WORK

Following a project review in 1982 it was concluded that future work would concentrate on:

(a) quantifying genetic parameters of productivity from full-sib progeny tests established over the past decade in cooperation with the Ontario Ministry of Natural Resources,

(b) refining patterns of geographic variation and environmental adaptation from range-wide provenance tests established by cooperators throughout the boreal forests of Canada,

(c) employing techniques of growth acceleration and biochemical analysis for early testing and studies of population structure,

(d) creating and testing species and provenance hybrids of black spruce, especially with P. omorilea (Poncik) Purkyne and P. glehnii (Fr. Schmidt) mast.

BIOCHEMICAL GENETICS 1981-1983

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Keywords: Population Genetics, Isozymes, Biochemistry, Picea glauca, Picea mariana, Larix laricina, Populus tremuloides

The present study officers assumed responsibilities for this study in June 1982. Thus, this report deals only with research accomplished during the period June/82 to August/83. The emphasis in this past year has been on white spruce (Picea glauca [Moench] Voss), tamarack (Larix laricina [Du Roi] K. Koch), black spruce (Picea mariana [Mill.] B.S.P.), and trembling aspen (Populus tremuloides Michx.). Two major areas of work have been advanced using these species; population genetics and the biochemistry of enzyme extraction.

POPULATION GENETICS

White spruce

Extraction protocols were developed for isoenzyme analysis of needle and bud tissues of white spruce. Genetic control of allozyme variants was demonstrated using progeny from a diallel cross involving five parent trees. These analyses also demonstrated the utility of isozymes as simple genetic markers capable of certifying the genetic integrity of controlled crosses and of ramets within grafted clones in a clone bank where a number of errors of identity were detected.

A fortuitous seed-year in 1973 provided materials for a study of the genetic structure of a single white spruce stand. In this study, the inheritance of allozyme variants was confirmed using haploid megagametophytic tissues from mature, viable seeds. As well, the population structure (using inferred genotypes from the haploid tissues) mating system, and effectively transmitted pollen pools were studied using open-pollinated families from 47 single trees. Results indicated that the parental generation was in approximate Hardy-Weinberg equilibrium and that the filial generation was derived from approximate random mating. However, there was significant heterogeneity in the effectively incorporated pollen pool and a finite number of genetically effective males participating in the mating event.

Needle tissue was collected from a random sample of 50 individuals and between seven and 14 phenotypically selected individuals from each of nine stands of white spruce in the Upper Ottawa Valley. The phenotypically selected individuals represent candidates for a breeding program (see Murray and Cheliak, these proceedings). This tissue provided enzymes from which the population structure of this intensive population sample was estimated. Results indicate that these stands cannot be considered as a genetically homogenous group. Furthermore, they demonstrate the need for biologically and genetically sound sampling strategies to adequately represent the range of genetic variation in a species, even at the single breeding population level.

Tamarack

Haploid megagemetophytic tissues served as the source of enzymes from which a range-wide survey of genetic variation in this species was investigated. These results include studies dealing with the inheritance and linkage of allozyme variants, single and multilocus population structure, and variation and the mating system in natural stands of this species. Results to date indicate that the species harbors a large amount of inter- and intra-population variation. Therefore, breeding programs to improve quantitative traits in this species should be successful. Additionally, we have been able to demonstrate that several collections, labelled as single-tree collections, actually represent seed collections of at least two trees. These types of errors can have serious impacts on estimates of genetic parameters made from progeny tests which assume that seed lots were from single trees.

Black spruce

Gwen O'Reilly, a graduate student with Dr. W.H. Parker of Lakehead University, completed a study comparing the genetic structure of paired samples of upland and lowland black spruce populations. Seeds from approximately 20 trees in each of five northern populations of black spruce in Ontario formed the basis of this study. Results indicated that upland and lowland populations of black spruce are differentiated from each other on the basis of their single locus as well as multilocus structure. The lowland populations were consistently more genetically variable than their upland counterparts. However, the upland populations were more genetically differentiated from each other than were the lowland populations.

Trembling aspen

All members of a clone have exactly the same genotype. Therefore, using simple genetic markers, we should be able to delineate and certify clones (i.e. collections of ramets, all with the same multilocus genotype) in natural populations. Putative ramets from 10 phenotypically distinct clones were delineated in the field using conventional morphological characters. Newly expanding leaf tissue from these ramets was

used as a source of enzymes in an attempt to certify phenotypically homogeneous groups as genotypically homogeneous. Results indicated that a phenotypically homogeneous group could actually be composed of up to five electrophoretically homogeneous groups.

BIOCHEMISTRY

Methods to improve the analysis of isoenzymes by starch gel electrophoresis of vegetative tissues of five conifers were investigated. The study involved extracting bud, bark and needle tissues of jack pine, Scots pine, white spruce, black spruce, and tamarack with 16 existing or modified extraction buffers containing various amounts and types of enzyme protective agents. It was observed that few, if any, enzyme protective chemicals are needed for buds with scales removed. However, in order to obtain good enzyme activity from needle and bark tissues, the presence of protective agents in the extraction buffer was essential. The total enzyme activity, resolution, and number of bands following starch gel electrophoresis were affected by the types and combinations of protective agents of each of the 16 extraction buffers.

Malate dehydrogenase activity was determined quantitatively for white spruce needles following extraction with buffers containing protective agents added singly or in various combinations. A range of concentrations as well as three separate pH's were tested for each protective agent. Further experiments will examine additional enzymes quantitatively, e.g., acid phosphatase, superoxide dismutase, 6-phosphogluconate dehydrogenase, glucose-6-phosphate dehydrogenase, and others. Needles as well as bud and bark tissues will be used. It is expected that a more efficient buffer can be constructed to maintain enzyme activity of vegetative extracts from as wide a range of enzymes as possible.

Isoenzyme patterns by starch gel electrophoresis were examined following various periods of imbibition and germination of lodgepole pine seeds. Embryos were excised and isoenzymes of esterase, glutamate-oxaloacetate transaminase, leucine aminopeptidase, and peroxidase were examined. Changes were most dramatic for peroxidase, as the number of bands and activity increased greatly with imbibition and germination. Tissue-specific differences were observed between the root and shoot tissues. Again, most differences were observed with peroxidase.

Future studies with B.S.P. Wang will examine enzyme activity in relation to some seed problems. For example, it was observed that aged larch seeds were not suitable for enzyme analysis. Most enzymes examined had reduced activity as well as poorer resolution. In addition, extra bands were obtained in some cases. For example, a fast migrating band of phosphoglucose isomerase was observed in aged seeds as compared with new seeds. Other studies using the spectrophotometric analysis of enzymes will examine changes in enzyme concentrations in relation to seed deterioration in storage, during seed maturation and germination, and during cold stratification as well as the release of seed dormancy.

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INSECT AND DISEASE RESEARCH IN TREE IMPROVEMENT AND SEED PRODUCTION -- PETAWAWA, 1981-1982

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Keywords: Spruce, seed and cone insects, monitoring, pheromones, systemic insecticides, Beauveria bassiana, gall rust, leader weevil, Scots pine, resistance.

INTRODUCTION

Research on insects and diseases at Petawawa National Forestry Institute for 1981-82 has focused primarily on management and control of insects responsible for seed losses in white spruce, Picea glauca [Moench] Voss. Because of the high priority attached to finding solutions to seed and cone insect problems only a small proportion of time has been devoted to studies on selection and testing for resistance to insects and diseases. This report outlines our activities and progress for the period 1981-82.

SEED AND CONE INSECTS: SPRUCE

Our strategy for finding solutions to seed and cone insect problems is an integrated pest management approach which means: assessing and evaluating damage and losses; monitoring populations and predicting outbreaks which cause unacceptable levels of damage; using cost-effective and environmentally acceptable chemical and biological controls; prescribing stand establishment and management practices which will reduce outbreaks and damage.

Evaluating losses and monitoring insects

Management techniques to minimize seed losses to cone insects in white spruce are being evaluated by comparing seed yields, insect attack and cone crops in a variety of stands ranging from unmanaged seed collection areas with varying tree densities to intensively managed clonal seed orchards. Most losses are attributed to the following insects: spruce budworm, Choristoneura fumiferana Clem., coneworm, Dioryctria reniculleloides Mutuura and Munroe, seed moth, Laspeyresia youngana (Kearfott), cone maggot, Hylemya anthracina (Czerny). Surveys conducted since 1979 in three stand types varying in seed tree density

are providing information about when and where to collect cones and possible effect of stand structure on seed yields and losses to insects. A cooperative study with Dr. G.G. Grant of Forest Pest Management Institute at Sault Ste. Marie was initiated in 1980 to evaluate sex-attractant pheromones for use as a monitoring tool for the spruce seed moth. Effective lures have been identified and flight monitoring since 1980 is providing needed information on relationships among flowering, insect flight activity and weather factors.

Chemical control

Data and advice were provided to Dr. D. Barnes, Manager, Regulatory and Environmental Affairs, Cyanamid Canada Inc. to support 'Minor Use Registration' of dimethoate for cone and seed insect control by means of foliar-spray applications. Our data also suggest that the systemic insecticides lannate and orthene might be useful for control of white spruce seed and cone insects. More data on the effectiveness of these two insecticides is needed.

Application of carbofuran insecticide to soil provides foliage protection from budworm feeding on white spruce seed trees (Fogal et al. 1981). Granular carbofuran should be worked into the soil to prevent bird mortality and application should be timed to precede a rainfall to enhance uptake by the trees. Applying carbofuran as a liquid soil drench to black spruce, Picea mariana (Mill.) B.S.P., trees provides better foliage protection than granules in the year of treatment. Both granular and liquid applications provide protection in the year following treatment. More data on efficacy for cone and seed protection, potential phytotoxic effects and on environmental hazards are required before the registration of this insecticide for use on white and black spruce seed trees can be considered.

Experiments were initiated in 1981 to determine if the injection of systemic insecticides into the stems of white spruce trees would control seed and cone insects. Dicrotophos at doses of .56 and 1.12 gAI/cm DBH and oxydemetonmethyl at .36 and .72 gAI/cm DBH provided increases in numbers of sound seeds per cone of 80 percent or more in the year of treatment. The effect persisted into the second year with increases of 60 percent or more. Phytotoxic stress due to treatment was negligible. Experiments are underway to test effectiveness of these chemicals over a wide geographic range within the province of Ontario and to evaluate effect of treatments on seed germinability.

Information activities resulted in publication of two reports on chemical control. One was a state of the art account of methods for control of budworm on seed trees (Fogal, 1982a) the other a literature review covering all aspects of control of seed and cone insects on white and black spruce (Fogal 1982b).

Biological control

Initial investigations with fungal diseases of insects revealed that several seed and cone insects of white spruce were susceptible to

Beauveria bassiana (Fogal 1981a). This fungus might have potential as a biological control agent. A method and facilities for producing conidiospores of B. bassiana were developed at PNFI. With contract funds from PNFI and a grant from the Ontario Pesticides Advisory Committee, laboratory and field tests explored possibilities for use of this fungus for control of seed and cone insects. A soil bioassay system was developed for testing B. bassiana conidiospores on the spruce cone maggot which pupates in the duff beneath the trees. Tests suggest that treatments of soil with B. bassiana conidiospores can reduce by as much as 34 percent the numbers of cone maggot puparia containing living larvae or pupae. A field study to investigate the possibility of protecting seeds of white spruce from several cone-feeding insects by treating flowers and conelets with conidiospores was completed. Treatment of recently-closed flowers enhanced seed yield by as much as 55 percent without causing damage to developing cones.

SELECTION AND TESTING FOR RESISTANCE TO INSECTS AND DISEASES

Activities have been confined largely to information exchange. A report on the relevance of tree improvement to forest pest management was presented at the Canadian Forest Pest Control Forum (Fogal 1981b) and contributions were submitted to the Newfoundland Royal Commission on management and control of the spruce budworm (Fogal and Strunz 1981, Strunz and Fogal 1981). In addition a review on variations in susceptibility of native and introduced conifers was published (Fogal et al. 1982).

In cooperation with Dr. M. Carson and Mrs. S. Carson from the Forest Research Institute, Rotorua, New Zealand, Dr. C.W. Yeatman and I began analysis of progeny tests established by Mr. M. Holst in 1968 to test heritabilities of winter dessication and susceptibility of Scots pine, Pinus sylvestris L. to gall rust, Endocronartium harknessii (J.P. Moore) V. Hiratsuka and to the leader weevil, Pissodes strobi Peck. Analyses of variance of winter dessication established that seedlot differences were highly significant. Parent-offspring regression was highly significant and narrow sense heritability was estimated to be 0.66. Differences in weevil damage among seedlots were also highly significant, the parent-offspring regression was significant and heritability was estimated to be 0.44. Strong evidence of qualitative resistance to gall rust was observed and it may be controlled by only a few genes. Added to this, there is additional evidence of quantitative variation in resistance underlying the major gene effects. A manuscript is in preparation.

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GENETICS OF WHITE SPRUCE, LARCHES AND HARDWOODS, PETAWAWA 1981-1983

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Keywords: provenance, Larix laricina, Larix decidua, land race

In the past two years a significant amount of time has been devoted to new provenance experiments in white spruce (Picea glauca (Moench) Voss) and tamarack (Larix laricina (Du Roi) K. Koch), and to assembly of clonal breeding populations of white spruce and European larch (Larix decidua Mill.). Much of this work has been enhanced by increased use of isoenzyme analysis in the study of population genetic structure and mating systems. In addition, existing research on the genetics of white spruce, larch and hardwoods has been continued with the analysis and interpretation of data collected in experiments referred to in proceedings of previous C.T.I.A. meetings.

WHITE SPRUCE

Provenance

For many years high priority has been given to research into identifying and quantifying range-wide and regional genetic variation in white spruce. By 1983 the establishment phase of a new series of cooperative range-wide provenance tests (Ying 1980) was almost complete. White spruce seeds have been sent to cooperators in seven provinces in Canada and four states in the U.S.A. Records show that 30 provenance tests have already been planted. Staff from Petawawa National Forestry Institute (PNFI) and the Ontario Ministry of Natural Resources (OMNR) have been active in the field in Ontario where five range-wide and eight regional provenance tests have been planted in different environments across the province. Genecological research will continue to be an important part of the research effort on white spruce as data from these and older tests are collected, analyzed, and published.

Breeding, Selection and Progeny Testing

Increased emphasis is being given to research that will provide basic quantitative genetic information with potentially broad application to the development of breeding strategies for white spruce in advanced generations. Work begun in 1982 includes the assembly of a breeding

population that will contain about 400 white spruce clones selected from the local Upper Ottawa Valley population. So far, 247 trees in 28 stands have been selected visually on the basis of general vigour and stem form. Selection and grafting should be complete by 1985. Some of this work was done in cooperation with the OMNR which will include many of the selections in a seed orchard. A progeny test was planted at close spacing in the PNFI nursery with open pollinated seed from four of the selected trees in each of eight stands. Progeny performance in this test will be compared with that in conventional field tests.

The genetic structure and mating system in several stands of white spruce have been studied using isoenzyme analysis techniques. This work is discussed in a report by Cheliak and Pitel in these proceedings.

LARCH

Native Larch

Although seeds for use in a range-wide provenance test of tamarack have been received from 105 locations in Canada and the U.S.A., parts of the range have still been inadequately sampled due to poor seed production. However, information about available seed are being sent to cooperators in order that progress can be made with design and establishment of field tests. Efforts are being made to fill serious gaps in the distribution of samples.

Isoenzyme analysis of samples of the tamarack seed collected indicates that there is a high degree of inter-stand variation.

Exotic larches

Plantations of European larch established at several different locations since the 1950s have provided strong evidence of variation in growth, stem form, and branch habit within and among seedlots or provenances. Superior, hardy phenotypes in those plantations have been identified. Scions from 115 of the selected trees have already been grafted and planted at PNFI to start a foundation population for use in research on land race development.

Evaluation and treatment of Japanese larch (Larix leptolepis (Sieb. and Zucc.) Gord.) plantations in Ontario and Quebec have been continued, mostly by cooperators in the OMNR and the Canadian International Paper Company.

HARDWOODS

No new research on the genetics of hardwoods has been undertaken since the previous Member's Report was submitted. Activity has been limited to evaluation and tending of existing plantations of white ash (Fraxinus americana L.), green ash (Fraxinus pennsylvanica Marsh.),

paper birch (Betula papyrifera Marsh.), and Norway maple (Acer platanoides L.).

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NATIONAL TREE SEED CENTRE
1981-1982

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Keywords: chilling, crop production, germination, information, procurement, processing, seed bank, statistics, stimulation, storage, testing

Since the last progress report, the National Tree Seed Centre has had some changes both in the program structure and the personnel. Two study officers, B.D. Haddon and D.A. Winston, were transferred to the Forest Statistics and Systems Branch, and Canadian Forestry Service headquarters, respectively. They were replaced by P. Janas and H. Schooley. The program of the Centre was reorganized from one project, to two autonomous projects; (1) Research and Development headed by B.S.P. Wang and, (2) Client Services led by P. Janas.

The reorganization provided clearly defined objectives for the two projects and should benefit both research and services. However, the new structure could not be implemented immediately due to the unexpected transfer of the former service project leader, B.D. Haddon, and the lack of additional technical assistance.

In this report we present the highlights of progress on our research and service activities.

RESEARCH AND DEVELOPMENT

Seed Germination:

A one year experiment on endogenous control of germination rhythm in white spruce (Picea glauca [Moench] Voss), jack pine (Pinus banksiana Lamb.), and lodgepole pine (Pinus contorta Dougl.) seeds was completed. Results indicated that there was no consistent trend of endogenous control of germination rhythm in all three species tested, although significant monthly and seasonal variations were noted in both the rate and total germination in white spruce and lodgepole pine seeds. These variations were slightly to moderately reduced by increased photoperiod (16 hour) but almost completely eliminated by a 3 week pre-chilling treatment.

A cooperative evaluation of seed yield and quality of black spruce from manually and mechanically harvested cones with the Ontario Ministry of Natural Resources and Great Lakes Forest Research Centre was completed. The evaluation suggested that both seed yield and quality of hand-picked cones are superior to agricultural combine-harvested cones, but the differences are important only if the efficiency of combine-harvesting of cones is significantly greater than hand picking. The evaluation results also emphasized the importance of pre-chilling treatment in improving rate and uniformity of germination of black spruce seeds.

Testing of the PILP-funded prototype germination boxes with respect to their quality and suitability for seed research and testing was completed, and a report is being prepared.

A manuscript on environmental and genetic factors affecting tree and shrub seeds by B.S.P. Wang, J.A. Pitel, and D.P. Webb was published, and another manuscript on germination of dormant seeds by B.S.P. Wang and J.A. Pitel was submitted to the International Seed Testing Association as a chapter in a proposed Forest Tree Seed Handbook.

A preliminary trial of the utilization of chilling treatment as a vigour test with low, medium, and high vigour seedlots of pine, spruce and douglas-fir (Pseudotsuga menziesii [Mirb.] Franco) showed that the technique appears to be effective for all species except red pine (Pinus resinosa Ait.). Laboratory germination was found to be closely correlated with greenhouse seed emergence and conductivity. Further research is needed to refine the vigour testing technique.

Seed Storage:

A 1982 monitoring test of seeds stored at 2°C and -18°C for long periods revealed that there was a drastic decline in germinability of eastern white pine (Pinus strobus L.) seedlots after 15 years of storage at 2°C. There was no loss of germinability of the same seedlots stored at -18°C. Since the last test in 1980, the decrease in germination of six out of seven lots ranged from 12 to 46 per cent. These results seem to point to the superiority of sub-freezing temperatures for long-term storage of seed of this species and possibly of other conifers and hardwoods.

The Proceedings of the 1980 International Symposium on Forest Tree Seed Storage held in Petawawa, compiled and edited by B.S.P. Wang and J.A. Pitel, was published by the Canadian Forestry Service, Ottawa. Copies of the Proceedings are available from the Technical Information and Distribution unit of the Petawawa National Forestry Institute. A review of the Proceedings was prepared by B.S.P. Wang and J.A. Pitel for publication.

Seed Crop Production and Stimulation:

Work on white spruce stimulation by nitrogen at Glencairn Seed Orchard for a contract with Ontario Ministry of Natural Resources was

carried out according to agreement. Cone and soil samples were collected and analyzed, and a report will be prepared. Studies to characterize the effects of frost on red pine flower production will be continued with the establishment of weather towers. A manuscript on the frost damage to red pine flowers was prepared by D.A. Winston and R.L. Macnaughton for publication. Data on effects of fertilizer and thinning on cone production of jack pine and spruce were collected and are being analyzed.

A joint proposal for genetic improvement and seed production of white spruce in the Upper Ottawa Valley, prepared by D.A. Winston and G. Murray, was accepted by the Ontario Ministry of Natural Resources for establishing a cooperative white spruce seed orchard in Beachburg area.

Miscellaneous:

The 3rd and 4th drafts of "Forest tree seed regulations" compiled by D.F.W. Pollard, D.G. Edwards, and B.S.P. Wang were sent by CFS headquarters to various governments, universities, and forest industries for comment.

B.S.P. Wang lectured on seed problems at the Northeast Forestry Institute, Harbin, China, and continued his advisory service to CIDA's project, "ASEAN-Canada Forest Tree Seed Centre", in Thailand.

CLIENT SERVICES

Seed Extraction, Processing and Testing:

A total of 991 separate seedlots were processed in the seed extraction plant. The majority of these were destined for research programs at P.N.F.I. and outside agencies. These included over 700 lots of white spruce, approximately 200 lots of red pine and tamarack (Larix laricina [Du Roi] K. Koch), and 33 lots of Scots pine (Pinus sylvestris L.). The processing of the Scots pine seedlots was for the Christmas Tree Grower's Association of Ontario genetic improvement initiative.

Service, routine, and regulatory testing of tree seed for moisture content, purity, germination, determination of 1000-seed weight and assessment of processing injury continue to represent an integral and major component of the Centre's service responsibilities.

Seed Procurement, Distribution and Information Services:

The Seed Bank now contains more than 4000 seedlots of 140 species and continues to expand to include single tree collections (which are of great value to geneticists) and collections representative of gene pools endangered and unique indigenous populations of tree species.

A worldwide network of contacts has been established to procure and distribute valuable collections of seed and other reproductive material for the Seed Bank as requested by other persons or agencies.

The Seed Centre continues to act as the main clearing house for Canadian tree seed exchange with the Soviet Union. Recent diplomatic ties with the People's Republic of China have benefitted research scientists and arboreta who have acquired Chinese seed via the Seed Bank. In total, 96 seedlots comprising 75 species have been received from the People's Republic of China since the inception of the exchange program.

A total of 454 seedlots and 80 cone packages comprised of 120 species was distributed to clients in 8 Canadian provinces and 16 other countries in response to 85 requests for seed and cones.

An updated listing of seed available from the Centre's storage vaults was published as an information report (B.D. Haddon 1982). A computer record system has been developed for all reproductive material at Petawawa National Forestry Institute and has undergone continual refinement.

As a result of the considerable interest to Alnus species, the Seed Bank has renewed its intentions to serve as the North American centre for the International Energy Agency's Alnus seed collection project. This seed will be utilized for nitrogen fixation research, biomass production studies, and related projects.

Literature and technical consultation on forest tree seed opportunities and problems was provided to 40 clients in 5 Canadian provinces and 10 other countries. These covered such diverse topics as seed availability, collection, processing, testing, storage, germination, and sowing procedures.

National Seed Statistics:

As part of the Canadian Forestry Service's National Statistics program (FORSTATS), the National Tree Seed Centre has assisted in compiling a report on seed procurement and processing, which will help identify the quantity and patterns of seed usage in reforestation programs. The Regional Committee on FORSTATS and provincial agencies have cooperated closely in the first national tree seed statistics survey. A report containing summaries of seed collection, processing, and usage statistics was compiled, and this will be available shortly to interested individuals and agencies.

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P.N.F.I. GENETICS AND BREEDING: GENETICS OF JACK PINE: 1982-83

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Keywords: Pinus banksiana, Petawawa, provenance, progeny tests, advanced generation breeding

The Genetics and Breeding Project at the Petawawa National Forestry Institute vigorously pursued a program of reconstruction, of both scientific capability and research facilities, during the period under review. At the same time, close attention was paid to maintaining and adding to the essential genetic information base, the seed, clones, plantations and trees growing at Petawawa and elsewhere in boreal and eastern Canada. Particular components of the Project are reported elsewhere by Dr. Murray, Dr. Fogal, Dr. Cheliak, Mr. Pitel, and Mr. Boyle. The essential operating resources are reviewed here, together with a brief report on genetics research in jack pine.

PERSONNEL

No changes in staff occurred during the period of review. Dr. Bill Cheliak completed his Ph.D. studies at the University of Alberta, Edmonton, and came to PNFI in June 1982 to initiate new investigations of population and quantitative genetic variation in pine, spruce, and larch. Mr. Tim Boyle left for U.N.B. in September 1981 to undertake graduate studies with Dr. Kris Morgenstern. Tim's thesis research is a study of genetic structure in a natural black spruce population growing in New Brunswick. He will return to PNFI in January, 1985.

Mr. Andrew Hurley, Biology Department, Queens University, came as a visiting graduate student in May 1983 to initiate research towards a Ph.D. in population dynamics and behavior of red squirrels in young pine stands, with special relevance to jack pine seed orchards.

Mr. Brian Horton completed a contract to prepare a report on breeding Scots pine for Christmas trees based on earlier work of Mark Holst and more recent evaluations of the selected clones and families.

Miss Isabell Kneppeck, undergraduate student, University of Toronto, joined us for eight months of a cooperative PEY term sponsored by the Canadian Forestry Service. Her special studies demonstrated the practical value of the Pilodyn wood tester to indicate variation in wood density among trees and families of jack pine.

Students employed during the summer under the COSEP program provided essential assistance in all research and operational aspects of the work of the project. We were also greatly assisted by students and others employed in special programs operating in all seasons. Information was entered into computer records, plantations were improved by thinning and pruning, and the nursery was well cared for. These are just a few of the tasks they carried out so effectively.

CONTACTS

Close liaison was maintained with scientists and foresters of the Ontario Ministry of Natural Resources through participation in the COJFRC Tree Improvement Working Group as well as during field trips to research sites in Ontario. A new working group on Pest Resistance was initiated in May, 1983. New working relationships were initiated with faculty members of the University of Toronto, Lakehead University, and University of Alberta as a result of collaboration in the planning and conduct of research supported by NSERC development grants to forestry schools. Technical forestry schools at Algonquin College, Pembroke, and Sir Sandford Fleming College, Lindsay, were assisted in their training through field tours and lectures to students in tree improvement. Research was initiated and consultative exchanges were held with industrial and provincial representatives from Quebec, Ontario, and the Prairie Provinces. We worked closely with the Ontario Christmas Tree Growers Association to demonstrate the potential for genetic improvement of Scots pine Christmas trees. Members of the Association, together with OMNR, intend to use selected clones and seed for further testing and in the creation of operational seed orchards in southern Ontario.

FACILITIES

Increasingly, emphasis is being placed on container systems for propagation of seedling stock and for grafting. Containers permit greater precision and repeatability in propagation, as well as flexibility in experiment design and distribution of units and sets of materials. The finer ranges of genetic variability now being studied call for better environmental control in time and uniformity in space than was provided by our old greenhouses dating from the 1950s. Good environmental control is also essential for optimising growth acceleration, and effective use of expensive energy is mandatory. A program of greenhouse renovation was completed successfully in which two large structures were completely reglazed with modern materials and systems to minimize air leakage and direct heat losses. Custom-designed rolling benches more than double available growing space and provide better access to growing stock.

Specifications were developed for a new Genetics Research Complex to replace existing outdated small greenhouses and draw related program components together. To be constructed in 1984, the Complex includes a computer modulated greenhouse and associated preparation rooms, cold storage vaults for the National Tree Seed Bank, laboratories, offices, and a safe records storage space. Particular provision has been made to accommodate visiting scientists.

SELECTION AND IMPROVEMENT OF EXOTICS

Petawawa has a 60-year record of introduction and testing of exotic pine, spruce, and larch both on-site and elsewhere in eastern Canada. Early provenance trials identified the sources best adapted to climate, soils, and latitude. Progeny tests demonstrated the value of individual tree selection within the better provenances. Canadian foundation populations, or regionally-adapted gene pools, are currently being assembled for Norway spruce, European, Japanese, and Siberian larches, and for Scots pine by selecting plus trees growing throughout Quebec and Ontario and creating grafted breeding populations at PNFI. In due course, seed and scions will be available to breeders for second-generation selection or for creating production-scale seed orchards.

GENETICS OF JACK PINE

Investigations have continued of the established provenance and progeny tests. The Spoor Lake pilot demonstration and testing of breeding strategies is now well established, with the first generation of seedling seed orchards, a clonal orchard, progeny test, and seed production area.

Open-pollinated families of plus trees and trees within families were selected by weighted index selection to identify individuals for second-generation breeding. At the same time, full-sib families were created by controlled-breeding among clones of plus trees identified in the progeny tests. Information to be derived from the new pedigreed families will guide applied breeding programs and more accurately quantify expected gains.

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GENECOLOGY OF BALSAM POPLAR IN NORTHWESTERN ONTARIO AND NORTHERN WISCONSIN

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Keywords: Populus balsamifera L., geographic variation, clonal test.

Fifty-clone test populations from each of four locations on a latitudinal gradient (NW Wisconsin, 45°N to Bearskin Lake, 53°N) at longitude 90°W are being studied in the Thunder Bay area. The objective is to evaluate genetic variance in growth and phenological characteristics within and among populations along the gradient. Material has been collected, and clones are being expanded in the Lakehead University nursery. Studies of dormancy relations and environmental preconditioning will begin in the winter of 1983-84, and a long-term clonal test will be established in the summer of 1984. The study is supported by NSERC grant number A0351.

FOREST GENETICS RESEARCH ACTIVITIES AT LAKEHEAD UNIVERSITY 1981-1983

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Keywords: seed orchard, isozyme analysis, height growth, flavonoids, plus-tree selection

During the past two years, the activity in forest genetics at the School of Forestry has increased with expanded graduate student enrollment and research funding. The positions of myself and Dr. Parker have been reversed so that I have a cross appointment between the School of Forestry and the Department of Biology and Dr. Parker is officially associated entirely with the School of Forestry. Dr. Parker's research activities have focused on flavonoid and morphological variation in natural stands of Abies and on experimental methods of plus-tree selection in black spruce. Dr. Farmer is presently investigating the genecology of Alnus in the boreal forest region. My own activities have focused on a comparison of isozyme characteristics between regeneration and natural stands of Pinus banksiana and Picea mariana.

ISOZYME COMPARISON OF NATURAL AND ARTIFICIALLY REGENERATED JACK PINE

Isozyme analyses of three jack pine populations have been conducted with the goal of comparing the genetic structure of plantation stock and natural populations. The effect of optimizing environmental conditions in the nursery on the subsequent genetic structure of forest tree populations remains an unaddressed question. From an evolutionary perspective, the processes of natural and artificial regeneration impose vastly different selective regimes on forest trees at the crucial developmental states of germination and seedling growth. Furthermore these two processes differ strikingly in seed origin. Natural regeneration sources derive from local populations while outplant reforestation stock generally originate from seeds collected over a widespread area. Thus, the hypothesis of differing genetic structures for the natural and artificial regeneration populations was examined using isozyme marker loci.

Three adjacent jack pine populations in site region 4W of northwestern Ontario were chosen and consisted of a 50-60 year old natural stand, a 14-year-old container stock plantation, and a 14-year-old

"volunteer" population resulting from natural regeneration within the plantation. Needles from one hundred trees sampled from each population were electrophoretically analysed. Seven polymorphic enzyme systems were resolved as follows: fluorescent esterase, two peroxidase systems, amino peptidase, phosphohexose isomerase, glycerate dehydrogenase, and malate dehydrogenase. Statistics intended to summarize the genetic organization were calculated for each of the three populations and compared. Results indicate that the three populations are homogeneous with respect to gene frequencies based on G statistic calculations. Genetic distances show the greatest disparity between the adult and the nursery grown plantation. Genetic statistics describing genotype distributions (F statistics) indicate that most of the genetic variation exists within each population with only 1% of the variation differentiating populations. Furthermore, the populations are generally characterized by a slight excess of homozygotes. It is concluded that the present techniques could not detect significant genetic differences among the jack pine populations.

HEIGHT GROWTH COMPARISON BETWEEN SELECTED AND NATURAL SEED SOURCE BLACK SPRUCE UNDER FIELD CONDITIONS

Adjacent regeneration plantations of black spruce were evaluated and compared for height growth performance. Seed origin was the major distinguishing characteristics differentiating the two populations; one derived from a black spruce clonal seed orchard (selected source), and the other derived from seeds collected from natural stand genotypes within seed zone 3W. All seeds and seedlings were treated uniformly throughout the germination, early nursery growth and outplant stages. One hundred and twenty trees from each site were systematically sampled and measured for growth increments for four years 1979 through 1982. Height increments were compared using t-tests with separate variance estimates. The results indicate that height growths of the two seed source populations are statistically homogeneous for each measured year of growth. These are not surprising findings in the context of the expected genetic improvement for height growth in black spruce. However, a consistent trend was elucidated from a qualitative comparison of the percentage of overall growth. When compared to the overall mean growth of all sampled seedlings the improved seed source trees consistently increased in height growth with the concomitent consistent decrease in height growth of the natural seed source trees. Assessment of growth increment over the next few years is planned to ascertain if the trend will continue.

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GENETICS AND TREE IMPROVEMENT RESEARCH ALBERTA FOREST SERVICE 1981-1983

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Key words: forest genetics, tree breeding, tree seed, provenance testing, seed production, white spruce, lodgepole pine, exotic tree species.

The genetic and tree improvement program of the Alberta Forest Service has been in place since 1976. Program activities have concentrated on species testing, provenance research, seed production and related research and genetics studies. This report describes the progress of the work for the period 1981-83.

SPECIES TESTING

A larch species trial was outplanted in 1980 in central Alberta to evaluate the comparative performance of tamarack (1 seedlot), siberian (raivola) larch (1 seedlot) and western larch (7 seedlots). Results two growing seasons after planting showed that tamarack and siberian larch grow faster and are more winter hardy than western larch. Mean height of tamarack and siberian larch was 97 cm and 88 cm respectively compared to 60 cm for western larch. Winter damage to the terminals was noted on 53 per cent of the western larch. Tamarack and siberian larch showed 16 per cent winter damage. There was no relationship between height growth, winter damage and seed source of western larch.

A Himalayan conifer species trial using container seedlings was established in central Alberta in 1981. It contains high elevation Pinus excelsa (1 seedlot), Pinus gerandiana (1 seedlot), Picea smithiana (2 seedlots) and Abies pindrow (2 seedlots) from the Himalayas in India. The climate and topography of the area is similar to the eastern slopes of the Rocky Mountains in Alberta. Two years after outplanting, none of the species show winter hardiness in the central Alberta test environment.

A maple species trial using container seedling stock was established as a nursery trial in 1980. Evaluation of the trial showed none of the selected red maple (7 seedlots) or sugar maple (2 seedlots) were winter hardy in central Alberta.

In 1980, a study was initiated to compare the field performance of white spruce, black spruce, lodgepole pine, tamarack and white birch in pure and mixed plantings with green alder on a sandy nutrient-poor forest soil. Trial will be assessed in 1984.

A European black alder trial using container seedlings was outplanted in a field trial in central Alberta in 1982. The trial contains six seedlots originating from the U.S.S.R., Poland, Finland, Denmark and Scotland. Of the 170 seedlings outplanted, 138 survived the first winter. However, all seedlings suffered severe to complete dieback. Seventy-one per cent of the surviving seedlings produced new growth. There was no relationship between survival, degree of dieback or suckering, and seed source.

PROVENANCE RESEARCH

The white spruce provenance research program is a range-wide study involving 15 test sites. Nineteen to 23 provenances are common to all sites and 3 - 5 local seedlots are planted at each site for comparison purposes. As of spring 1983, twelve of the 15 trials have been established. Mean survival two growing seasons after planting was 96 per cent. Analysis of variance of survival data showed highly significant ($P \leq 0.01$) differences due to site location. There was no relationship between survival and seed source.

Outplanting of a Canada range-wide white spruce trial in central Alberta was completed in the spring of 1982. It consists of 45 seed sources. Survival at the end of the second growing season was 98.4 per cent. This plantation is part of a co-operative study initiated by the Petawawa National Forestry Institute.

Evaluation of a ponderosa pine seed source trial established with four year old transplant stock in 1980 showed no relationship between survival or winter hardiness and seed source. Once seedling height is above snow level, winter damage occurred. However a small group of individuals from several of the 14 seed sources outplanted are winter hardy.

Survival assessment of two Scots pine field trials consisting of 25 seed sources originating from above 50°N latitude in the U.S.S.R. was completed. The trials are located in central and northern Alberta. Mean survival was 81 per cent and 84 per cent at the central and northern test sites respectively. Height growth at the central location showed a geographical pattern. It decreased with increased latitudinal origin.

SEED PRODUCTION AND RELATED RESEARCH

A study was started in 1979 to evaluate the effect of continuous photoperiod on flowering of white spruce and lodgepole pine. The experimental stock was subject to continuous light for eight months, then were

outplanted in a field trial in 1980. Two years after outplanting, 2.3 per cent of the lodgepole pine produced 1 - 4 female strobili. Male flowers (1 - 2) were observed on 1.4 per cent. The accelerated growth white spruce and the controls produced no flowers. The third growing season after planting, 19 per cent of the accelerated growth pine produced female flowers (1 - 18). Male flower production was limited to a single pine. Again no flowering occurred on the accelerated growth spruce or controls.

A second accelerated growth trial was initiated in 1980 to evaluate the effect of 24-hour photoperiod on the greenhouse performance, subsequent field performance and flowering response of white spruce, black spruce, Engelmann spruce, tamarack, siberian larch and lodgepole pine. Mean greenhouse height after receiving the accelerated growth treatment for eight months was: white spruce, 60 cm; black spruce, 82 cm; Engelmann spruce, 56 cm; tamarack, 122 cm; siberian larch, 125 cm; and lodgepole pine, 19 cm. All species with the exception of lodgepole pine maintained continuous growth over the treatment period. Lodgepole pine set bud after every 2 - 3 weeks of active growth and stayed quiescent 2 - 4 weeks before flushing and resuming growth.

At the end of the greenhouse study the seedlings receiving the accelerated growth treatment were outplanted in a field trial. Two years after planting all tamarack seedlings produced 1 - 10 cones, but no male flowers. The other species did not flower. The trial suffered extensive browsing by deer during the winter of 1981, making growth comparisons meaningless.

A demonstration study on the comparative growth, development, flowering and seed production of rooted cuttings versus seedling propagules of selected plus-tree white spruce and lodgepole pine was initiated in 1981.

As part of the provincial tree improvement program, white spruce and lodgepole pine clone banks as well as a 3.3 hectare white spruce seedling seed orchard were established at Smoky Lake. Management of these plantations currently entails site and stock maintenance. Several studies were initiated to generate an information base on which the plantation manager can base cultural prescriptions and resolve practical problems. The studies include:

1. Monitoring of the relationship between flower phenology and local climate.

2. Monitoring of pollen contamination from indigenous white spruce and jack pine.

3. Evaluation of flower production, seed production and seed quality of clonal and seed orchard materials.

4. Effect of accelerated growth seedling rearing regime on subsequent development, flowering and seed production of clonal and

seedling material.

5. Factors affecting the harvest, storage and use of pollen.

GENETIC STUDIES

In 1978-79, 395 controlled pollinations were completed on Larix laricina and L. Siberica. Inter- and intraspecific crosses were made. Seed was collected and extracted from the crosses as well as from self-pollinations. In 1983, planting stock from 61 L. Siberica x siberica and 4 L. laricina x laricina were outplanted in transplant beds to be established in a breeding arboretum at a later date. No successful L. siberica x laricina or L. laricina x siberica crosses were made.

PLANT PROPAGATION AND SEED BANK

The plant propagation facilities of the Genetics Section, Alberta Forest Service, is responsible for the production of experimental planting stock for genetic and tree improvement research as well as co-operative projects with the forest industries. During the report period, production totalled 21,800 seedlings and 1,620 grafts.

A total of 91 seedlot entries were added to the seed bank. The number of seedlots extracted and processed was 52. These represent open-pollinated seedlots from selected trees and seed source stands as well as general collections for research and seed exchanges with other agencies.

Systematic germination testing of 1,960 experimental seedlots was completed. A long term storage facility to be held at -18°C was acquired by the Genetics Section.

A study was completed in 1983 to compare greenhouse versus field grafting. Results showed greenhouse grafting success was 95 per cent compared to 78 per cent for field grafting. Differences in grafting success are attributed to ease of grafting, more ideal post-grafting environment and better graft maintenance in the greenhouse compared to the field.

Prior to 1982, white spruce greenhouse grafting success averaged 38 per cent. At this time, scions were grafted onto rootstock that were starting to flush. Two weeks after grafting the new growth on approximately 15 per cent of the grafted rootstock would begin to wilt and, along with the scion, would die. The reasons for this have not been determined. In 1982, due to delayed scion collections, grafting took place on fully flushed, actively growing rootstock. Grafting success using actively growing rootstock in 1982-83 averaged 60 per cent. Future grafting will use actively growing rootstock only.

GENETIC IMPROVEMENT OF JACK PINE FOR THE PRAIRIE PROVINCES 1981-1983

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T6H 3S5

The genetic improvement program for jack pine (Pinus banksiana Lamb.) for Manitoba and Saskatchewan, initiated in 1967, seeks to provide genetically superior stock to cooperators for establishment of seed orchards or alternative mass-production facilities. Superior genotypes are identified by assessment of open-pollinated family tests for three breeding districts, while a clone bank provides propagation materials of selected families (Klein 1982c,d).

A highlight of the past two years was the measurement of the eastern breeding district family test at 10 years after planting. Superior families were selected based on the results and reporting is in progress. Grafting of seed-orchard trees continued for all three breeding districts, but planting of these grafts in a seed orchard has begun only for the eastern breeding district. Fewer than 100 additional grafts are needed for the clone bank and grafts to fill 900 clone-bank positions are planted in a holding area. Controlled breeding in family-test plantations will be tried as a means of producing seed-orchard trees. Selection thinning has been completed in the seedling seed orchard planted in 1972.

FAMILY-TEST MEASUREMENT

The four plantations in eastern Manitoba constituting the eastern breeding district family test were assessed at 10 years from planting. Height and diameter were measured and stem quality was rated on a scale of 1 (least crooked) to 5 (most crooked). A multiple-trait selection index was somewhat subjectively constructed and an index score computed for each progeny. Forty families were selected, based on their progenies' index scores, for seed orchard use out of 209 eastern district families in the test. Genetic gain from a seed orchard of these families was estimated at 30% for volume and 13% for stem quality. A volume gain of 15% can be realized immediately by cone collection in two defined source areas according to a plot of progeny means on source locations. A report is in preparation on the application of the results to selection.

APPLICATION OF FAMILY-TEST RESULTS

Grafting of seed-orchard trees began in 1979 (Klein 1982a) and has been done each year since. In 1983 more than 2000 grafts were jointly made with cooperators for the three breeding districts. Scions were collected entirely in preliminary clone banks in 1979 and 1980, but most are now collected in the clone bank (Klein 1982d).

Grafts for Saskatchewan seed orchards and for Manitoba's central breeding district seed orchard are in holding plantations. They are grafts of families selected for superior 5-year progeny mean height. When 10-year selection is done, grafts of families still of select rank will be planted in seed orchards and the remainder will be discarded. Grafts of eastern breeding district families selected for superior 10-year volume and stem quality have been planted in a 1.3-ha seed orchard designed to hold 30 blocks of 40 families at 3-m spacing. This seed orchard is scheduled to be filled by 1985. It is expected to produce 15-25% of the annual jack pine seed requirements for southeastern Manitoba beginning about 1995.

Grafting has been used to produce seed-orchard trees in this breeding program because that has been the only method feasible to date. Controlled pollination of clone-bank grafts or family-test trees of selected families offers the possibility of producing trees of equivalent genetic quality at lower cost. Jack pine seed-orchard trees grown from seed are likely to produce larger seed crops at a younger age than grafts while circumventing the risks and tending problems associated with grafts of this species. Controlled breeding can not yet be done in the clone bank, but nearly all of the larger trees in the three eastern breeding district family-test plantations inspected in March 1983 had cones and pollen-bearing buds. In the spring of 1984 we will attempt to carry out controlled pollination using superior progeny trees of the selected families.

PROGRESS ON CLONE BANK COMPLETION

The clone bank for the jack pine breeding program will contain 3185 grafts of 637 families when it is filled (Klein 1982d). It now contains about 2200 grafts. More than 900 of the 1000 unstocked planting positions will be filled over the next few years by grafts that are now being tended in a holding plantation under plastic mulch at the Northern Forest Research Centre (NoFRC). Soil conditions are far from ideal in this plantation, but neither the clone bank nor the grafting pot has proved to be a satisfactory habitat for promoting early growth of grafts.

Clone bank grafting in 1982 reduced the number of missing grafts from 485 to 102. Most of this gain was from grafting selected progeny trees of 63 western and central breeding district families lacking a parent clone. The success rate of 96% was considerably higher than for the 118 eastern breeding district families requiring progeny grafts, though the reason for the difference is not known. A success rate of

about 90% was achieved with a number of clones that had previously yielded little or no success by cutting scion-bearing branches at second- or third-year wood in February and grafting in early March. Bottle grafting was of no value for difficult clones.

Grafts made during the winter of 1982 grew poorly, with needles less than 1 cm in length at the end of the growing season, despite supplementary illumination from cool-white fluorescent tubes and generally intensive tending. Better growth was obtained on grafts made in November 1982 and incubated under a combination of fluorescent and incandescent lighting. This finding may have had a small part in the decision to install high-pressure sodium lamps in place of the fluorescent fixtures in the NoFRC greenhouses.

Clone bank grafting was only moderately successful in 1983, perhaps because scion collection and grafting could not be done before April.

SEEDLING SEED ORCHARD

This seed orchard was planted in 1972 with plots containing one seedling of each of 20 open-pollinated progenies from one source area at 0.6-m spacing, and 24 blocks containing one plot from each of 11 source areas in southeastern Manitoba (Klein 1974). The plantation was thinned by phenotypic selection for superior height and stem quality among trees on the same plot to five trees per plot in 1977 and to one tree per plot in 1981. Mean height of the remaining trees was 552 cm and the total increase in mean height from the two thinnings was 67 cm. In 1983, 58 trees were culled, leaving 208 trees at somewhat irregular spacing on 0.3 ha. There was no cone count in 1983.

The original plan was to manage the seed orchard as the final thinning left it, but we now plan to transplant these 6-8 m trees to a square layout at 5-m spacing. Each of the 208 trees has been assigned a position in the new layout. A report on this seed orchard is in preparation.

PROVENANCE EXPERIMENTS

The range-wide jack pine provenance experiment plantation in southeastern Manitoba was measured at 10 years from planting. Analysis of the data is in progress. An establishment report was completed on the black spruce (*Picea mariana* (Mill.) B. & P.) geographic variation plantations in Alberta, Saskatchewan, and Manitoba.

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JACK PINE AND WHITE SPRUCE TREE IMPROVEMENT PRINCE ALBERT PULPWOOD

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Keywords: jack pine, clonal orchard, progeny trials, wood specific gravity, white spruce, seed production areas

Since the direction of the tree improvement program was outlined in the previous report (Roddy 1981), the program has been expanded in the last 2 years to include white spruce as well as jack pine. The individual programs for each of these species are dealt with in this report. A jack pine wood specific gravity study which was completed in 1983 is also briefly summarized.

JACK PINE

Seed Orchard

Grafting to fill in 8 hectares of a seed orchard based on 32 intensively selected clones continues. Field grafting success was 85% in both 1982 and 1983. Inarching was tried in 1983 on difficult to graft clones with 82% success to date. Soft tissue grafting (on the current years growth) was also tried, in order to extend the grafting season, with approximately 59% success.

Greenhouse grafting for outplanting purposes met with 88% success in 1982 and 94% success in 1983. The 1983 grafts were done in early April, had excellent growth, and were outplanted in June.

Cone production has started in the oldest section of the orchard, but pollen production is limiting. Therefore that part of the orchard was hand pollinated this year with pollen from two phenotypically good trees in natural stands. The first seed crop will be harvested in the fall of 1984.

Selection and Progeny Testing

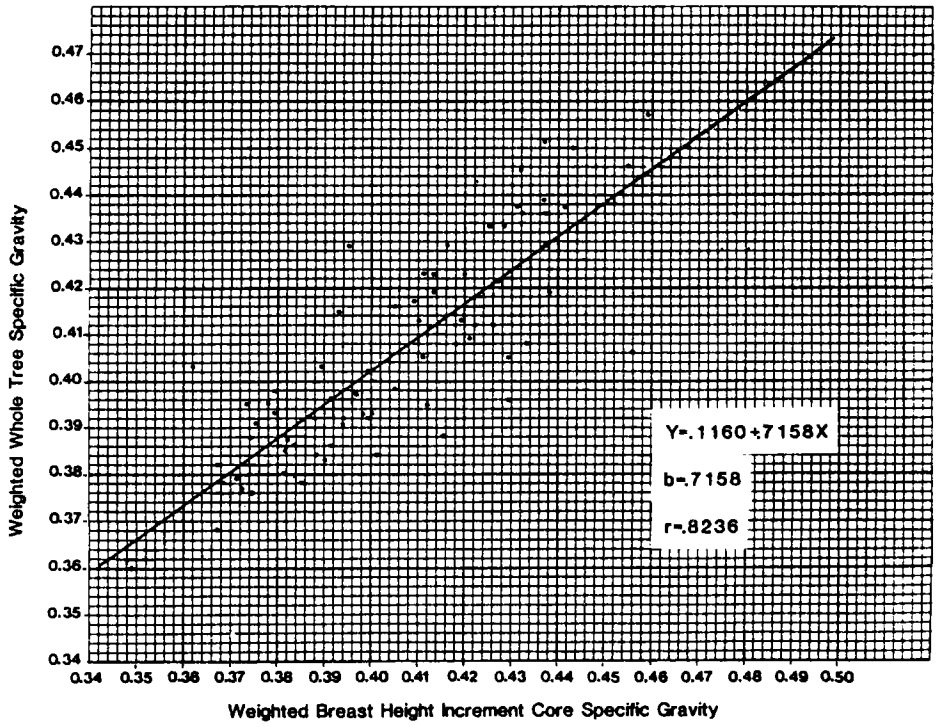
The selection of 200 dominant trees with the desired traits will be completed by October, 1983. The progeny from these trees will all be established in replicated trials on several sites by 1985, and a second seed orchard established on the basis of the trial results.

Wood Specific Gravity Study

An increase in fibre yields and wood quality of improved stock is aimed at in the tree improvement program through increases in wood density or specific gravity. A wood specific gravity study was therefore carried out on selected trees and will help define the role each tree will play in the program. The results of the study (Roddy 1983) are briefly summarized below.

Whole tree specific gravity values[2] ranged from .360 to .467 with an average of .405. There is a strong correlation between the specific gravity of a breast height core of wood and the specific gravity of the entire tree, as shown by Figure 1. Therefore, breast height wood cores can be used to estimate whole tree specific gravity values from the regression line in Figure 1.

FIGURE 1 RELATIONSHIP OF CORE SPECIFIC GRAVITY TO WEIGHTED WHOLE TREE SPECIFIC GRAVITY FOR JACK PINE TREES

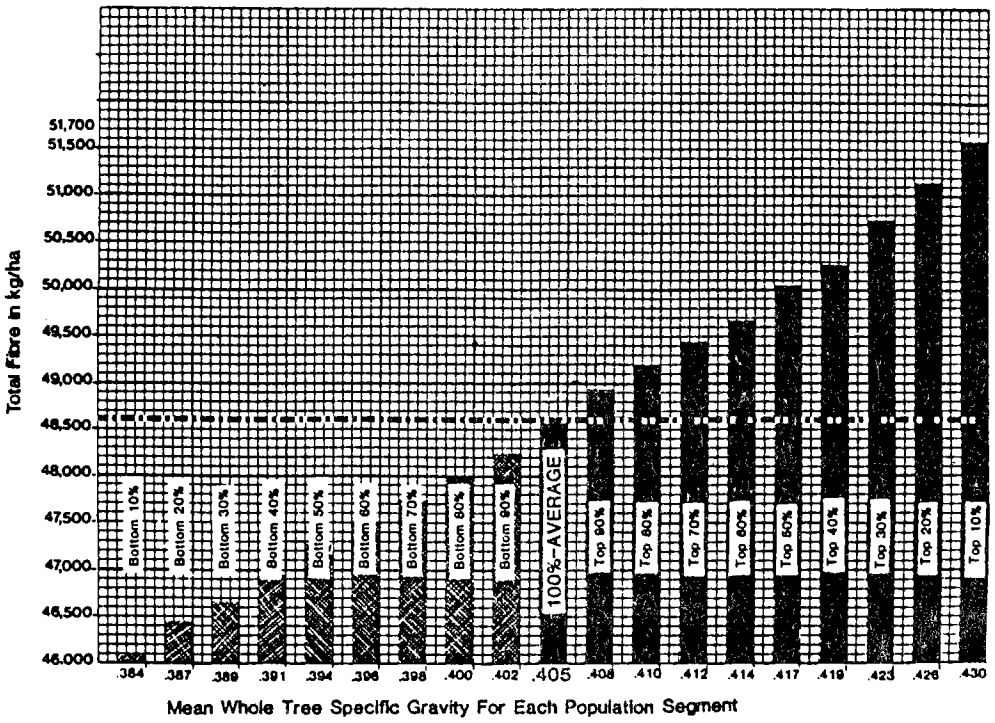


[2] Specific gravity is the ovendry weight of wood in grams, per cubic centimeter of green volume, (g/cm^3).

Juvenile wood (arbitrarily classed as the first 10 rings from the pith) is considerably lighter than the remaining mature wood (an average specific gravity of .039 lighter), thus yielding less fibre per volume of wood.

The selection effect of specific gravity to total fibre weight for different segments of the population of sampled trees is shown in Figure 2. On the basis of the gains shown in Figure 2 and the data collected on the range of jack pine specific gravities, a lower specific gravity limit can be placed on all select trees included in the program.

FIGURE 2 THE SELECTION EFFECT OF SPECIFIC GRAVITY TO TOTAL FIBER WEIGHT FOR EACH POPULATION SEGMENT OF SAMPLED JACK PINE TREES



WHITE SPRUCE

Selection

Five intensively selected super trees were found in 1982-83, and 35 more will be chosen in 1983-84. Selection is made using both check tree and individual tree methods, depending upon the individual stand conditions. Selection criteria include above average volume, absence of insects or diseases, straightness, pruning, and crown form. The specific gravity of a core of wood taken at breast height will also be measured.

Seed Orchard

Eight hectares of rootstock are established and 5 super trees have been grafted with 74% success to date. Thirty-five more super trees will be grafted in 1984, to make an orchard based on 40 clones.

Management of both the jack pine and white spruce seed orchards is an ongoing process which includes grass cutting, weed control (through hoeing and the use of Roundup herbicide), pest control, and soil amelioration. A systematic insecticide (Cygon) was used for the first time in 1983 in order to control defoliating and mining insects. Success was limited however as it was not applied early in the season nor in successive applications. Sulpher has been incorporated into the soil around each tree and sulphate fertilizers applied, in order to lower the soil PH to the optimum level, (5-5.5) for conifer growth.

Seed Production Areas

Five white spruce seed production areas have been located. These will be thinned as soon as possible, and harvested as seed production and seed needs dictate. This will give an interm seed supply until the spruce orchard begins seed production.

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FOREST GENETICS ACTIVITIES AT THE UNIVERSITY OF ALBERTA 1981-1983

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Keywords: Isozymes, electrophoresis, population genetics, differentiation, mating systems, heterozygosity, wood quality, progeny tests, molecular genetics.

Activities have involved graduate students and associates and have focussed on population genetics utilizing starch-gel electrophoresis as the principle research technique. Other studies include wood property variation, early evaluation of progeny performance, quantitative inheritance and molecular genetics.

MATING SYSTEMS OF CONIFERS

Dr. William M. Cheliak completed his Ph:D. study of the mating system of jack pine (Pinus banksiana Lamb.) in a stand near Bruderheim, Alberta (Cheliak 1983 a, b). Three crown strata and four independent fertilization years were studied using open-pollinated seeds from cones harvested in 1980 from thirty trees. Analyses of observed segregation ratios of four of five polymorphic isozyme loci showed good correspondence to the 1:1 ratios expected under simple Mendelian control; allozymes of glucose-6-phosphate dehydrogenase did not segregate in the expected 1:1 ratio. Heterogeneity could be the result of pollen pool heterogeneity, segregation distortion and/or primitive lethal gene combinations resulting in early embryo abortion. The mixed mating system model with a finite number of effective males accurately described the mating system of jack pine. The average outcrossing rate was estimated to be 88±.047%. However, there were significant differences in the mating system among three of the four years; there was an apparent linear decline of the effective selfing rate with age of the seed. Real changes in the mating system as well as higher mortality of selfed embryos over time could account for these observations. No differences could be demonstrated among the three crown strata of this stand. There was evidence of some additional inbreeding due to family structures in the stand; however, this was a minor component of total inbreeding. These results have implications in applied breeding programs for estimation of genetic parameters and inference of genetic differences from open-pollinated progeny arrays. One paper from this study has been published (Cheliak et al. 1983) and several others are in preparation.

Mr. John N. King completed a study of the mating system of 37 white spruce (Picea glauca [Moench] Voss) from a seed production area near Mitsue Lake, Alberta. The initial part of the work consisted of a study of inheritance and linkage of the isozymes (King and Dancik 1983). Seed was collected for two seed years. Analysis of four polymorphic and unambiguous enzyme loci (GDH, IDH, PGM, and PGI) indicated that there were no significant shifts in genetic structure among the parental population and the two progeny years. A mixed mating system model with a low level (<10%) of selfing best explains the mating system of the stand.

Mr. Albert Sproule is beginning a study of the mating system of black spruce (Picea mariana [Mill.] B.S.P.) for his Ph.D. thesis. He will be investigating spatial and temporal variation of the mating system in three stands in central Alberta.

The mating system studies have been funded by NSERC, the CFS, and the Alberta Forest Service.

ALLOZYME HETEROZYGOSITY AND ENVIRONMENTAL VARIATION

Dr. D.R. Govindaraju has been working on the response of genetic variation in jack pine. His work includes: (a) The relationship between allozyme variation and environmental variation; (b) The relationship between allozyme heterozygosity and environmental variation; and (c) intergenotypic interactions in mixtures. Data were collected on several quantitative characters from a number of genetically variable families. Preliminary results indicate that environment plays an important role not only in determining the relationship between biochemical variation and quantitative characters but also in the degree of expression of these characters. Further studies and statistical analyses are underway in order to understand the differential response of families to various environmental conditions.

Dr. Govindaraju has been supported by a Special NSERC Postdoctoral Fellowship in Forestry and by the new NSERC Forestry Development Grant (see below).

QUANTITATIVE INHERITANCE

Two studies of quantitative inheritance of growth and wood characters have been initiated. Mr. John King is investigating several traits of full-sib families of Douglas-fir (Pseudotsuga menziesii Dougl.) at Cowichan Lake, B.C., for his Ph.D. thesis. Mr. Alvin Yanchuk is investigating several properties of families of lodgepole pine (Pinus contorta Dougl. var. latifolia Engelm.) at Red Rock, B.C., for his Ph.D. thesis. Both Mr. King and Mr. Yanchuk are co-supervised by Dr. Francis C. Yeh, B.C. Ministry of Forests and Associate Academic staff member at the University of Alberta. This work has been supported by a CFS Research Agreement, NSERC, and the B.C. Ministry of Forests. Chris Heaman and Keith Illingworth have provided valuable advice and support.

WOOD DENSITY AND FIBRE LENGTH OF ASPEN

Mr. Alvin D. Yanchuk completed an M.Sc. study of intra- and inter-clonal variation of wood density and fibre length of trembling aspen (Populus tremuloides Michx.) in one stand in north-central Alberta (Yanchuk 1982).

Four trees from each of three putative clones were sampled to determine the patterns of wood density variation within stems and within clones. Sample disks were removed at five heights from each tree to examine variation among cardinal directions and across the southern radius at each height. Although only three clones were sampled, there were significant differences among clones. Wood density tends to be high at the bottom of the tree, decreases to a minimum at midheight, then increases again near the top of the tree. In the radial direction, wood density is high near the pith, decreases, then increases again in the mature wood zone (after rings 15-20+). Average wood density values within the twelve stems varied from 0.348 to 0.402 g/cc (Yanchuk et al., 1983a).

Fifteen putative trembling aspen clones were sampled to examine patterns of variation and determine the heritability of wood density and fibre length among clones. Large increment cores from the southern radius at breast height of each of five to nine trees in each clone were divided into four-year sections from the pith outward. All trees sampled were at least 36 years of age. Wood density measurements were made on each four-year section, and fibre lengths were measured on every second four-year increment period. There were significant clonal differences for both wood density and fibre length. Broad-sense heritabilities for wood density and fibre length were 0.35 and 0.43, respectively. Wood density is generally high near the pith, decreases substantially a short distance from the pith, then increases in the mature wood zone. Fibre length is short near the pith and increases markedly across the radius. There was a slight negative phenotypic correlation between wood density and growth rate and a slight positive phenotypic correlation between fibre length and growth rate. Genetic correlations indicated these relationships are under moderate genetic control (Yanchuk et al., 1983b).

This study was supported by the CFS Research Agreement with the Department and NSERC support to Dr. M. Micko of the Department of Agricultural Engineering.

EARLY EVALUATION OF PROGENY PERFORMANCE

Ms. Dianne Williams has begun a study of early juvenile performance of black spruce families grown under optimum conditions. She is attempting to relate such early performance to later performance of the same families in plantations. Materials for the study were provided by the Petawawa National Forestry Institute. The study is being conducted in cooperation with Dr. R.P. Pharis of the University of Calgary.

COOPERATIVE GENETIC STUDIES WITH AFS

The University has entered into a cooperative agreement with the Alberta Forest Service (AFS) for studies of mutual benefit. Under the agreement, the AFS provides half of the salary of a new Assistant Professor, Dr. L. Zack Florence, and funds for student and laboratory support. Work scheduled under the agreement includes genotyping of clone bank materials, assistance in establishment of progeny tests and design of provenance tests, statistical analysis of family tests, and data processing. Of prime importance has been the closer working relationship of the two organizations and the opportunities for students to be involved in practical programs.

NSERC FORESTRY DEVELOPMENT GRANT

The first of the new Forestry Development Grants from NSERC, funding a project on genetic variation and adaptation among populations of lodgepole pine, started 1 January 1983. The grant provides partial support for L. Zack Florence's position, a technologist in the isozyme laboratory, field collections, supplies, and travel. Cooperators include K. Morgan, C. Strobeck, and F.E. Nargang (Dept. of Genetics), N.K. Dhir (AFS), J.I. Klein and W.M. Cheliak (CFS), R.P. Pharis (U. Calgary), F.C. Yeh, K.O. Higginbotham and A.K. Hellum (Forest Science), M.M. Micko (Agricultural Engineering) and G.E. Ball (Entomology). As part of the studies of Dancik and Florence on population structure, microhabitat differentiation, and the mating system of lodgepole pine, the project supports the work of graduate students Greg Lee (population structure and differentiation), Dan Perry (mating system), and Joyce Kenny, who with Zack Florence is working on characterizing the actin gene(s) by cloning and restriction enzyme analysis.

NEW PERSONNEL

Mary Aleksiuk, M.Sc., and Elaine Moase, M.Sc., joined us as technologists in the isozyme laboratory in 1982. Alexis MacGregor replaced Elaine in 1983.

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PROGRESS IN HORMONAL CONE INDUCTION IN PINACEAE CONIFERS

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Keywords: Pinaceae, Pinus radiata, Pinus taeda, Pseudotsuga menziesii, flowering, gibberellins A4/7

This report has two objectives: (1) to provide an updated listing of the world-wide literature documentating the successful use of gibberellins (GAs) to promote flowering in conifers of the Pinaceae family; and (2) to describe some of our research during 1981-82 which was aimed at improving GA formulations and application techniques.

UPDATED BIBLIOGRAPHY

Tables were published in 1977 (32) which gave some examples of the positive flowering effects of the $GA_{4/7}$ mixture on Pinaceae family conifers. This information was updated in Pharis et al. (34), and more recently in Ross et al. (50). A more recent version is shown below:

Species of Pinaceae Family Conifers Shown to Flower in Response to Application of a Mixture of the Plant Hormones, Gibberellin $A_{4/7}$.

Species	References
Larix leptolepsis	2
L. decidua	2
Picea abies	6,8,9,23,26,31
P. glauca	cited in 31,32
P. sitchensis	37,38,53,54,55,56,57,58
Pinus banksiana	4
P. contorta	31,35,36,59
P. densiflora	16*,19,20,21,22
P. elliottii	14, cited in 32
P. palustris	15
P. radiata	51,52
P. sylvestris	5,7,8,24,25,26,27
P. taeda	10,11,12,13,14,21,22,35,47
P. thunbergii	16+,19,20
Pseudotsuga menziesii	1,28,29,30,31,32,33,34,35,42,43, 44,45,46,49
Tsuga heterophylla	3,17,39,40,41,48

* Not only did GA_7 (probably $GA_{4/7}$ mixture) tend to promote female flowering at high concentrations (500 ppm), GA_3 also tended to promote flowering.

\+ GA_7 (probably $GA_{4/7}$ mixture) tended to promote male flowering at high concentrations (500 ppm).

It is apparent from the 57 references noted in the Table that the promotion of early and/or enhanced flowering in Pinaceae family conifers by the hormone mixture, gibberellin $A_{4/7}$, is indeed a reality. Sixteen families, in 5 genera of Pinaceae have responded positively. However, when seedlings are very young, and/or when environmental conditions are unfavourable for flowering (e.g. wet, cool, cloudy weather with low solar insolation during the period of cone bud differentiation/initiation), then cultural treatments (e.g. non-destructive girdling, nitrate fertilization, modest water stress, root-pruning, high temperature, pot-culture) may be required, and many of the publications cited in the Table detail these cultural treatments. In fact, these cultural treatments are usually highly synergistic with $GA_{4/7}$, even when environmental conditions are quite favourable for flowering.

GA DERIVATIVES AND SYNERGISTS

Although $GA_{4/7}$ is being widely used to promote early and enhanced flowering in many Pinaceae family conifers, the relative activity each of GA_4 and GA_7, and of other contaminating GAs in the fungal-produced mixture, has never been determined. Studies (unpublished results, R. Pharis, M. Greenwood, R. Hand, R. Griffin, S. Ross) during 1981-82 on Pseudotsuga menziesii (Mirb.) Franco, Pinus taeda L. and P. radiata D. Don, have shown that while GA_7 is the most active component, it interacts synergistically with GA_4 in mixture. However, for Pseudotsuga menziesii, GA_4 and GA_7 in widely different ratios (as found between batches of $GA_{4/7}$ mixture) were equally active; as well, the flowering response was independent of the absence or presence of other contaminating GAs, including up to 30% of added GA_9.

Usually GAs are applied in their free acid form; however, in angiosperms certain derivatives (most especially C-2,2-dimethyl gibberellin A_4) have proved to be far more (10 to 100x) active than the parent GA (GA_4) (18). This GA_4 derivative was tested on P. radiata, P. taeda, and Pseudotsuga menziesii (R. Pharis, S. Ross, F. Hand, R. Griffin, M. Greenwood, J. MacMillan, J. Turner, L. Mander, unpublished), relative to GA_4, and the $GA_{4/7}$ mixture. Unfortunately, the C-2 dimethyl GA_4 had no more activity in flowering than GA_4 per se, the activity of which was relatively low relative to the $GA_{4/7}$ mixture. This at least confirms the conclusion that GA_7 is the most active component of the $GA_{4/7}$ mixture. However, based on vegetative growth responses (in Douglas fir), there is evidence that the GA_4 derivative is more active than GA_4 per se (Ross and Pharis, unpublished).

GA FORMULATIONS AND APPLICATION TECHNIQUES

Although the cost of $GA_{4/7}$ mixture is decreasing in real dollars as both demand and production increase, it is still relatively expensive (It is currently available from Imperial Chemical Industries Ltd., Plant Protection Division, Fernhurst, Haslemere, Surrey, U.K. GU27 3JE for commercial use at ca. U.S. $10.50 per gram in kilogram quantities; available from R.P. Pharis, through an arrangement with ICI for research use at ca. U.S. $9.00 + Can. duty, per gram in orders of 2-100 grams). Stem-injection techniques are highly effective and very conserving of GAs, but not practical for treatment of large seed-orchard trees. And, although convenient, foliar-spray techniques in current use are wasteful of GAs, they are also generally less effective than stem injections for most conifers (Tsuga heterophylla is an exception).

The waxy cuticle layer of needles and new shoots is an effective barrier to absorption of chemicals in aqueous solutions, as GAs are

presently applied. Cationic surfactants, such as Aromox-C12W (Armak Chemicals, Ltd., Toronto) at 0.1% active ingredient (v/v), can be used to improve GA uptake to a certain extent. Special paraffinic spray oils are now being widely used with crop plants, not only to facilitate the foliar absorption of chemicals, but also to minimize their loss through evaporation. Tests of several proprietary and potential spray oils, however, showed most to be highly phytotoxic to seedlings of several conifers at concentrations in water (20%) that are perfectly safe on many angiosperms (Ross, unpublished report, File E.P. 935.02). But one, Sunspray 7E (Sun Oil Co., Marcus Hook, PA, U.S.A.) caused little injury at 5% in water, and Sunspray 6E, which the manufacturer recommends for more sensitive plants, is presently being evaluated at a lower concentration of 2%.

Conventional mist-spraying equipment also is a very inefficient way of applying expensive chemicals such as $GA_{4/7}$. Testing of new ultra-low-volume (ULV) spray equipment has unfortunately been hampered by the spray oils used being phytotoxic. However, in pesticide applications ULV sprays have been found to give usually better biological control at a fraction of the chemical required with mist sprayers. The latter produce a wide range of droplet sizes (6-700), the smaller of which (< 30) drift and rapidly evaporate, while the larger (> 20) are lost to gravity or result in overkill. With ULV sprayers, droplet size is controlled within a narrow range (60-100) to minimize these losses. And, as a result of the greater surface:volume ratio of the smaller mean droplet size, foliar absorption of the applied chemical is also greatly improved.

Another advantage of the smaller droplets is that they remain suspended in air stream, being carried out in eddy currents created within the crown to provide better target coverage.

Results of tests on new surfactants/carriers/ULV application techniques should be known within 6 months.

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A BREEDING PROGRAM IN COASTAL DOUGALS-FIR (P. MENZIESII MIRB. (FRANCO)) 1981-1983

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Keywords: Douglas-fir, recurrent selection, progeny testing, disconnected diallels.

Tree improvement work in coastal Douglas-fir has been proceeding since its initiation by Dr. Alan Orr-Ewing in 1957. Early emphasis was placed on phenotypic selection and seed orchard establishment. Emphasis is now being placed on a breeding program where full-sib progenies from the original, wild-stand, selections are being established in field trials. Selections will be made in these plantations for second generation orchards and continued breeding while information is being generated to guide future breeding efforts.

A detailed outline of the extensive progeny testing and second generation selection program in coastal Douglas-fir was given previously (CTIA Proceedings Pt. 1, 1981). Progenies produced through a disconnected, modified diallel mating design with 6 parent groupings amongst the selected plus trees, are being planted at lower and middle elevations in the south coastal region. As these plantations become established, information is being generated on genetic parameters, parental breeding values, for index selection for future seed production and for breeding populations . Because the plantings are widely distributed, genotype - environment interactions for these crosses can be studied and guidance provided for the use of genetically improved seed for reforestation.

The crossing program was started in 1973 and, since 1975, seven series of crosses have been planted on a total of 77 sites. This amounts to over two hundred hectares of plantation and involves over 200,000 pedigreed seedlings. The objectives called for the inclusion of about 350 parents. Of these, 312 are already represented on the sites and a further 60 parents were included in pollinations in 1982 and 1983. Progenies from these should be available for sowing by 1984.

As can be seen from the brief outline, the program is still in the establishment phase and most of the work since the last progress report has been devoted to planting and maintenance of this widespread series of tests. The stock is planted as 1-0 "styro 8 plugs" and, therefore, in the higher site areas, weeding is essential in the early years. Browsing by deer and grouse continues to cause serious problems

affecting survival and, particularly, increasing within-family variation. It is also seriously delaying the return of useful performance information. Open-ended milk cartons are used to offer some protection to the developing leaders where heavy browsing is anticipated, but this measure can only provide limited protection during the first years after planting. Elk are now starting to damage some plantations as well.

After the 1982 growing season, all eleven sites of the first series were measured for total height and increment. Sixty parent trees were included in the series and, while analysis of the data is still proceeding, some interesting patterns are evident at this early stage, seven years after field planting. At this age, stability of ranking of parental general effects for many of the 60 entries across many or all of the sites is encouraging, although it must be stressed that with plantation means varying between 200 and 360 cm it may well be too early to draw long-term conclusions. Survival in general has been very good and, at present, adaptability can largely only be examined as an intergral part of growth performance. Widespread frost damage has occurred on a single site of the second series and is being examined in detail. At this stage there are still indications that within-population variation at the family level is very high and that this may override the population trends appearing in the Douglas-fir provenance study reported elsewhere by Ying. However, crosses made between coastal Washington parents and local plus trees are performing well in the early years, which supports the general inference of the population study.

By using root pruning and gibberellic acid treatments, younger ramets from proven provenances were brought into production at the Cowichan Lake Reseach Station in 1983 and, with some effective girdling treatments bringing in selected older ramets, the 1983 crossing program ensured that the existing breeding population has been reasonably well sampled, although expanded sampling amongst U.S. and Johnstone Straits' populations is planned.

The U.S. sources at present in the clonal collection largely came from selections of the Industrial Forestry Association, contributed by Dr. Jack Duffield and Joe Wheat in 1963, together with material from the U.S. Forest Service orchard at Dennie Ahl. Additional U.S. sources are available at the Station in the provenances assembled by Dr. Alan Orr-Ewing, which are just starting to produce reproductive buds, but the promise shown in the studies to date suggest more U.S. material would be worth including. Through cooperation with individuals and the forest industry in Washington and Oregon, attempts are being made to expand the collection. Open-pollinated seed and scions from selected genotypes are being provided by the cooperators. The clones will be held in the breeding collection while open-pollinated progeny tests will be planted. This will enable a future breeder to maintain an option to include in the long term program U.S. clones which have experienced some testing under British Columbia conditions.

Progress in a program of this size is bound to be slow but accumulation of information on which to base decisions, and of pedigreed plant material is continuing.

In an earlier research study (E.P. 707), where 22 plus tree parents were brought together in a factorial mating design, each being crossed with the same four pollen "testers", measures of height and diameter were taken in 1982 (10 years from seed). The analyses indicate that the general findings have not changed appreciably since the 1977 assessment (Yeh and Heaman 1982). On the two test sites used for the study at Cowichan and Victoria, genotype by environment interactions were not important and the components for general combining ability far outweighed those for specific effects. The latest data were presented at the Western Forest Genetic Association meeting in 1982 at Corvallis.

Essentially this project is a pilot study, being three years in advance of the main breeding effort, and it also provides useful research material. Concurrently it is providing the material basis of a Ph.D. project for John King, University of Alberta. Detailed study of a wide variety of traits is being undertaken which will provide a basis on which to build the index selection approach in the major breeding program.

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TREE BREEDING AND ASSOCIATED RESEARCH BRITISH COLUMBIA MINISTRY OF FORESTS 1981-1983

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Keywords: Tree improvment cooperatives, tree breeding, provenance, propagation, seed orchards.

Changes in personnel and program highlights during the past two years are reported for the British Columbia Ministry of Forests' Tree Improvement Section, prefacing more detailed reports by scientists involved in this and the associated seed orchard program.

PERSONNEL

Staff changes in the Tree Improvement Section of this Research Branch reflect needs and opportunities presented by the rapidly-developing cooperative programs of the Coast and Interior Tree Improvement Councils (Illingworth 1981). The inception of a program for the genetic improvement of Douglas-fir east of the Coast Range was advanced to 1982, permitting advantage to be taken of a good cone crop in the central interior. To prepare a breeding strategy at rather short notice, and to drive the project, necessitated the transfer of Barry Jaquish from his previous duties in interior spruce progeny testing - another large and new development in the spruce program which is now being implemented by Gyula Kiss.

In February, 1983, Michael Carlson, having completed his doctoral work at the University of California, joined the section as forest geneticist at Kalamalka Research Station and Seed Orchard where he will study and breed lodgepole pine. His arrival at last permits the full-time assignment of Dr. Cheng Ying to the direction of a large program of provenance research and, in particular, to commitments leading to the early revision of seed transfer rules and, where appropriate, to the redefinition of seed orchard zones for the major conifers.

As part of a staff reorganization at Cowichan Lake Research Station, Anne Wood (Univ. Guelph) was appointed as horticulturist to study cultural problems associated with propagation and clone banks, and Jack Woods (Univ. Montana) was appointed Gene Archive Officer to plan, develop and manage archives of genetic material for purposes of breeding, research and gene conservation.

The accumulation in test plantations, gene archives, breeding arboreta and seed orchards of a substantial inventory of pedigreed or source-authenticated materials is providing increasing opportunities for research by students and scientists in other disciplines and agencies. During the past two years, research has embraced chemotaxonomy, reproductive morphology and physiology, growth phenology, entomology, pathology and wood science, as well as forest tree and population genetics. Doctoral candidates include J. King, A. Yanchuk, W. Cheliak (Univ. Alberta), C. O'Reilly (Univ. Victoria) and S.E.T. John (N.C. State Univ.). Scientists visiting Dr. F. Yeh's population genetics laboratory, for study periods of two or more months, include Dr. Arno Brune (Univ. Vicosa, Brazil) and Dr. Martha Davis (Univ. Michigan, Flint, Mich.).

PROGRAMS

Cooperative programs in tree breeding, seed orchards and in research associated with these activities have been established for coastal Douglas-fir, western hemlock, lodgepole pine, interior spruces and, commencing with parental selections in spring, 1982, for interior Douglas-fir. To meet goals recently established by the Coast and the Interior Tree Improvement Councils, all programs were reviewed during the past two years and, where appropriate, breeding objectives and strategies for achieving them were adjusted. In particular, following cost-benefit evaluation of some seed orchard options, emphasis has been shifted away from the establishment of more untested clonal seed orchards and towards the early establishment of progeny tests and the preservation of cloned parental selections in gene archives, breeding arboreta and holding areas (for eventual transfer of 50 percent of the clones to seed orchards, as indicated by early progeny test data). This approach has proved very effective with the interior spruce breeding program, which is now producing tested clones for the establishment of 1.5 generation orchards to supply seven seed orchard zones with genetically-improved seed.

Other highlights from individual programs are:

PROVENANCE

- Fifteen year assessments were made on replicated interior spruce provenance tests in the Central Interior. Analyses indicate that, while site had an overwhelming effect on survival and height growth, provenances performed consistently over a wide range of sites, and several low elevation provenances from the Shuswap - North Thompson area were markedly superior in height growth to local populations. Coupled with ten year data from progeny trials, these results promise considerable savings from a relaxation of seed transfer rules and for the enlargement of breeding zones for this species.

- Several fast-growing, well-adapted coastal Douglas-fir provenances have been identified from 15 year-old test plantations facilitating the enrichment of the Douglas-fir breeding population through the

introduction of seed and scions from 150 parental selections in coastal Washington and Oregon.

- Ten year old Sitka spruce provenances from the Oregon coast seem well-adapted and are forty to fifty percent taller than local populations when tested on Vancouver Island and the Queen Charlotte Islands. Seed and scion introductions have been made for seed orchards and pilot plantations.

- A range-wide provenance study of noble fir was established at twelve mid- to high-elevation coastal sites.

BREEDING PROGRAMS

- The first series of controlled matings for coastal Douglas-fir is almost complete, being held up only by lack of flowers on the remaining unmated clones. Flower induction techniques permitted another 150 matings in 1982 and 1983. There are now 372 parents in the program. Seven year field data from the first series of 177 crosses, planted at 11 sites, were recently collected.

- Ten year data on growth, survival, flowering and health of 780 wind-pollinated lodgepole pine families at Red Rock are being analysed. The results will guide the development of the lodgepole pine program which is currently being reviewed by Mike Carlson.

- Successful induction of flowering on container-grown ramets of western hemlock by Steve Ross has been incorporated into the hemlock breeding program. The first trial matings using this technique comprised 11 clones and 13 pollen lots.

- A contract to Forintek Canada Corp. provides for the development and testing of procedures for the rapid evaluation of specific gravity in young Douglas-fir trees of known parentage. Data collection is complete. (Wood density is routinely estimated from sample cores of parent trees in the lodgepole pine, hemlock and interior Douglas-fir programs, the intention being to permit a low level of culling among parents, based on this trait).

RESEARCH STATIONS

As centres for training, for propagation, progeny rearing and for the preservation of genetic materials, the research stations at Cowichan Lake, Red Rock and Kalamalka (Vernon) have assumed key roles.

Since 1982, a total of 60,000 grafts of nine species have been made, and 60,000 cuttings, mostly of yellow cypress and western hemlock have been rooted. Some 85,000 ramets are being tended in holding areas, pending their shipment to orchards and clone banks. Approximately 400,000 seedlings are also being grown for rootstocks and progeny tests.

An inventory of genetic materials established in gene archives at Cowichan Lake was completed and a plan prepared to guide future work.

An additional 15 ha were prepared for clone banks at Cowichan; at Red Rock, a further 64 ha were recently cleared for clone banks and progeny tests.

Notable among training programs was a two-day workshop at Cowichan Lake on the topic of pest control and cultural treatment of propagated stock, which was attended by technical staff of agencies in the cooperative programs.

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GENETIC IMPROVEMENT OF DOUGLAS-FIR IN THE BRITISH COLUMBIA INTERIOR 1982-1983

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Keywords: Interior Douglas-fir, breeding strategy, grafting, parent tree selection, progeny testing, wood properties.

In 1982, a program for the genetic improvement program of Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) was initiated in the British Columbia Interior. Its objectives are:

1. To produce sufficient quantities of broadly adapted and genetically improved seed to meet the expected reforestation requirements for the species, and

2. To conduct associated research aimed at improving selection, breeding, and testing methods and procedures.

BREEDING STRATEGY

The program is concentrated primarily on the highly productive areas of the Interior Wet Belt and the surrounding transition zone. Within this large, ecologically diverse area, seven interim breeding zones have been delineated on the basis of biogeoclimatic information.

The breeding strategy for the species entails the selection of 150-300 parent trees from wild stands within each zone. Each selection will be evaluated in wind-pollinated (w.p.) progeny tests on a minimum of five sites per breeding zone. Grafts of each parent will be established in the Barnes Creek gene archive and in a breeding orchard at Vernon. First-phase seed orchards will be established on the basis of six-year w.p. progeny test results.

PARENT TREE SELECTIONS

In 1982, Ministry of Forests personnel and 17 member agencies of the Interior Tree Improvement Cooperative selected some 800 parent trees from the four most northerly breeding zones. Criteria for selection emphasized height and diameter growth, stem form, and

branching habit. Wind-pollinated seed was collected from 779 of the selections. Increment cores were collected from 632 of the selections for the determination of wood specific gravity by Forintek Canada Corporation.

The 1983 selection program is focused on the southern breeding zones. Two industrial cooperators, B.C. Timber and Tolko Industries, have selected 450 low-mid elevation parent trees in two breeding zones. These same cooperators will also collect w.p. seed and scion material from their respective selections.

GRAFTING

A total of 136 of the parents selected in 1982 were grafted at the Cowichan Lake Research Station (CLRS). Propagation of the remaining 1982 selections is scheduled for the spring of 1984.

PROGENY TESTING

In spring 1983, w.p. seed from 400 northern selections was sown at CLRS for progeny testing in the Cariboo Transition (CT) breeding zone.. This set of families represents all the parent trees selected within the CT breeding zone, along with a number from adjacent breeding zones. All families will be outplanted on six test sites in spring, 1984. The objectives are to:

1. screen the selected parents for GCA,
2. generate information on genotype x environment interaction,
3. provide better information for breeding zone refinement and for developing seed transfer rules, and possibly
4. to provide a population for second-generation selection.

COWICHAN LAKE RESEARCH STATION, B.C. 1981-1983

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Studies on vegetative propagation and on managment of propagules for enhancing cone and pollen production within a breeding arboretum or seed orchard have been continued. Both stem girdling and root pruning treatments have been applied successfully to Douglas-fir.

ROOT DEVELOPMENT IN DOUGLAS-FIR

At the Cowichan Lake Research Station, fifteen year old rooted cuttings and seedlings were growing in adjacent plots and a study of root development was started in spring 1981. The objective of the study is to observe differences in root form and root volume and to relate it to stem form, stability and cone production. Since the number of trees excavated in 1981 was low, some additional trees were included in 1982. Following excavating, the stems were measured, the roots were washed clean and their volume determined.

Preliminary observations indicate that some distinct differences exist in root form and root volume between the two types of trees.

A final report on this study will be prepared in the fall of 1983.

ROOT PRUNING IN DOUGLAS-FIR

Following earlier root pruning experiments in the Douglas-fir clone banks which resulted in increased cone production (Karlsson 1977), a study was established to observe the long term effects on trees which were subjected to repeated root pruning treatments. In October 1975 a plantation of full sib families, established in 1969, was root pruned for the first time using a tree spade. The trees in this experiment

have now been treated three times, with the second root pruning taking place in the fall of 1978 and the third in March of 1982. The most recent root pruning was lighter than the previous ones, since only two of the four spades of the tree spade were inserted. After the first root pruning, there were some cones on the treated trees but none on the control. The second root pruning caused a heavy cone crop on the treated trees in 1980, while the control this time had some sporadic cones. An assessment in December 1982 indicated a large number of female buds on the root pruned trees and some, but much fewer, reproductive buds on the controls. The root pruned trees, following the first two treatments, were definitely smaller and had narrower crowns than the control trees. Differences in height and crown width measured in the fall of 1981 gave the following approximate values:

	Height m	Crown diameter m
Treated	5.90	2.90
Control	7.50	3.70

Following the third root pruning, the height growth on the treated trees was further reduced in relation to the control trees. Because of the reduction in crown volume and cone producing area on the treated trees, it is possible that when in the next few years the untreated trees reach the age for natural cone production, the production on these may exceed the total past and present cone yield on the treated trees. Should this be the case root pruning to enhance cone production should only be recommended where early production requires it.

GIRDLING OF DOUGLAS-FIR TO INCREASE FLOWER PRODUCTION

Stem girdling to enhance flowering in Douglas-fir has been tried for several years in the clonebanks at Cowichan Lake Research Station. In the first trials in 1973 and 1974, 1/4" wide bark strips were removed from two offset half-circumferences of the stem. The effect of this type of girdling on the flowering was inconclusive. Therefore, in May 1975, the treatment was changed to a complete 1/8" wide girdle, and from this a significant increase in the 1976 flower production was noticed. There was also a noticeable carry-over effect to 1977. Although many trees turned chlorotic for sometime in the fall following the complete girdling, it did not seem to have any adverse effects on them since there was no mortality directly related to the treatment. In 1976, to stress the trees somewhat less, the treatment on a number of new trees was done as an incomplete girdle, with a 2.5 cm wide strip of bark being left as a bridge. This kind of treatment did not result in any more cones than on the control. Of the girdled trees from 1975, two trees were broken by heavy snow loads and it was felt that, at least temporarily, the treated trees were more susceptible to breakage. During a thinning operation in 1980, two trees were removed which had been girdled in 1975. These stems were cut on a saw to allow

GENETIC IMPROVEMENT OF WHITE AND ENGELMANN SPRUCE IN BRITISH COLUMBIA 1981-1983

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Keywords: White spruce, Engelmann spruce, provenance trials, tree improvement, progeny trials, tree breeding, clone bank, seed orchard, hybridization, albinism.

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

The following progress has been made since the last reporting period (Kiss 1981):

PROVENANCE TRIALS

Fifteen-year (17 years from seed) height and diameter measurements of 39 provenances of white and Engelmann spruce, planted on three test sites in north central British Columbia, were recently evaluated. A report was prepared (Jaquish et al. 1983) and submitted to the Ministry Task Group currently reviewing provincial rules for seed transfer and seed orchard zones.

In general, the results indicated that local seed sources are not always best. Better provenances originated from low- to mid-elevations of the transitional zones between the central interior's wet and dry belts. High elevation provenances from the southern interior generally performed poorly and were subject to higher mortality and suffered more frost damage at all sites than those from low- to mid-elevations.

PROGENY TRIALS

Ten-year (13 years from seed) height measurements were carried out for the Prince George Selection Unit progenies. Analyses of the data are currently in progress.

Working plans have been prepared for open-pollinated progeny testing of 550 new interior spruce selections. Seven test sites in three Seed Orchard Zones are presently under preparation. The prime objective of the trials is to rank the parents for general combining ability. The best clones will be used for the establishment of improved seed orchards and for further breeding. Approximately 60,000 seedlings are being raised for the project in a greenhouse at Red Rock. Plantations are scheduled for establishment in the spring of 1984.

A pilot project comparing controlled cross seedlings with open-pollinated progenies was established in 1982. Three test sites were selected to sample a cross section of B.C. (Red Rock, southwest of Prince George; Barnes Creek, northeast of Vernon; Perry Creek, northwest of Cranbrook). Four seedlings replicated five times at each test site represent each of the 25 crosses and five open-pollinated progenies.

CONTROLLED CROSSING PROGRAM

A proposal to carry out a comprehensive controlled crossing program was accepted in principle.

According to plans, four breeding units (B.U.) were created: one each for the three British Columbia selection units (Prince George, Prince Rupert, and East Kootenay) and one for material assembled from various eastern North American sources. Each B.U. (from British Columbia) contains ten previously tested trees while the remaining B.U. contains ten random trees. Thus, the total number of parents used in the experiment will be 40.

There will be two levels of crossing: within B.U.'s and among B.U.'s. The within B.U. crossing design is a half diallel with selfs and a few reciprocal crosses (five in each diallel). In addition, each tree from a given B.U. will be crossed with two trees of each of the other three breeding units. Thus, a total of 390 crosses are planned. Already about half of the crosses have been completed.

Field testing will sample major geographical zones of the province (North, Central, and South) with three test sites in each zone.

Results of the experiment will provide greater insight into the genetics of interior spruce. They will also reveal the adaptability of different crosses to various climatic zones, and will provide information for the design of a cost-effective advanced generation breeding program.

NOTE OF INTEREST

Albinism

Reference has been made to three selected trees, originating from the Prince George Selection Unit, identified as carriers of albino genes (Kiss 1981). Two of the trees, P.G. 101 and P.G. 143, are carriers of a "silver" mutant, while P.G. 102 is a carrier of a "golden" mutant. It was suggested that the mutants might be alleles of the same locus.

Subsequent crossing of P.G. 101 with P.G. 102 produced no albino seedlings indicating that the two types of albino seedlings are caused by mutations at two different loci. In order to clarify the situation, a complete diallel cross was carried out in 1983 using the three carriers as parents. Results of the experiment should be available in 1984.

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THE ACCOMPLISHMENTS OF THE SILVICULTURE BRANCH, B.C. MINISTRY OF FORESTS IN COOPERATIVE TREE IMPROVEMENT, 1981-1983

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Key Words: tree improvement cooperatives, tree selection, propagation, seed orchards.

This report highlights the recent contributions of staff within the Silviculture Branch to cooperative tree improvement in B.C. The main headings (e.g. planning and administration, parent tree selection, orchard management) reflect the prime areas of contribution. The secondary headings reflect the fact that coastal and interior cooperatives exist within the province.

Legislation enabling the development of cooperatives in B.C. and the respective roles of the Silviculture Branch, Research Branch and forest companies have been reported previously (Illingworth 1980; Konishi et al. 1980).

PLANNING AND ADMINISTRATION

Several policies and agreements which impact on cooperative seed orchard management were prepared by the Branch (with input from both government and industry specialists). These include:

1. The Seed Orchard Policy: a document which specifies methods of compensation for capital expenditures and operating costs within orchards managed by forest companies.

2. The Cone and Seed Policy: a document which, in part, defines the rules for allocating orchard seed among agencies within the cooperatives.

3. The Seed Orchard Agreement: a contract that lists the legal obligations of government and industry for cooperative orchards managed by companies.

Branch staff were also actively involved in the preparation of several comprehensive reports including:

1. An historical review of tree improvement in coastal B.C. and an in-depth description of the current cooperative program (Crown et al. 1982).

2. An economic analysis of four interior Douglas-fir tree improvement and seed orchard options (unpublished).

3. An examination of the information requirements for parent tree selection, propagation and orchard management plus an evaluation of possible options for computerization (unpublished).

In addition the Branch helped to (i) update the projected long-term planting requirements for the province and (ii) establish the terms of reference, membership, and operation of the two Technical Planning Committees in the interior cooperative.

PARENT TREE SELECTION

Coast

The Branch coordinated the coastal parent tree selection program which comprised ten companies and/or agencies. The number of trees selected in 1981 and 1982 is presented by species in Table 1. In total, 873 trees were added to the coastal register which now exceeds 4000 selections. Over one third of the trees selected in 1981/82 were western hemlock. The Branch also processed industrial cost claims for tree selection and provided an inspection service to ensure that selection standards were fulfilled.

Table 1. Summary of the number of parent trees selected in the coastal cooperative (1981-82).

Year	Species[a]								Total
	Fd	Hw	Ss	Ba	Cy	Cr	Bg	Se	
1981	86	201	78	63	41	65	6	0	540
1982	12	113	65	42	73	24	1	3	333
									873

[a]Species abbreviations are defined as follows:

Fd - Douglas-fir (Pseudostuga menziesii (Mirb.) Franco)
Hw - western hemlock (Tsuga heterophylla (Raf.) Sarg.)
Ss - Sitka spruce (Picea sitchensis (Bong.) Carr)
Ba - amabilis fir (Abies amabilis (Dougl.) Forbes)
Cy - yellow cedar (Chamaecyparis nootkatensis (D. Don) Spach)
Cr - western red cedar (Thuja plicata Donn)
Bg - grand fir (Abies grandis (Dougl.) Lindl.)
Se - Engelmann spruce (Picea engelmannii Parry)

Interior

Branch staff were active participants in the interior selection program. A total of 775 interior spruce (Picea glauca (Moench) Voss, P. engelmannii) selections were added to the interior register in 1981 and 1982. Some 300 lodgepole pine (Pinus contorta var. latifolia (Dougl.) Engelm.) and 800 interior Douglas fir were additionally selected. Over 6,000 trees have now been selected in the interior. The Branch helped to present several selection workshops for the many new cooperators in the interior program.

PROPAGATION

The Branch is responsible for two propagation centres in the province: one at Skimikin (near Salmon Arm), the other at Red Rock (near Prince George). New facilities were constructed at each centre and an expanded program of about 24,000 grafts/year is now possible. Poor propagule survival was unfortunately encountered at Skimikin in 1981 and 1982 due to a chemical imbalance in the potting mix. Grafting for 1.5 generation interior spruce commenced recently at Skimikin.

ORCHARD MANAGEMENT

Coast

Four productive Douglas-fir orchards, totalling 23.6 ha, were intensively managed by the Branch. Management practises included cone induction (through root pruning), overhead misting, supplemental mass pollination, control of cone and seed insects, thinning and fertilization. The seed harvest from these orchards totalled 17 kg in 1981 and 200 kg in 1982 (sufficient to yield in excess of 7 million plantable seedlings). Additional site preparation activities (plowing, rock removal, cover crop establishment) were undertaken for three new orchards which will total 9.9. ha.

The Branch was also responsible for monitoring the activities and for approving cost claims for orchards managed by industry. Three such orchards, totalling 8.2 ha, were productive and yielded 3 and 34 kg of seed (mostly Douglas-fir) in 1981 and 1982 respectively. An additional fifteen new industrial orchards, totalling 41.7 ha, were at various stages of development (Crown et al. 1982).

Interior

Orchard management in the interior was confined to three locations; all of which were a Branch responsibility. At Red Rock, four lodgepole pine orchards, totalling 14.8 ha, were intensively managed. The first commercial sized crop was harvested in 1982 (1.4 kg of seed which equates to about 0.6 million seedlings). Staff also continued to assist

The Research Branch in maintaining experimental plantations and preparing sites for clone banks and progeny tests on the Red Rock Forest Researve.

At Vernon and Skimikin nine young interior spruce orchards were hand and machine weeded, fertilized and irrigated. Cover crops were established and vacant positions within the orchards were filled. The installation of the trickle irrigation systems was also completed. The first commercial sized crop is expected at Skimikin this year.

No interior orchards have as yet been established by forest companies.

ORCHARD MANAGEMENT TRIALS

The Branch conducted various trials pertaining to orchard management. The following lists the main topics studied in recent years:

1. nitrogen fertilization of Douglas-fir seed orchards for cone induction.

2. supplemental mass pollination techniques.

3. the efficiency of a hydraulic sprayer versus a Hardi mist-blower for controlling cone and seed insects.

4. bulk pollen extraction procedures for Douglas-fir and lodgepole pine.

5. efficiency of seed production in Douglas-fir and lodgepole pine orchards.

6. efficacy of various pesticides and application methods for insect and weed control.

7. fertilization of young spruce orchards for vegetative growth.

8. efficiency of several lodgepole pine cone collection methods.

9. the relationship between filled seeds per halfcut and filled seeds per cone for interior spruce.

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WESTERN HEMLOCK TREE IMPROVEMENT FOR COASTAL BRITISH COLUMBIA 1981-1983

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Keywords: Tsuga heterophylla, tree selection, breeding, progeny testing.

The program began April 1, 1977, although over 300 parent ("plus") trees had been selected to that date by both government and private agencies. Also, provenance data were forthcoming from the Canadian Forestry Service's 15-population study, and family performance for 63 parents were obtainable from 2 parent-evaluation tests established by Tahsis Co. in 1971-'73.

After careful consideration of the alternatives, a program of selecting, cloning and screening many parent trees by open-pollinated progeny plantations prior to breeding was adopted. Under this program, 23 test plantations were established to provide rankings on a total of 146 parents. The first assessment, on 8 sites containing progeny of 32 parents, is planned for age 5 (fall, 1983). Two years without seed crops, plus silvicultural changes resulting in reduced hemlock planting targets, combined with advances in propagation success and cone-induction trials (see progress reports by Ross and Webber), led to a re-evaluation of the program, particularly concerning the progress toward obtaining 2nd-generation seed. The revised strategy entails:

1. Establishment of a priority breeding zone comprising low- to mid-elevations, west Vancouver Island and, to a lesser degree, adjacent zones;

2. Definition of a breeding population comprising some 500 parental selections, mainly from the breeding zone itself. Proportions to be included from other areas have been established;

3. Wood density will be included among the selection criteria and will form a basis for limited, preliminary culling of candidate parent trees;

4. Evaluation of parental selections through field tests of controlled crosses, rather than of open-pollinated progenies as originally proposed. This strategy will be facilitated by reliance upon flower-induction techniques

which have been shown to be particularly effective with western hemmlock (Forest Research Review 1980/81:5). A partial diallel mating design will be used to generate progenies for testing and, concomittantly, a pedigreed second generation for future selections;

5. The ability to cull established clonal seed orchards, already restricted by a very incomplete seed inventory, will be further reduced by the revised strategy. However, this will be more than compensated by the significantly advanced production of a pedigreed second generation.

As far as possible an effort will be made to effect a smooth transition to the revised program, utilizing the considerable quantity of materials and information already available and still being generated.

To complete approved orchards, parent tree selection by Coast Tree Improvement Council (CTIC) agencies was continued to targets set within geographic and elevation zones by the tree breeder. Selection and propagation of an additional 84 trees brought the overall total in the seed orchard program to 1334. Clonal lists of all seed orchards were reviewed and, where appropriate, revised on the basis of remeasurement and analysis of established provenance (Canadian Forestry Service) and progeny tests (Tahsis Company).

The seed-orchard program is proceeding well, with establishment well advanced on five and propagation proceeding on three more of the nine approved orchards. Collectable quantities of cones appeared in spring, 1983 on the oldest orchard (Tahsis Co.) without any cone-induction treatment. Although the health and vigour of these ramets appeared good, cultural techniques will be used to induce adequate cone crops, even in those orchards situated in the most suitable climatic zone. Also, supplemental pollination may be necessary to broaden the genetic base beyond the most-fecund clones, and to maximize seed yields.

Cross pollinations were completed among 12 study trees in the Duncan-Cowichan area, Vancouver Island, to complete a diallel. The progenies will be planted in 1983 or spring 1984 to provide needed information on genetic control and correlations among parameters of interest in western hemlock to guide generation and evaluation of the progeny tests.

The first controlled crosses under the revised breeding program were conducted on a small scale in 1983 at the Cowichan Lake Research Station, Vancouver Island. In 1982 potted ramets were subjected to a cone-induction regime recommended by Dr. Steve Ross (Ross 1983). The flexibility of breeding on potted ramets was readily apparent. Ramets designated to supply pollen remained indoors in February while those designated as cone parents were moved outdoors to retard bud development. Once pollen had been collected and processed, the cone-parent ramets, on which bagging had been completed, were moved

indoors gradually to phase the pollen application over a 2-week period under ideal working conditions, rather than in inclement weather outdoors. Cone development appears normal, indicating the first of several years of successful breeding, thanks to the research programs of Ross (following Ebell) and Webber, and to the presence of qualified and skilled technical support in the propagating center and nursery.

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CONTAINER SEED ORCHARD AND CROWN MANAGEMENT RESEARCH

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Keywords: cone induction, container seed orchards, crown management, environmental stress, gibberellins.

This report describes progress during 1981-82 in two areas of research aimed at improving the efficiency of seed-orchard programs for commercially important B.C. conifers. One is the development of containerized orchards as a cost-effective alternative to traditional soil-based orchards, both for accelerating breeding programs and the volume production of improved seeds for reforestation. The other deals with crown management as a means to controlling the rapid height growth in existing (soil-based) orchards, and thereby facilitating the harvesting of cones and other management practices such as booster pollination and cone enhancement.

CONTAINER SEED ORCHARD PROGRAM

Western Hemlock

The successful use in 1980 (see Haeussler and Ross 1982) of gibberellin $A_{4/7}$($GA_{4/7}$) and drought treatment within an unheated polyethylene house to induce profuse female and male flowering in young potted western hemlock (Tsuga heterophylla (Raf.) Sarg.) ramets was repeated in 1981 on a second group of ramets. However, an unacceptable percentage (ca. 50%) of plants treated in both years died, and the surviving ramets were in such a weakened state physiologically that vegetative recovery was inadequate for retreatment in 1982. Surprisingly, this was not reflected in a high abortion of cones (only 11-22%), most of which showed vigorous development with high sets of filled seed when supplementally pollinated (see progress report by J.E. Webber).

This problem of mortality and poor vigor is specifically highlighted to emphasize the point that containerized-orchard trees, of western hemlock especially, are much more susceptible than field-grown trees to mismanagement. Due to inexperience and other factors outside our immediate control, the ramets used (left-over production stock) were of poor quality at the start, and then suffered from excessive temperature build-ups (over 40°C on occasions) within the polyethylene house, as well as salt toxicity from over fertilization. Two subsequent studies in 1982

have demonstrated that, with good quality stock and proper management, profuse flowering in potted western hemlock orchard ramets can be achieved without mortality or serious deterioration of plant vigor.

Pilot testing of the containerized orchard concept to induce early flowering in western hemlock for breeding purposes began in 1982, in collaboration with Dr. M.D. Meagher and Ms. A.M. Wood at the Ministry's Cowichan Lake Research Station. Potted 6-year-old ramets (rooted cuttings 1.5-2.5 m tall) of 7 parent-tree clones were placed in a greenhouse on 5 May for treatment as follows. One group of 3 ramets per clone received 1.2 g of $Ca(NO_3)_2$ L^{-1} of rooting media at vegetative bud burst followed with 6 weeks of drought and weekly foliar sprays of 200 mg $GA_{4/7}$ L^{-1} in water containing 0.05% (a.i.) Aromox-C12W surfactant. A second group of ramets was similarly treated following rootpruning and repotting from 11 L to 27 L containers, and a third group was left untreated.

Results of this trial are summarized in Table 1. Even without treatment, ramets of all 7 clones flowered as a result of being potbound and subjected to a favorably warm environment within the glasshouse. Treatment with $GA_{4/7}$ alone increased the production of seed-cone buds by a factor of 10 fold and that of pollen-cone buds by nearly 2 fold. Periodic repotting of containerized stock is essential to accomodate an increase in plant size and to replace the artificial potting media which degrades over time. Brix and Portlock (1982) had found, however, that the reduction in water stress associated with repotting into larger containers substantially depressed the flowering response to $GA_{4/7}$ treatment in western hemlock. This was not apparent in the present study where rootpruning was employed to water stress the repotted ramets. Both treatments enhanced flowering in all clones, although there was evidence for a treatment x clone effect with respect to the response to $GA_{4/7}$ with and without repotting/rootpruning. The interaction was highly significant (P = .005) for male flowering and nearly significant (P = .07) for female flowering.

Table 1. Flowering responses by potted 6-year-old rooted western hemlock ramets within a greenhouse to gibberellin $A_{4/7}$ + $Ca(NO_3)_2$ and drought (GA), with and without rootpruning/repotting (RP) vs. controls (clonal means for 3 ramets/treatment). (S.D. Ross and A.M. Wood, unpublished data, 1983 (file E.P. 865.07)).

	Female conelets/plant (no. ± S.E.)			Pollen cones/plant (no. ± S.E.)		
Clone	Control	GA alone	GA + RP	Control	GA alone	GA + RP
295	82(81)	610(144)	885(31)	529(529)	986(384)	2475(1055)
296	4(3)	249(73)	554(99)	238(187)	371(187)	1752(432)
297	66(66)	472(55)	509(27)	686(682)	1120(355)	1066(118)
298	167(109)	712(20)	683(104)	175(83)	1506(473)	397(52)
299	10(7)	418(292)	455(184)	199(184)	800(586)	546(158)
300	23(9)	960(66)	690(60)	1392(241)	4190(332)	2619(172)
301	4(4)	356(175)	231(65)	86(48)	345(320)	88(33)
$\bar{X}$	51(23)	540(91)	572(78)	472(173)	1331(501)	1277(385)

Controlled pollinations were performed on induced flowers of selected clones as part of the operational breeding program. Results of this pilot test of the containerized breeding orchard concept for western hemlock were sufficiently encouraging that the approach has been expanded to semi-operational status in 1983 (see progress report of M. Meagher).

It has now been amply demonstrated that containerized ramets of western hemlock can be reliably induced to flower profusely by treatment with $GA_{4/7}$ and drought within an unheated polyethylene house. The possibility that equally good flowering may be achieved more economically using this treatment outdoors was tested in a collaborative 1982 study with Dr. R.C. Bower of MacMillan Bloedel Ltd. Also compared was $GA_{4/7}$ treatment in conjunction with heat alone in a temperature-controlled greenhouse, as has been recommended by Pollard and Portlock (1981). The study is being written up for submission to the Canadian Journal of Forest Research. Therefore, it will suffice to note that: (1) under all environmental regimes, $GA_{4/7}$ treatments lasting 12 weeks were more effective than those half as long in the promotion both of female and male flowering; and (2) for this longer duration, drought outdoors was significantly more effective than that in the polyethylene house, with high temperature alone in the heated glasshouse being least effective. This comparison is being repeated as part of a newly-initiated long-term study to assess relative cost benefits of outdoor vs. indoor containerized orchards of western hemlock, and of both of these in relation to the traditional soil-based seed orchard.

Interior Spruce.

After previous failure associated with poor stock quality (see Haeussler and Ross 1982), successful promotion of flowering was achieved in 1982 for potted Engelman spruce (Picea engelmannii Perry) using, basically, techniques developed in Europe for other Picea spp. Short (3-wk) exposure to high temperature within a heated (30^{o} day.20^{o} night) polyethylene house was sufficient to induce flowering, although the optimal treatment period differed for seed cones (late stage of slow shoot elongation) and pollen cones(early, rapid elongation growth). Moderate moisture stress (plants watered at -.75 pre-dawn PMS) enhanced the production of pollen cones, but inhibited production of seed cones from optimally-timed heat treatment. In response to these best treatments within the heated house, the potted 5- and 6-year-old grafts initiated an average of 44 seed-cone buds and 52 pollen-cone buds each, compared to respectively, only 1 and 1 each for control plants left outdoors. Topically-applied $GA_{4/7}$ was tested on 4 mid-crown branches per plant, where it enhanced female flowering but had little effect on pollen cones. The grafts showed no ill effect of treatments, with generally vigorous vegetative growth and little abortion of cones observed the following year.

CROWN MANAGEMENT RESEARCH

In 1982, as a cooperative effort with Silviculture Branch and Western Forest Products Ltd., long-term studies on crown management were

initiated in (one each) young and older seed orchard (or clone bank) of Douglas-fir (Pseudotsuga menziesii (Mirb) Franco) and western hemlock. The studies will evaluate different crown pruning techniques for effectiveness in (1) controlling height growth, and (2) redirecting rapid extension growth into abundant lateral shoots with a high potential for differentiating seed- and/or pollen-cone buds.

First-year effects on height growth and flowering for Douglas-fir in response to three levels each of top pruning and inter-whorl branch pruning, with and without $GA_{4/7}$ stem injections, are only now being assessed, but initial indications are encouraging. For young western hemlock, top pruning appears to be effective in overcoming the sparse branching habit characteristic of vegetative propagules of mature clones of this species. Responses to $GA_{4/7}$ foliar-spray treatment in 1983 will determine whether or not the increased lateral branching is reflected in increased flowering potential.

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TREE IMPROVEMENT PHYSIOLOGY RESEARCH, B.C. MINISTRY OF FORESTS 1981-1983

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Keywords: pollen, viability tests, supplemental pollination, boosting, cone enhancement

Emphasis on pollen and flowering research continues towards identifying restraints and developing techniques for producing abundant supplies of genetically improved seed at an early age. This research is being applied to seed orchards and breeding programmes in Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco), western hemlock (Tsuga heterophylla (Raf.) Sarg.), white spruce (Picea glauca (Moench) Voss) and lodgepole pine (Pinus contorta Dougl.)

POLLEN MANAGEMENT

Pollen Bud Storage

In operational processing of Douglas-fir seed orchard pollen, extraction units are often full and pollen-cone buds must be stored. In this trial the effect of storing buds at 4°C was tested for 5 durations (0, 2, 4, 6 and 8 days) after which the pollen was extracted and stored in serum vials for two years at -26°C. All lots were tested using controlled pollination technique.

Seed yield data suggests that no practical deleterious effect on pollen quality occurred by storing buds up to 8 days. Although yields decreased from 21 filled seeds per cone (at 0 days) to 18.4 filled seeds per cone (at 8 days), this difference was not significant ($p \leq 0.05$).

Pollen Storage Trials

It is known from previous storage trials that Douglas-fir pollen will retain its fertility over at least a 5-year period if first dried to a moisture content of 2-6% and is then stored in evacuated containers at -26°C. This trial did not consider pollen at higher moisture contents nor did it include storage under inert atmospheres (i.e., nitrogen).

In a recent trial, Douglas-fir pollen lots at 4 moisture contents (4, 8, 12, 16%) were stored in two container types (laminated foil pouches

and glass) under three atmospheres (vacuum, air and nitrogen) and two storage temperatures (+4° & -26°C). Pollen has now been processed and will be field tested (using controlled pollinations) over the next three years.

Similar storage trials are being evaluated for white spruce and western hemlock pollen as well.

Pollen Viability Assays

In B.C. we are harvesting and storing large quantities of pollen without a reliable measure of quality (i.e., index of viability or potential fertility). Pollen fertility can be assessed using controlled crossing but this test takes too long to be of immediate use for quality control Results from quick viability tests based on adenosine triphosphate (ATP), in vitro germination assays and tetrazolium stains (Ching et al. 1975, Ching and Ching 1976) failed to correlate with filled seeds per cone in controlled pollinations.

More recently respiration has been included as a routine test (Binder and Ballantyne 1975) and conductivity procedures modified. Pollen to be tested for conductivity is now measured as cold and hot (boiled) leachate. The ratio of the two indicates the % of total leachates extracted under cold conditions. The field test was also modified. Previous results with serial dilution of pollen with dead pollen showed no significant reduction in seed yield up to 50% dilution. Therefore, to make pollen viability more limiting in field tests, each lot was pollinated undiluted and at 50% dilution.

Seed yields for both levels of dilution were compared to respiration, conductivity ratio and in vitro germination assays. An apparent linear relationship occurred for respiration ($r_{100\%} = 0.69^{*}$ and $r_{50\%} = 0.88^{**}$) but not for conductivity or germination. Tests are continuing and results will be reported when available.

SUPPLEMENTAL POLLINATION

Time of Pollination

With the establishment of lodgepole pine and western hemlock seed orchards, work began to determine the optimal time of pollination and level of pollen applied to produce maximum seed yields. Since the pollination mechanism of lodgepole pine, western hemlock and Douglas-fir are all different (Owens et al. 1981 and ref. therein), it was not possible to directly apply experience from pollination trials with Douglas-fir.

In the lodgepole pine seed orchard (Red Rock, Prince George, B.C.) seven supplemental pollen application periods were tested: 0, 2, 4, 6, 8, 10 and 12 days beyond bud burst. For all periods, seed yields from 0.5 ml boosted pollen were compared to the non-boosted controls. For periods 2, 6 and 10 days, four levels of pollen boosting (0, 0.02, 0.1 and 0.5 ml) were compared. Supplemental pollination resulted in a 28% increase in

in filled seeds per cone over non-boosted controls when pollen (0.5 ml/bag) was applied within the first 4 days after bud burst. Later pollinations were ineffective. This was attributed to the high pollen cloud density from both within and outside the orchard.

Level of pollen application showed similar results. When applied early (i.e., 2 days), 0.5 ml produced the largest increase (4.3, 5.8, 8.8 and 12.0 filled seeds per cone for control, 0.02 ml, 0.1 ml and 0.5 ml respectively). However, when applied later (i.e., 10 days), quantity of pollen applied was of marginal importance (16.9, 15.1, 15.0 and 17.1 filled seeds per cone for control, 0.02 ml, 0.01 ml and 0.5 ml respectively).

Since natural (contaminating) and seed orchard pollen supplies at the Red Rock lodgepole pine seed orchard are abundant, there is little need to add supplemental pollen to increase seed yields alone. However, by boosting early, pollen of known genetic source is in a more favourable position to be entrapped by the pollination drop and subsequently be involved in fertilization. The actual effect of diluting contaminating pollen with supplemental pollen will be tested in future trials.

In the western hemlock study, potted ramets from the container seed orchard programme were used. Six clones with a moderate to heavy pollen crop were moved into a glass greenhouse after the pollen-cone buds finished early meiotic activity (period of rapid swelling). Another 5 clones with a moderate to heavy seed cone crop were moved outside to slow development. Using this technique, about two weeks delay between pollen forcing and seed-cone bud flushing was achieved. This gave enough time to collect and process pollen for the time of boosting study.

Five treatment periods were considered, based on the number of days beyond bud burst. In this study, bud burst was defined as that stage when 50% of the treatment buds had their scales exposed over the entire diameter of the bud. Filled seeds per cone increased from 12 at bud burst to 22.4 for 8 days beyond bud burst. Although no other pollen source was available to the treatment of strobili, the results for later periods (6 and 8 days) may be confounded by earlier pollinations since isolation bags were not used. This test is being repeated using isolation bags and including a sixth time period, 12 days.

CONE ENHANCEMENT

A cooperative project involving the author and Dr. S.D. Ross of the Research Branch, Ministry of Forests, Dr. J.N. Owens (University of Victoria), and Dr. R.P. Pharis (University of Calgary) is investigating the physiology of flowering in response to gibberellin ($GA_{4/7}$) and root-pruning treatments in Douglas-fir. Treatments were applied singly and in combination to 9- and 10-year-old half-sibling progeny of families selected according to their past history of flowering. Shoot samples of treated trees were returned to the laboratory and prepared for detailed anatomical and hormonal analysis. Results of laboratory analysis will be reported later, and results of flowering and growth response are given here.

Flowering was significantly affected by the $GA_{4/7}$ and rootpruning treatments and the magnitude of this response was mediated by the trees previous flowering history. Rootpruning resulted in a significant 69-fold increase in total seed-cone bud production in poor flowering trees. Gibberellin treatment was less effective (about a two-fold increase in poor flowering trees), but when combined with rootpruning treatments produced a dramatic synergistic effect resulting in a 250-fold increase in total seed-cone bud production for poor flowering trees. Although the magnitude of the increased flowering response for good flowering families was less (because of the better flowering in control trees) the actual number of flowers produced per tree was considerably greater. Rootpruning significantly enhanced seed-cone production by 20-fold, and $GA_{4/7}$ treatment enhanced production by 9-fold. The combination of both treatments produced a 38-fold increase.

Growth was also significantly affected by both treatments. Rootpruning inhibited shoot extension by about 45%, and this growth reduction was unaffected by the trees previous flowering history. However, $GA_{4/7}$ treatment resulted in a significant 15% increase in growth for trees with a poor flowering record but had no effect on trees with a good flowering history. There was also a $GA_{4/7}$ enhancement of growth for rootpruned trees and this response was greater for trees that had not previously flowered (but not significantly different).

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GROWTH ASSESSMENTS OF ROOTSTOCKS AND GRAFTS IN TWO GROWING MEDIA AND TWO CONTAINER DESIGNS 1981-1983

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Keywords: Grafts, growing media, container design.

The solution of cultural problems is an integral part of the operational grafting program at Cowichan Lake Research Station. The study reported here aims to identify the growing medium and container type best suited for optimum rootstock and scion growth of western hemlock (Tsuga heterophylla (Raf.) Sarg.), Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) and amabilis fir (Abies amabilis (Dougl.) Forbes).

It was engendered by the need to have rootstocks which are not only healthy but have actively growing roots at the time of grafting. Cultural procedures at this research station entail trees being held in cool greenhouses under low light intensity and with automatic irrigation from the time they are potted in the fall until they are used for grafting in the spring of the following year. A porous, well-drained growing medium is, therefore, required to minimize the occurrence of root dieback.

The study, which was started in 1982, tests two growing media: (a) Light (1 peat:2 perlite) and (b) Heavy (3 peat:2 perlite:1 sand) in combination with two container types: (a) 4.5 l square with ribbed walls and open mesh bottom, and (b) 3.2 l round.

It was found that, during the winter months, medium (a) allowed more control over the watering regime and promoted more root growth than medium (b). Measurement of physical properties (bulk density, porosity and soil water retention) showed the light medium (a) to be more physically stable also.

The square pots directed roots downward to the open mesh bottom where they were air-pruned, thus preventing the root spiralling which was evident in the round pots. Consequently, grafts grown in square pots did not require repotting in the year of grafting, providing a substantial economic saving to the propagation program.

As a result of this study, the light medium tested has been modified to provide better water and nutrient retention, and the revised formulations are being tested in combination with the square pot.

BRITISH COLUMBIA COASTAL GENE ARCHIVES

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Keywords: Gene archives, clonebanks, gene conservation.

The primary objective of the coastal gene archive is to conserve valuable genetic material from coastal forest tree species. This primarily involves maintenance of clonal material from selected parent trees, and valuable trees resulting from experimental breeding. This material is available to breeders and other researchers, and is a source of vegetative material for seed orchard development. This report briefly discusses the background, current status and proposed development in the gene archives.

BACKGROUND

The coastal gene archives contain the products of tree selection and breeding by the British Columbia Ministry of Forests, dating back to 1952. Located at the Cowichan Lake Research Station on southern Vancouver Island, the gene archives consist primarily of cloned Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) from selected parent trees. There is also a large Douglas-fir provenance arboretum containing 188 population samples from throughout the species' range (Orr-Ewing 1973), as well as material from Douglas-fir inbreeding experiments, with several lines inbred to the S_3 generation (Orr-Ewing 1977).

Other major plantations in the gene archives include a native tree arboretum, yellow cedar (Chamaecyparis nootkatensis (D. Don) Spach) clonebank and hedging orchard (Karlsson 1981), Douglas-fir inter-racial cross progeny test (Orr-Ewing and Yeh 1978), and a lodgepole pine (Pinus contorta Dougl.) provenance collection.

DEVELOPMENT

During 1982 the gene archives staff was expanded, and a plan completed which outlines clonebank development for 15 coastal tree species. In the spring of 1983, 227 clones of western hemlock (Tsuga

heterophylla (Raf.) Sarg.) and another 105 clones of Douglas-fir were established. This brought the total number of established Douglas-fir clones to 818.

Site preparation and development are continuing in 1983, and it is anticipated that about 25,000 ramets representing 3,000 clones and 10 species will be established over the next five years. When first generation selections have been completed for all 15 species, the gene archives will contain a total of about 8,000 clones, as well as experimental material. The coastal gene archives are becoming an increasingly valuable resource for tree improvement and other related research.

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POPULATION GENETICS OF FOREST TREES

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Keywords: Population genetics, isozymes, selfing, seed orchards, spruce complex.

Population genetic studies have relied upon isozymes as genetic markers to elucidate the structure of forest trees (Yeh 1979). During the past two years, however, emphasis has been placed upon the use of isozymes to address two areas that are of immediate concern to practical foresters. These are rate of selfing in seed stands and seed orchards, and the identification of spruce hybrid seedlots to ensure proper culturing in the nursery.

ESTIMATION OF SELFING RATE

Much attention has been placed upon the development of equations to estimate selfing rate accurately (El-Kassaby et al. 1981; Cheliak et al. 1983). Empirical studies showed statistically similar selfing rates for seed stands and seed orchards. Average selfing rates were approximately 13 percent for coastal Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) and 18 percent for Sitka spruce (Picea sitchensis (Bong.) Carr.).

IDENTIFICATION OF SPRUCE HYBRID SEEDLOTS

Correct identification of spruce hybrid seedlots prior to sowing is a desirable step to ensure proper culturing in the nursery. Gel electrophoresis, which is a biochemical technique, offers the potential to characterize spruce hybrid seedlots rapidly and economically.

A study was initiated in April, 1983, to explore the potential use of isozymes for the identification of hybrid spruce seedlots. Data for isozyme surveys were based upon a representative sample of reforestation seedlots that included two interior spruces, two Sitka spruces and five hybrid spruces. A total of 18 isozymes were the basis

for describing isozyme variation of the seedlots. Observed patterns of isozyme variation lend support to the notion that isozyme profiles of seedlots could aid in the identification of spruce hybrids.

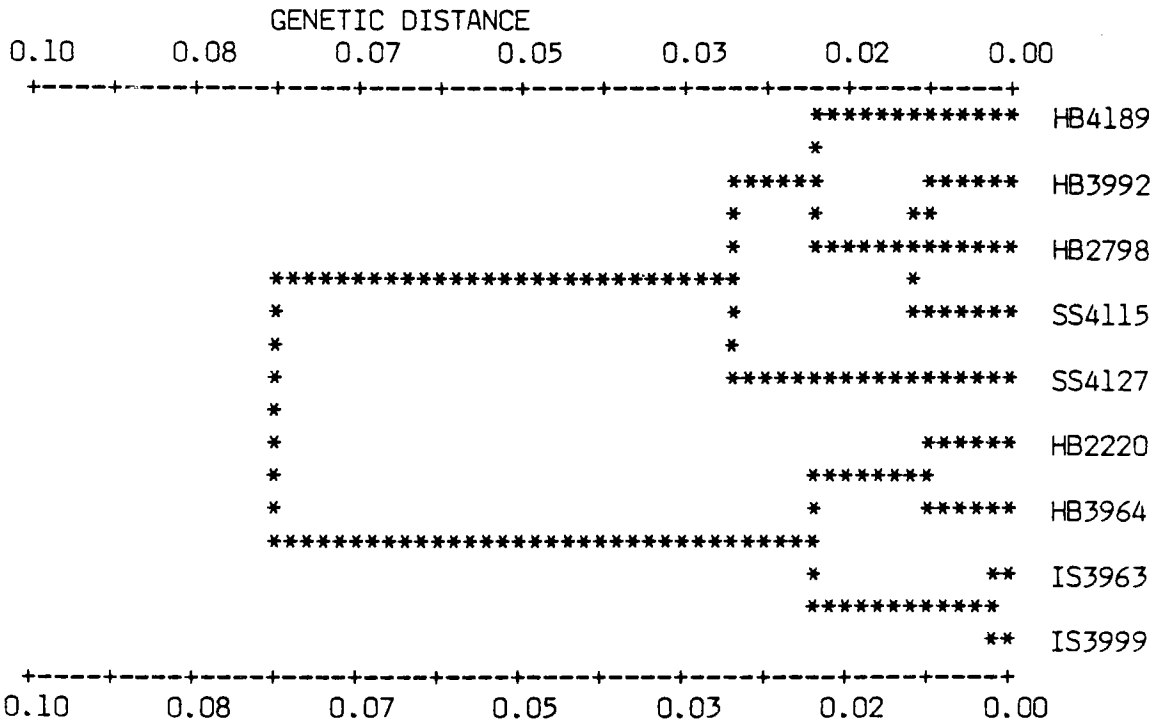
Of the 18 isozymes surveyed, six (DIA-2, GDH, G6P, 6PG-1, 6PG-2 and NOTDH) were diagnostic in the sense that each exhibited distinct gene frequencies for Sitka and interior spruces (Table 1). Thus, the six isozymes, either alone or together, can unequivocally characterize the original nine seedlots into two distinct clusters (Figure 1). Despite the original reforestation classification of all five hybrid seedlots as being Sitka, the isozyme data suggested that two of the five hybrid seedlots (HB2220 and HB3964) had significantly more of the interior spruce rather than Sitka spruce genes. Thus, prescribing Sitka culturing to these two spruce hybrid seedlots would result in reduced vigor and survival for the seedlings.

There are numerous explanations as to why and how the two interior spruce hybrid seedlots were mis-classified as being Sitka. My personal judgement is that many of the morphological characters (i.e. cone and needle) are unreliable to address a very complex phenomenon such as introgression. Regardless of the whys and hows, this study points to the need for the inclusion of an isozyme survey of hybrid spruce seedlots as part of the seed classification scheme. Based on our experience with the spruces, we estimate a need of four man-days to screen each seedlot. Costs for the chemicals amount to $30.00 per seedlot. This is a small price to pay for ensuring proper culturing of spruce hybrid seedlots in the nursery.

Table 1. Allele frequencies in populations 1 through 9

	POPULATION								
LOCUS	1	2	3	4	5	6	7	8	9
DIA-2									
1	0.745	0.783	0.510	0.631	0.649	0.558	0.284	0.950	0.862
2	0.255	0.217	0.490	0.369	0.351	0.442	0.716	0.050	0.138
GDH									
1	0.895	0.759	0.622	0.800	0.622	0.932	0.956	0.489	0.482
2	0.105	0.241	0.356	0.173	0.378	0.045	0.044	0.511	0.518
3	0.0	0.0	0.022	0.027	0.0	0.023	0.0	0.0	0.0
G6P									
1	0.462	0.261	0.407	0.543	0.146	0.583	0.512	0.153	0.144
2	0.538	0.739	0.593	0.457	0.854	0.417	0.488	0.847	0.856
6PG-1									
1	0.642	0.302	0.922	0.775	0.520	0.941	0.977	0.152	0.109
2	0.358	0.698	0.078	0.225	0.480	0.059	0.023	0.848	0.891
6PG-3									
1	0.635	0.768	0.443	0.568	0.768	0.310	0.393	0.938	0.857
2	0.344	0.179	0.557	0.432	0.162	0.583	0.607	0.021	0.042
3	0.021	0.053	0.0	0.0	0.071	0.107	0.0	0.042	0.101
NOTDH									
1	0.787	0.698	0.830	0.792	0.571	0.828	0.614	0.593	0.645
2	0.213	0.104	0.170	0.208	0.165	0.172	0.386	0.0	0.018
3	0.0	0.198	0.0	0.0	0.264	0.0	0.0	0.407	0.336

Figure 1. Cluster of spruce seedlots



SS = Sitka spruce; IS = Interior spruce; HB = Hybrid

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PROVENANCE RESEARCH BY THE BRITISH COLUMBIA MINISTRY OF FORESTS 1981-1983

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Keywords: Provenance, amabilis fir (Abies amabilis (Dougl.) Forbes), grand fir (A. grandis (Dougl.) Lindl.), noble fir (A. procera Rehd.), Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco), Sitka spruce (Picea sitchensis (Bong.) Carr.), western hemlock (Tsuga heterophylla (Raf.) Sarg.), lodgepole pine (Pinus contorta Dougl. ex Loud.).

Provenance research in British Columbia has been in progress for nearly 20 years. A network of over 150 test plots has been established. Some of these tests are 15 years old and are now starting to produce valuable information.

Assessment and maintenance of these trials were completed according to schedule despite recent financial constraints. In addition, a range-wide collection of eighteen noble fir provenances was planted together with trees of local seedlots of amabilis fir and western hemlock at twelve locations in the Vancouver Island and coast ranges.

COASTAL DOUGLAS-FIR

Height and diameter after 10 growing seasons were measured at 9 locations in 1981 and 1982. This brings the total number of sites with 10th year growth data to 32. Correlation coefficients between the 6th and 10th year total height varied among sites from 0.75 to 0.97, with only two of them below 0.8.

These statistics indicate no significant change in ranking among provenances for height growth, providing continued support for conclusions based on sixth year data (Illingworth 1978). In consequence, coast Douglas-fir breeding zones and seed transfer rules are currently being re-examined and the Douglas-fir breeding population is being 'enriched' by the introduction of fast-growing, adapted clones and seed from western Washington.

SITKA SPRUCE

Height growth and survival six years after planting were recorded for nine tests in 1980. There was no significant change in survival from the third to the sixth growing season, survival at all sites exceeding 90 percent. Age/age correlation in height growth was nearly perfect at productive sites with a mild climate, e.g. Holberg, Vancouver Island, but low or negative at harsh inland sites, e.g., Dragon Lake, north of Terrace:

Correlation of 6-year height with 1-year and 3-year height, by sites

Year	Holberg	Nass	Maroon Cr.	Dragon L.
1	.91	.47	- .23	- .46
3	1.00	.66	.84	.15

Selection for growth at good sites can be made at a young age with very little risk.

TRUE FIRS

The operational objective of the noble fir provenance study is to evaluate its potential as a reforestation species at high elevation sites in the coastal region. Survival after the first winter was high at the six sites on Vancouver Island (86 to 97%). On the lower mainland, survival was poor at a site located in the coast-interior transition zone (25%) and moderate to high at other sites (51 to 89%). Preliminary indications are that noble fir is a potential reforestation species for high elevations with a relatively mild climate such as in the Coastal Western Hemlock and the Mountain Hemlock Zones.

The grand fir provenance test aims mainly to identify fast-growing seed sources that could be potential substitutes for Sitka spruce at sites with a severe white pine weevil problem. In 1980, four

tests were established on Vancouver Island and the lower mainland. Survival averaged 95% after 3 winters, varying from 90 to 99% among provenances. The tallest provenance grew twice as fast as the shortest one at most sites. However, the trees are still too young to draw any realistic conclusion.

LODGEPOLE PINE

The lodgepole pine provenance program is the most comprehensive one (Ying 1981). Data interpretation and their practical application to genetic improvement and seed transfer have received the highest priority. The tenth year assessment of height growth and other characteristics is due in the fall, 1983. This additional information will improve considerably the data base for refining seed transfer guidelines and breeding strategy.

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TREE SEED RESEARCH AND CERTIFICATION, PACIFIC FOREST RESEARCH CENTRE 1981-1982

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Key words: seed prechilling, moisture content, seed blight, spruce cone rust, seed quality, flower enhancement, seed certification, Douglas-fir cone gall midge, Douglas-fir cone moth, spruce seedworm, seed chalcids.

This report describes research on flower enhancement, seed quality, and the official seed testing and certification programs at the Pacific Forest Research Centre. It also covers studies of the seed-born Sirococcus blight (Sirococcus strobilinus Preuss) and inland spruce cone rust (Chrysomyxa pirolata Wint.); the Douglas-fir cone gall midge (Contarinia oregonensis Foote), a cone worm (Dioryctria pseudotsugella Munroe), the spruce seedworm (Cydia strobilella Linneaus) and seed chalcids (Megastigmus).

IMPROVING THE USE EFFICIENCY OF CONIFER SEEDLOTS

D.G. Edwards

Research on the prechill (stratification)-redry procedure for stimulating germination in Abies seeds continued with trials at the BCMF Campbell River nursery (in collaboration with Dr. C.L. Leadem). End of the growing season differences from seedlings raised from routinely (2 months) prechilled seeds were slight or non-existent under the warm, humid conditions maintained in the nursery facility; the additional seed handling involved in carrying out the redry procedure could not be justified. Work continues to test the responses under less favorable (cold) nursery environments. A drum drying device was constructed for handling large quantities of seeds at the redry stage.

Studies were begun to determine if more efficient sorting of germinable and non-germinable Abies seeds could be obtained following redrying of prechilled seeds. This method relies on the ability of vigorously germinable seeds to retain moisture within the tissues, while non-germinable, or poorly germinable, seeds dry out more quickly. This creates a moisture content, and hence weight, differential that can be utilized in sorting; heavier (more moist) seeds sink in a column of water while light (dry) seeds float. The procedure worked reasonably

well for prechilled-redried Abies seeds, with germinability of the "sinkers" approaching 90%, but too many germinable seeds occurred in the "floaters". Changing the procedure to correspond more closely with a similar Swedish method has shown some very promising results with Picea glauca (Moench) Voss, Pinus contorta Dougl. and Pseudotsuga menziesii (Mirb.) Franco. In some cases, seedlot quality has improved to over 95% with the loss of less than 10% germinable seeds; it still has to be determined if these "lost" seeds are of low vigour.

FLOWER ENHANCEMENT

F.T. Portlock

Work has continued on the enhancement of strobilus production in young seedlings and rooted cuttings of western hemlock (Tsuga heterophylla (Raf.) Sarg.) using gibberellic acid ($GA_{4/7}$) and fertilizer ($Ca(NO_3)_2$). Studies of the effects of high moisture stress and high temperature have been completed and reported. Work has continued on the effects of late-season temperatures and reduced photoperiod on normally induced strobili. Results are to be published shortly.

CONE AND SEED INSECT STUDIES

G.E. Miller

A monitoring scheme, based on egg counts, for estimating Douglas-fir cone gall midge (Contarinia oregonensis) egg populations and determining the need for an insecticide application has been developed and is used operationally in Douglas-fir seed orchards. Sampling schemes are now being developed for estimating numbers of Douglas-fir conelets in seed orchards and numbers of Douglas-fir cone moth (Barbara colfaxiana) eggs.

Pheromone identification is continuing for Douglas-fir cone gall midge, Douglas-fir cone moth, a coneworm (Dioryctria pseudotsugella) and spruce seedworm (Cydia strobilella). A gland which may well be the site of pheromone production has been identified in the Douglas-fir cone gall midge. Trap shape and colour had little effect on sticky trap catches of the Douglas-fir cone moth using a synthetic male attractant. An attractant for spruce seedworm has not been fully identified but Z-8-dodecenyl acetate is a component.

A heat treatment has been developed for killing seed chalcids (Megastigmus spp.) in harvested Abies seeds. Cones, on trees injected with acephate, oxydemeton-methyl or bidrin (Mauget® injectors), were still heavily attacked by coneworms. Mr. D. Summers (BCMF) collaborated on this injector trial and is screening other insecticides and application methods for cone and seed insect control.

Dr. T.S. Sahota discovered that the Douglas-fir cone moth overwinters as pharate adults, not as pupae as reported in the literature. Colour can be used to separate moths that will emerge after diapausing one winter from those that enter prolonged diapause. Studies are continuing into factors which induce prolonged diapause.

CONE AND SEED DISEASE RESEARCH

J.R. Sutherland

Research continues on determining when and how the Sirococcus blight fungus (S. strobilinus) becomes seed-borne so that both fungus occurrence on seeds (mainly spruces) and disease outbreaks on germinants in container nurseries can be prevented. Studies were initiated on the biology, epidemiology and control of Inland spruce cone rust (Chrysomyxa pirolata), especially at the Skimikin seed orchard at Salmon Arm. Although the rust's life cycle is known, additional information has been obtained on development and morphology of the various spore stages, histopathology and biology of the rust in the non-conifer host (mainly Pyrola spp.) and spore release. The latter is very important in timing of fungicide sprays. Preliminary indications are that Ferbam fungicide controls the disease without affecting the quantity or quality of seeds.

OFFICIAL TESTING OF TREE SEEDS

D.G. Edwards

Certificates of seed quality (purity, germination) for 242 commercial seedlots, from 27 conifer and 1 broadleaf species, were issued in 1981/82; an additional 59 tests were completed on seedlots not requiring certificates. This represents more than double the amount of official testing done in 1979/80. Testing in 1982 decreased markedly reflecting the economic downturn experienced globally. As in the past, a high proportion (85%) of the certificates issued were "blue", i.e. the test results applied only to the sample submitted by the owner. The proportion of Pseudotsuga menziesii seedlots tested increased significantly in the last 2 years.

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

F.T. Portlock

As Certifying Authority for the Pacific and Yukon Region of the CFS, seed inspectors of this Centre inspected and certified cone collections, and issued certificates of provenance, for seeds for export; all seedlots were certified under the Source Identity category.

In 1981-82, 115 certificates for 1268.7 kg. of Pinus contorta and Picea sitchensis seeds were issued.

In 1982-83, 138 certificates for 1274.5 kg of seeds were issued. Species collected included Pinus contorta, Pseudotsuga menziesii, Abies grandis and Thuja plicata.

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MACMILLAN BLOEDEL LIMITED PROGRESS REPORT 1981-1983

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Keywords: Seed Orchards, Cone Induction, 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, cone induction research, progeny testing and provenance test measurements.

SEED ORCHARDS

MacMillan Bloedel Limited is a member of the Coastal Tree Improvement Cooperative (CTIC) and is committed to establishing and managing five 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)
- sitka spruce (Picea sitchensis (Bong.) Carr.)

Establishment of the western hemlock orchard commenced in 1982, with further planting in 1983. Establishment of the other four orchards is scheduled to occur through 1985.

CONE INDUCTION STUDIES

The Company has been involved in three cone induction studies. Two of these, western hemlock and Douglas-fir, have been in cooperation with S.D. Ross (British Columbia Ministry of Forests) and are covered in his report. The third study is with yellow cypress and uses the techniques of Owens and Molder (1977). This project was initiated in 1981 to test the use of gibberellic acid (GA_3) on natural stands of young yellow cypress.

The test consisted of GA_3 treatment at three periods and a control (no treatment). The treatment periods were May 25-June 22, June 15-July 13, and June 20-July 27. All treatments consisted of spraying

trees to runoff twice weekly for a five-week period with 100 mg/l GA_3 in an aqueous 0.1% Tween 20 solution.

Fall 1981 and 1982 observations show a significant response in male and female flower development from all treatments and no response from the control. The cones will be harvested in the fall of 1983.

PROGENY TESTS

Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco)

The project was initiated in 1982 with the objectives of providing accurate genetic gain data to be used in AAC calculations, to rogue inferior clones from existing seed orchards, and to provide information to improve the adaptability of material coming from the orchards.

Seed production for the test material is through controlled pollination using ten clone pollen mixes. Six test sites will be established for each of the five orchards. Four sites will be selected to sample the range of planting sites within the biogeoclimatic subzone for which the orchard is designed and two will sample adjacent zones.

Crosses were completed on 80 clones in 1982, with crosses on an additional 29 clones completed in 1983. Sufficient crossing should be accomplished in 1984 to allow an initial sowing in 1985.

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 five growing seasons showed highly significant (.01) differences between locations, provenances and the location X provenance interaction. Heights were only significantly different for location and the interaction.

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. Survival and height were assessed at the same time as the provenance tests. Statistical analysis showed highly significant (.01) differences between locations, species and their interaction for both height and survival. Noble fir had survival equal to or greater than the other species in all plantations. It was, however, consistently shorter than western hemlock, mountain hemlock and western larch.

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 five growing seasons was assessed and statistical analysis showed a highly significant difference (.01) between provenances. However, only one provenance in one location had a survival rate greater than 80%. Height differences were only significantly different (.05) for locations.

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 - 79%, western larch - 64% and Douglas-fir - 44%, and were highly significantly different (.01). Lodgepole pine was also consistently taller than the other two species.

Western Redcedar

A small provenance trial was installed as part of a redcedar stock-type trial. Three provenances from Vancouver Island were used. Three test sites were chosen as close as possible to the original collection sites of each provenance. Third year assessments of height and survival were made in 1982. There were no significant differences in survival. There were, however, significant differences in height between provenances and between locations.

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PACIFIC FOREST PRODUCTS' DOUGLAS-FIR SEED ORCHARD MANAGEMENT AND RESEARCH 1982-1983

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Keywords: Pseudotsuga menziesii, tree improvement, breeding seed orchard management, reproductive phenology, pollen contamination, isoenzymes

The Pacific Forest Products' Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) tree improvemet program is currently focused on the management of 11.2 ha of seed orchard to produce genetically improved seed for reforestation. The breeding program to test the genetic worth of first generation seed orchard parents is nearing completion while a potted breeding seed orchard of new selections has been established. Several research projects have been completed or are currently underway to assess the effectiveness and to increase the efficiency of seed orchard management activities. Future plans include additional evaluation of seed orchard management procedures.

SEED ORCHARD MANAGEMENT

Breeding

The Douglas-fir breeding program objective to complete control crossing for 12 disconnected diallels (300 crosses) is now nearing completion. Table 1 presents the summary for the 1983 breeding program. A minimum of 400 filled seed is required to complete one cross. Several additional control crosses were made to test the viability of both Douglas-fir and Sitka spruce (Picea sitchensis (Bongard) Carriere) pollen stored over time.

TABLE 1 1983 Breeding Program Summary

Seed Orchard	No. Crosses	No. Bags
High Elevation	43	200
Low Elevation	52	259
Total	95	459

Potted Seed Orchard

Additional Douglas-fir selections introduced to broaden the genetic base of the Douglas-fir breeding population have been established in a potted breeding seed orchard. The potted seed orchard concept has been chosen to complete breeding sooner and at less cost than a conventional field seed orchard. The objective is to incorporate breeding gains into operational planting population more quickly.

A flower induction treatment for the 1984 crop year of GA 4/7 and moisture stress was given to 75% of the ramets of each clone (37 ramets). Preliminary results indicate positive results in both male and female flower bud response.

Cone Production

Table 2 presents the 1983 cone crop estimate for all seed orchards. The expected 1983 cone crop is approximately 500 bu (180 hL) giving a total estimated seedling production of about 4,500,000.

TABLE 2 Douglas-fir Seed Orchard
1983 Cone Crop Estimate

Seed Orchard	No. bu	No. hL
High Elevation	260	95
Low Elevation	40	15
Full-sib	195	70
Total	495	180

SEED ORCHARD RESEARCH

Reproductive Phenology

Two years of study (100% sampling of the seed orchard population) to assess the genetic variation of reproductive phenology in the high elevation seed orchard have been completed (El-Kassaby *et al.*, 1984). The study was a continuation of long term research (seven years) on phenology, pollen flight and cone production records. The study revealed a wide pollination period and suggested the existence of several sub-seed orchard populations in time. These conditions will affect both seed orchard seed quality and quantity by reducing the breeding population size and by lowering seed yield. Two proposals to maximize seed production by reducing the effect of panmictic disequilibrium were presented.

Another investigation addressing the effect of reproductive. phenology on seed orchard panmixis has also been published (Fashler and Sziklai, 1980).

Pollen Contamination

The objective of the 1982 pollen study was to define the level of local pollen contamination in the high elevation seed orchard by determining the proportion of pollen produced internally and externally to the seed orchard. This data formed the basis for a B.S.F. thesis (Clare,, 1982). Results indicated that the seed orchard was subject to external pollen contamination (computed maximum contamination 22%). The calculated acceptable level of contamination was 12.5%. Recommendations to reduce or eliminate the contamination included the application of reproductive bud delay (irrigation cooling) and supplemental bulk pollination.

Genetic Variation in Cone Production

Seven years of cone production data collected on an individual seedling/ramet basis was analyzed. Emphasis was placed on open-pollinated family analysis to provide a basis for seed orchard thinning (planned for all of 1983). Elimination of genetically inferior clones will be based primarily on progeny test performance. Significant variation among open-pollinated families within years and total cone production among years was observed. Computer simulated seed orchard thinning was performed using several options. The final thinning plan will also include spacing and genetic base constraints.

Reproductive Bud Delay

The effectiveness of irrigation cooling applied as a treatment to delay reproductive bud development on the 1976 and 1978 cone crops has been reported (Fashler and Devitt, 1980). Further study to evaluate the impact of cooling on seed orchard panmictic equilibrium will compare the reproductive bud development in cooled years (1976, 1978 and 1983) to non-cooled years (1980, 1981 and 1982).

The Pacific Forest Products seed orchard has continued to provide facilities and data for co-operative research with other institutions and organizations. For example, student research at the University of B.C. (pollen contamination), co-operative research with Dr. Y. El-Kassaby of U.B.C. (reproductive phenology, cone production genetic variation, reproductive bud delay and x-ray energy-dispersion), and research material for Drs. J. Webber and S. Ross of the B.C. Ministry of Forests, Research Branch (pollen viability and flower induction).

Future plans in seed orchard research include the application of isoenzyme technology to seed orchard operations and management. The genetic composition of the high elevation seed orchard will be studied to estimate a) selfing rate, b) pollen contamination and c) panmixis. These factors will be assessed for i) the seed orchard population as a whole and ii) for three seed orchard sub-populations stratified according to reproductive phenology in time. This is intended to be a co-operative project among Pacific Forest Products, Dr. Y. El-Kassaby and the B.C. Ministry of Forests, Research Branch.

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STUDIES ON POPULATION VARIATION AND EVOLUTION IN CONIFERS

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Keywords: Pinus ponderosa, Abies, evolution, population variation, population differentiation

A series of studies was undertaken to elucidate factors which have an impact on evolution and population differentiation in conifers. There are three main questions: 1) What is the impact of natural selection? 2) What are the factors contributing to population variation? 3) What is the causal agent in evolution?

A study of Abies procera Rehd. (Maze and Parker, 1983), demonstrated that the factor which accounts for the greatest percent of phenotypic variation in populations is site history, whether trees became established in areas cleared by fire or clear-cut logging or under established forests. Geography and altitude accounted for relatively low percentage of variation. This implies that natural selection may produce an effect like genetic drift as populations track cyclic environmental changes. Because of the history of fires in the coniferous forests of western North America, perhaps natural selection has resulted in a mosaic of populations showing differentiation depending on the site where they became established. Such a pattern of variation could increase variability due to increasing the number of genotypes that may fuse during sexual reproduction.

A study on Pinus ponderosa Laws. (Maze, in press) was undertaken in order to clarify the impact of selection on population differentiation. The effects of growing in different habitats, being of different ages and sizes, becoming established under different past climates as evidenced by tree ring summaries (Parker, et al., 1981) and being different trees, on the pattern of variation in needle variables was estimated by calculating the percentage of variation in principal components analysis axis scores for which each of the above mentioned factors account. If selection has an impact, the effect of habitat differences or the conditions under which trees became established would account for most of the variation in the data. In all comparisons made, the greatest percentage of variation was accounted for by the fact that there were different trees in the population analyzed. This indicates that selection has little impact on

patterns of variation. While it may be argued that relevant selective factors were missed, it should be pointed out that such arguments can lead to the unacceptable stance of explaining away unpopular results by asserting that the important elements were not measured. A large percentage of variation that is apparently unaccounted for by selection is a prediction that would follow from a theory of evolution recently presented by Wiley and Brooks (1982).

If the evolutionary theory of Wiley and Brooks (1982) is correct, then there are several predictions one can make. As a species evolves, the correlation between developmentally independent variables will decline as non-structured variation increases within the species. When speciation occurs, and new lineages are established, the between lineage structure in data will overshadow the within lineage lack of structure and correlations between developmentally independent variables will increase. This prediction was tested (Maze, 1983) by comparing cone and needle variables at various taxonomic levels (both sub- and supraspecific) within Abies. The prediction was corroborated.

A brief paper on the ability of natural selection to explain the evolution of taxa was produced (Maze and Bradfield, 1982). That paper demonstrated that one is capable neither of confirming nor denying that natural selection is an agent in the evolution of species and higher taxa. Thus, the use of natural selection to explain the evolution of taxa becomes an untestable hypothesis and, as such, is beyond the realm of science. The evolution of taxa seems to be the result of the natural increase in variation shown by taxa and lineages as proposed by Wiley and Brooks (1982). This increase in variation in taxa is proposed to be a manifestation, in terms of information, of the second law of thermodynamics. As such, evolution is a biological example of a physical law.

As a related topic, there has been research in the kinds of explanations that can be applied in biological systems. One kind makes use of natural laws (statements that are true anywhere in the universe) and can be applied to evolution (Wiley and Brooks, 1982) or ontogeny (Maze and Scagel, 1983). Such explanations are causal, the causal agent being the natural law (Maze and Scagel, submitted). The other kind of explanation has a future known state (goal) as a part of it and is a teleological explanation (Beckner, 1959). The future known states (goals) in biology are survival and reproduction and the various functions related to survival and reproduction are the means whereby the goals are attained. Based on this analysis, it would seem that the new theory of evolution of Wiley and Brooks (1982) would have little impact on reforestation and tree improvement since these are teleological research problems and the theory of Wiley and Brooks (1982) is non-teleological. However, if Wiley and Brooks (1982) are correct, then it will be difficult indeed to maintain genetically uniform stock regardless of the techniques used.

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FOREST GENETICS AND TREE BREEDING AT THE FACULTY OF FORESTRY, UNIVERSITY OF BRITISH COLUMBIA, VANCOUVER, 1981-1983

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Key Words: forest genetics, education, karyotype, Douglas-fir, reproductive phenology, seed orchard, genetic variance.

The reorganization of the Faculty into three Departments and furthermore the implementation of the new 4-year curriculum provided an opportunity to develop two interest areas; one in "Forest Genetics and Artificial Regeneration" in Forest Resource Management, and the other in "Forest Genetics" in Forest Sciences Major Study Program. Although in the past Forest Genetics as a one term elective course was taken by 6-10% of the undergraduate students, the new program will allow students in the management field to enhance their knowledge mainly on the tree improvement aspect of the description, while students with teaching and research objectives in the field of science will have an opportunity to build up their genetics base during this undergraduate year. Each undergraduate student has been exposed to genetics and tree improvement principles during Dendrology and Silviculture I courses. Two graduate courses are also offered every year to graduate students in forest genetics and other related courses within the genetics program at UBC.

Dr. D. Lester, forest geneticist from Crown Zellerbach Ltd., was appointed as Adjunct Professor. He directs graduate students serving on their committees, and presents lectures and seminars to undergraduate and graduate students.

Dr. El-Kassaby, as a special NSERC postdoctoral fellow, published the results of his Ph.D. research, assisted graduate students in their theses analysis, gave lectures to undergraduate students and lectured at the Pacific Forest Research Centre on the use of isozyme research in forest genetics.

Dr. Y. Chen, Professor at Nanking Forestry School, is spending a year at the Faculty as a CIDA/NSERC scholar. He is working on the optimum temperature requirements on eleven provenances of the Chinese mahagony (Toona sinensis).

Dr. Sziklai cooperated with Professor Tompa at the Faculty of Forestry, Sopron University and published a textbook on forest genetics.

He is actively involved in the Coast and Interior Tree Improvement Committees. He cooperated with the Chinese Academy of Science to develop and implement a breeding program on Paulownia. He gave a series of lectures on forest genetics at the Nanking Forestry School.

GRADUATE STUDENT PROGRAM

Two graduate students completed their Master's Program requirements;

Mrs. R. Musoke on "Juvenile-mature correlations in selected Douglas-fir provenanced and progenies" in 1981. She studied growth and branch characteristics of thirteen year old Douglas-fir trees with the objectives of partitioning the variance into additive and non-additive, estimating heritabilities and juvenile-mature genetic correlations. High correlations could be used in early selection to reduce the progeny testing periods with possible advantage of increasing selection differential and hence genetic gains.

Most of the traits rendered non-significant additive variance, consequently non-significant heritabilities. Among the juvenile traits, embryo class and dormancy period revealed significant genetic correlations with the thirteen year-old root collar diameter (0.73 and 0.32 respectively).

Mrs. A.M. Colangeli defended her M.Sc. thesis on "Comparative karyotype analysis of the Pseudotsuga genus" in 1982. Numerical data were collected from the karyotypes of seven species in the Pseudotsuga genus, P. forrestii, P. sinensis, P. gaussenii, P. Japonica, P. wilsoniana, P. macrocarpa and both varieties of P. menziesii, (var. menziesii and var. glauca. A comparative karyotype study utilized chromosome number, secondary constrictions and chromosomal characteristics, to identify and separate the different species.

Both varieties of P. menziesii contained somatic chromosome number of 2n=26 consisting of five metacentrics, six submetacentrics and two telocentric pairs. P. macrocarpa and the five Asiatic species characterized with 2n=24 somatic chromosome number of which six are metacentric and six are submetacentric pairs.

An analysis of variance and a multivariate stepwise discriminant function analysis were employed to test the validity of using karyotype data such as arm ratio, centromere index, morphological index and relative length for characterizing the cytogenetical and the geographical differences for each of the six species with n=12. Good discrimination was shown among P. macrocarpa and the Asiatic species for both the analysis of variance and the multivariate analysis. The discrimination among the Asiatic species was further improved when the well separated P. macrocarpa was omitted.

A high level of discrimination was observed between the two varieties of Douglas-fir by both the t-test and the multivariate analysis. The multivariate analysis was particularly helpful in selecting variables that best separated the taxa.

Results were presented at the IUFRO Working Parties meeting in Sensenstein (1982), and was published in the Can. J. Bot. 61:536-544 (1983).

Presently three students are working towards their postgraduate degrees; Mrs. R. Davidson, Ph.D.; Mr. Z. Ibrahim, M.F.; and Mr. P. Jefferson, Ph.D.

RESEARCH

A. In cooperation with Mrs. A.M.K. Fashler, Pacific Forest Products' seed orchard manager, the following projects are presently under investigation:

1. Reproductive phenology and its impact on genetically improved seed production. Results were presented in the Northwest Scientific Assoc. Meeting in Olympia (1983) the manuscript has been accepted for publication by Silvae Genetica.

2. Assessment of pollen contamination in Pacific Forest Products' high elevation seed orchard. Results were presented in B.F.S. Thesis, Clare, L.R. (1983) and a manuscript for publication is in preparation.

3. Genetic variation of cone production. Seven years data of cone production were collected and analysed to study the magnitude of genetic variation and to utilize the information in the orchard's roguing strategy. Manuscript is in preparation.

4. Effect of irrigation cooling system on reproductive bud development. The reproductive bud development of every tree in the orchard was monitored for the past three years. The cooling system was in operation in 1983. The 1981 and 1982 data were collected under natural conditions. Assessment on the effect of cooling system will be made after completion of analysis.

B. The use of X-ray energy-dispersive technique for seed origin identification

In co-operation with Dr. J.A. McLean the feasibility of using the X-ray energy-dispersive trace element profiles technique for seed origin identification is one of the undergoing projects. Results were encouraging and the Sitka spruce study has been accepted for publication in the Can. J. For. Res. and a report of the lodgepole pine study was submitted for publication.

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ATTENDANCE, AUGUST 1983

PROCEEDINGS, PART 2

SYMPOSIUM:

CLONAL FORESTRY: ITS IMPACT ON TREE IMPROVEMENT AND OUR FUTURE FORESTS

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WORKSHOPS:

1. Production and Utilization of Genetically Improved Seed

C.W. Yeatman	Production of genetically improved jack pine seed for planting and direct seeding.
Y. Lamontagne	Strategies for the production of improved seed in Quebec.
J.D. Simpson	Progress on improved seed production in the Maritimes.
R.F. Calvert	Operational collection of spruce seed in Ontario.
B.S.P. Wang	Overview of utilization of improved seed.
J. Schilf	Processing and utilization of seed for production of container stock for reforestation in Alberta.
D.A. Skeates	Improved seed efficiency through high density accelerated production of coniferous transplants.
R.A. Klapprat	Seed efficiency in hardwood stock production.

2. Isozymes in Tree Improvement

3. North American Quantitative Forest Genetics Group Meeting - 1983.

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