

DO NOT REMOVE

FILE COPY

PROCEEDINGS
OF THE
TWENTIETH MEETING
OF THE
CANADIAN TREE IMPROVEMENT
ASSOCIATION

PART 1:
MINUTES AND MEMBERS' REPORTS

HELD IN
QUEBEC CITY, QUEBEC
AUGUST 19-22, 1985

EDITORS:
C.W. YEATMAN & T.J.B. BOYLE

Part 1. Minutes and Members' Reports

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

Part 2. New Ways in Forest Genetics

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

Additional copies of this publication are available from:

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

Produced by
Canadian Forestry Service,
for the
Canadian Tree Improvement Association,
Ottawa, 1986

COMPTES RENDUS
DE LA
VINGTIÈME CONFÉRENCE
DE
L'ASSOCIATION CANADIENNE POUR
L'AMÉLIORATION DES ARBRES
PARTIE I
PROCÈS-VERBAUX ET RAPPORTS DES MEMBRES

TENUE À
QUÉBEC (QUÉBEC)
DU 19 AU 22 AOÛT 1985

RÉDACTEURS
C.W. YEATMAN & T.J.B. BOYLE

Partie I. Procès-verbaux et rapports des
membres

Distribué aux membres de l'association et aux
autres sur demande au rédacteur,
A.C.A.A./C.T.I.A., Chalk River (Ontario)
Canada, K0J 1J0.

Partie II. Voies nouvelles en génétique
forestière

Distribué à l'échelle mondiale aux personnes
et aux organisations activement engagées ou
intéressées à la génétique forestière et à
l'amélioration des arbres.

Des exemplaires de cette publication peuvent
être obtenus à l'adresse suivante:

Rédacteur A.C.A.A./C.T.I.A.
Service canadien des forêts
Institut forestier national de Petawawa
Chalk River (Ontario) K0J 1J0

Publié par
le Service canadien des forêts
pour
l'Association canadienne pour
l'amélioration des arbres,
Ottawa, 1986

PROCEEDINGS OF THE TWENTIETH MEETING OF
THE CANADIAN TREE IMPROVEMENT ASSOCIATION

With the compliments of the Association

*Enquiries may be addressed to the authors or to Mr. J.F. Coles,
Executive Secretary, C.T.I.A./A.C.A.A., c/o Ontario Tree Improvement Council,
Johnston Hall, University of Guelph, Guelph, Ont. N1G 2W1.*

IF YOUR ADDRESS ON THE LABEL IS INCORRECT OR INCOMPLETE,
PLEASE RETURN CORRECTION SLIP BELOW

*Others interested in receiving Proceedings, notice of meetings
etc. may return the slip to be listed as Corresponding Members (Canadian) or
be placed on the mailing list for the Proceedings only (libraries,
institutions, foreign addressees). If you no longer wish to receive these
Proceedings, please check "delete" and return the completed slip to the
Editor.*

*The Twenty-first Meeting of the Association will be held in Truro,
Nova Scotia, August 17-21, 1987. Speakers will be invited to address the
topic of "Progressing together on Co-operative Tree Improvement Programs in
Canada". Canadian and foreign visitors are welcome. Further information will
be distributed in the winter 1986 to all members and to others on request.
Enquiries concerning the 21st Meeting should be addressed to: Mr. Howard
Frame, Tree Breeding Centre, Dept. of Lands and Forests, Debert, N.S.
B0M 1G0.*

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

PLEASE PRINT

Name: *Prof. Ms.
Dr. Mr.*

Address: *.
.
. Postal Code*

Please check one: *Correction
New addressee
Delete from C.T.I.A. mailing list*

Signed

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

Don gracieux de l'association

Les demandes de renseignements peuvent être adressées aux auteurs ou à J.F. Coles, Secrétaire général, A.C.A.A./C.T.I.A., c/o Ontario Tree Improvement Council, Johnston Hall, University of Guelph, Guelph, Ont. N1G 2W1.

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

Ceux qui seraient intéressés à recevoir les comptes rendus, les avis de réunions, etc., doivent retourner la formule pour être ajoutés à la liste des membres correspondants (Canadiens), ou à la liste d'envoi pour les comptes rendus seulement (bibliothèques, institutions, destinataires à l'étranger). Si vous ne desirez plus recevoir ces comptes rendus, veuillez cocher "rayer" et retourner la formule remplie au rédacteur.

La vingt et unième conférence de l'association aura lieu à Truro, en Nouvelle-Écosse, du 17 au 21 août 1987. Des orateurs seront invités à adresser le sujet de "Nos efforts vis-à-vis les programmes coopératifs de l'amélioration des arbres au Canada". Les intéressés au Canada et à l'étranger sont les bienvenus. Des renseignements supplémentaires seront distribués au cours de l'hiver de 1986 à tous les membres et à tous ceux qui en feront la demande. Si vous avez des questions à poser concernant la 21^e conférence veuillez les adresser à: M. Howard Frame, Tree Breeding Centre, Dept. of Lands and Forests, Debert, N.S. B0M 1G0.

À: T.J.B. Boyle, rédacteur, A.C.A.A./C.T.I.A.
Service canadien des forêts
Institut forestier national de Petawawa
Chalk River (Ontario) K0J 1J0

LETTRES MOULÉES

Nom: Dr
M.
Mme

Adresse:
.
. Code postal

s.v.p. cocher une seule case: Correction
Nouveau destinataire
Rayer le destinataire de la liste d'envoi
de l'A.C.A.A.

Signé

TABLE OF CONTENTS/TABLE DES MATIÈRES

	<u>Page</u>
LIST OF ACTIVE MEMBERS, CANADIAN TREE IMPROVEMENT ASSOCIATION ...	1
OBITUARY	11
HONORARY MEMBER	12
BUSINESS MEETING - MINUTES	
227 Minutes of Last Meeting	14
228 Chairman's Report	14
229 Financial Statement	14
229 Editor's Report	14
231 Membership	15
232 Business Arising from Previous Meetings	16
233 New Business	17
234 Future Meetings	18
235 Election of Officers	19
236 Adjournment	19
POSTER SESSION - TITLES AND AUTHORS	22
FIELD TOURS	30
SPEECHES	38
MEMBERS' REPORTS	
Newfoundland - Department of Forest Resources and Lands	
C. Harrison Tree Improvement in Newfoundland and Labrador: A Progress Report	45
Newfoundland - Canadian Forestry Service	
J.P. Hall Tree Breeding at the Newfoundland Forestry Centre	49
Nova Scotia - Department of Lands and Forests	
T.J. Mullin Cooperative Tree Improvement in H.M. Frame Nova Scotia: 1983-85	53
New Brunswick - Department of Natural Resources	
R.D. Bettie Tree Improvement at NB Department E.D. Stinson of Natural Resources	56

	<u>Page</u>
New Brunswick - Canadian Forestry Service	
D.P. Fowler Tree Breeding at the Maritimes Forest	
J.M. Bonga Research Centre: 1983 and 1984	58
Y.S. Park	
J.D. Simpson	
R.F. Smith	
New Brunswick - NBIP Forest Products Inc.	
H. Bitto NBIP's Efforts in NBTIC	
Cooperative Program	64
New Brunswick - University of New Brunswick	
G.R. Powell Tree Seed and Forest-Genetic Studies	
E.K. Morgenstern at the University of New Brunswick:	
1983-1985	66
Québec - Ministère de l'Énergie et des Ressources	
R. Beaudoin Amélioration des arbres forestiers	
A. Stipanovic au service de la recherche du	
G. Vallée ministère de l'Énergie et des	
Ressources du Québec	75
Y. Lamontagne Récolte de cônes et amélioration	
génétique des arbres forestiers au	
Québec	85
Québec - Service canadien des forêts	
A. Corriveau Activités de recherche du S.C.F. en	
J. Beaulieu en génétique et amélioration des	
G. Daoust arbres forestiers au Québec	87
Québec - Compagnie internationale de papier du Canada	
J. Begin C.I.P.'s Tree Improvement Activities ...	93
A. Dion	
G. Crook	
Québec - Université du Québec en Abitibi-Témiscamingue	
G.E. Caron Research in Tree Seed, Seedling Growth,	
and Pollination, 1983-85	98

		<u>Page</u>
Ontario - Ministry of Natural Resources		
W.D. Baker	Tree Improvement Progress in Ontario's Northwestern Region, 1983-1985	101
B.A. Barkley	Fast Growing Forests: Tree Improvement Strategy for Eastern Ontario	104
G.P. Buchert	Forest Genetics and Tree Improvement Research at Maple: 1983-1985	109
A.G. Gordon	Breeding, Genetics and Genecological Studies in Spruce for Tree Improvement in 1983 and 1984, Sault Ste. Marie, Ontario	112
R.B. Greenwood	Tree Improvement in Ontario's Northern Region	117
R.H. Ho	Cone Induction and <u>IN VITRO</u> Culture in Some Forest Tree Species	120
R.M. Rauter S. Stubber	Recent Developments in Ontario's Provincial Tree Improvement Program	124
V.H. Wearn	Northern Region's Black Spruce Tree Improvement Program	128
Ontario - Canadian Forestry Service Petawawa National Forestry Institute		
C.W. Yeatman	P.N.F.I. Genetics and Breeding: Genetics of Jack Pine: 1984-85	130
T.J.B. Boyle	Black Spruce Genetics, Petawawa National Forestry Institute 1983-85	133
G. Murray W.M. Cheliak	Genetics of White Spruce, Larches and Hardwoods, Petawawa: 1983-85	136
W.M. Cheliak J.A. Pitel	Molecular Genetics and Plant Tissue Culture: 1983-85	139
B.S.P. Wang P.S. Janas H.O. Schooley	National Tree Seed Centre: 1983-85	145

	<u>Page</u>
Ontario - Canadian Forestry Service Petawawa National Forestry Institute	
W.H. Fogal Control and Monitoring of Seed and Cone Insects of White and Black Spruce - Petawawa: 1983-84	150
Ontario - Lakehead University	
P. Knowles Forest Genetics Research Activities R.E. Farmer at Lakehead University: 1983-85 W.H. Parker	154
Ontario - University of Toronto	
L. Zsuffa Forest Genetics and Tree Breeding at R. Gambles the Faculty of Forestry, University of Toronto: 1984-85	156
Saskatchewan - Agriculture Canada, Tree Nursery Division, PFRA	
W.R. Schroeder Shelterbelt Tree Improvement, PFRA Tree Nursery: 1983-85	163
Saskatchewan - Prince Albert Pulpwood	
D.M. Roddy Prince Albert Pulpwood Tree Improvement Update	167
Alberta - Alberta Forest Service	
N.K. Dhir Genetics and Tree Improvement Program, J.M. Schilf Alberta Forest Service, 1983-85 A. Yanchuk	170
Alberta - Canadian Forestry Service	
J.I. Klein Jack Pine Seed Orchards for Manitoba, 1983-85	176
Alberta - University of Alberta	
B.P. Dancik Forest Genetics Activities at the University of Alberta, 1983-85	178

		<u>Page</u>
British Columbia - Ministry of Forests		
K. Illingworth	Tree Improvement and Associated Research, British Columbia Ministry of Forests, 1983-85	182
M.R. Carlson	Lodgepole Pine Breeding in the British Columbia Interior, 1983-85	183
J.C. Heaman	A Breeding Program in Coastal Douglas-Fir (<u>Pseudotsuga menziesii</u> Mirb, [Franco]), 1983-85	186
B.C. Jaquish	Genetic Improvement of Douglas-Fir in the British Columbia Interior, 1984-85	189
G.K. Kiss	Genetic Improvement of White and Engelmann Spruce in British Columbia, 1983-85	191
J. Konishi C. Bartram D. Summers M. Crown A. Wolfe M. Albricht P. Birzins C. Hewson	The Accomplishments of the Silviculture Branch, B.C. Ministry of Forests in Cooperative Tree Improvement, 1983-85	194
S.D. Ross A.M. Eastham	Seed Orchard Management Research	199
J. Russell	Clonal Propagation of Genetically Improved Stock for Production Planting	203
J.E. Webber	Improving Seed Yield and Genetic Quality of Seed Orchard Seed	204
J.H. Woods	Gene Archives and Western Hemlock Genetic Improvement in British Columbia	208
F.C. Yeh	Allozyme Variation in Conifers	212
C.C. Ying	Provenance Research in British Columbia: 1983-85	215

	<u>Page</u>
British Columbia - Canadian Forestry Service	
D.G. Edwards Cone and Seed Research and Seed G.E. Miller Certification, Pacific Forestry F.T. Portlock Centre, 1983-84	219
J.R. Sutherland	
M.D. Meagher Western White Pine Improvement R.S. Hunt Program for British Columbia	225
British Columbia - MacMillan Bloedel Ltd.	
R.C. Bower MacMillan Bloedel Limited Progress Report, 1984-85	227
British Columbia - CIP Forest Products Inc.	
Y.A. El-Kassaby CIP Forest Products' Tree Improvement Program and Forest Genetics Activities, 1983-85	231
British Columbia - University of British Columbia	
J. Maze Morphological Variation in Some R.K. Scagel Western Canadian Conifers	237
O. Sziklai Forest Genetics and Tree Breeding at the Faculty of Forestry, University of British Columbia, Vancouver, 1983-85	241
ABSTRACTS	
Wood Quality	246
Seed	248
APPENDICES	
Contents, Proceedings Part 2	
Symposium: New Ways in Forest Genetics	254
Attendance, August 1985	257

ACTIVE MEMBERS

August 1985

CANADIAN TREE IMPROVEMENT ASSOCIATION

Dr. J.D. Ambrose	University of Guelph Arboretum Guelph, Ontario, N1G 2W1
Mr. W.D. Baker	Min. Natural Resources 808 Robertson Street P.O. Box 5160 Kenora, Ontario, P9N 3x9
Dr. J. Balatinecz	Faculty of Forestry University of Toronto Toronto, Ontario, M5S 1A1
Dr. J.E. Barker	Western Forest Products Lost lake Seed Orchard 1020 Beckwith Avenue Victoria, B.C., V8X 3S4
Mr. B.A. Barkley	C/O Elma R.R. #2 Chesterville, Ontario, K0L 1H0
Mr. C.A. Bartram	Silviculture Branch B.C. Ministry of Forests 1450 Government Street Victoria, B.C., V8W 3E7
M. R. Beaudoin	Ministère de l'Energie et des Ressources Complexe Scientifique Ste. Foy, Québec, G1P 3W8
M. J. Beaulieu	Serv. Canadien des Forêts 1055 Rue du P.E.P.S. C.P. 3800 Ste. Foy, Québec, G1V 4C7
M. J. Bégin	CIP Incorporated 1115 Metcalfe Street, 12th Floor Sunlife Building Montreal, Quebec, H3B 2X1
Mr. L. Bennett	Ontario Pulp & Paper Co. Timmins, Ontario

Mr. Robert D. Bettie	Dept. Natural Resources Provincial Forest Nursery R.R. #6 Fredericton, N.B., E3B 4X7
Mr. Paul Birzins	B.C. Ministry of Forests Kalamalka Res. Station 3401 Reservoir Rd. Vernon, B.C., V1B 2C7
Mr. Helmut Bitto	NBIP Forest Products Inc. Woodlands Division P.O. Box 1950 Dalhousie, N.B., EOK 1B0
Mr. J.M. Bonga	Canadian Forestry Service Maritimes Forestry Centre P.O. Box 4000 Fredericton, N.B., E3P 5P7
Dr. R.C. Bower	Woodland Service Division MacMillan Bloedel Ltd. 65 Front Street Nanaimo, B.C., V9R 59
Dr. M.G. Boyer	Department of Biology York University 4700 Keele Street Downsview 463, Ontario, M3J 1P3
Dr. T.J.B. Boyle	Canadian Forestry Service Petawawa National Forestry Institute Chalk River, Ontario, K0J 1J0
Mr. J.D. Brophy	Ontario Pulp & Paper Co. Thorold, Ontario L2V 3Z5
Dr. G.P. Buchert	Ont. Tree Improvement and Forest Biomass Inst. Min. Natural Resources Maple, Ontario, L0J 1E0
Mr. Mike Butler	Dept. Energy and Forestry P.O. Box 2000 Charlottetown, P.E.I. C1A 7N8
Dr. M. Carlson	B.C. Ministry of Forests Kalamalka Research Stn. and Seed Orchard Vernon, B.C., V1B 2C7

Dr. G.E. Caron	Université du Québec en Abitibi-Temiscaming 42 rue Mgr Rheaume Est. C.P. 700 Rouyn, Québec, J9X 5E4
Dr. W.M. Cheliak	Canadian Forestry Service Petawawa National Forestry Institute Chalk River, Ontario, K0J 1J0
Mr. J.F. Coles	Ont. Tree Improvement Council Room 147, Johnston Hall University of Guelph Guelph, Ontario, N1G 2W1
Dr. Armand Corriveau	Service canadien des forêts 1055 Rue du P.E.P.S. C.P. 3800 Ste. Foy, Québec, G1V 4C7
Mr. Gregory Crook	C.I.P. Inc. R.R. #2 Calumet, Québec, J0V 1B0
Mr. Michael Crown	B.C. Ministry of Forest P.O. Box 816 Duncan, B.C., V9L 3Y2
Dr. B. Dancik	Dept. of Forest Science University of Alberta 720 Chem. Min. Eng. Bldg. Edmonton, Alberta, T6G 2G6
M. Gaetan Daoust	Service Canadien des forêts 1055 Rue du P.E.P.S. C.P. 3800 Ste. Foy, Québec, G1V 4C7
Dr. Narinder K. Dhir	Refor. & Rec. Branch Alberta Forest Service 9915-108 Street 8th Floor Mail Cage Edmonton, Alberta, T5K 2G9
Mr. A. Dion	CIP Inc. (Div. Forestière) 1053 Boul. Ducharme La Tuque, Québec, G9X 3P9

Mr. J. Dojack	Min. of Natural Resources District Office Geraldton, Ontario, POT 1M0
Dr. D.G. Edwards	Canadian Forestry Service Pacific Forestry Centre 506 West Burnside Road Victoria, B.C., V8Z 1M5
Dr. Y. El-Kassaby	C.I.P. Forest Products Inc. 8067 East Saanich Rd. R.R. #1 Saanichton, B.C., V0S 1M0
Dr. R.E. Farmer	School of Forestry Lakehead University Thunder Bay, Ontario, P7B 5E1
Ms. A.M.K. Fashler	Reg. Professional Forester P.O. Box 1603, Station A Vancouver, B.C., V6C 2P7
Dr. L. Zack Florence	Dept. Forest Science Univ. of Alberta Edmonton, Alberta T6G 2H1
Dr. W.H. Fogal	Canadian Forestry Service Petawawa National Forestry Institute Chalk River, Ontario, K0J 1J0
Dr. D.P. Fowler	Canadian Forestry Service Maritimes Forestry Centre P.O. Box 4000 Fredericton, N.B., E3B 5P7
Mr. H.M. Frame	Tree Breeding Centre N.S. Dept. Lands & Forests Debert, Nova Scotia, B0M 1G0
Dr. Robert Gambles	Research Associate Faculty of Forestry University of Toronto 203 College Street Toronto, Ontario, M5S 1A1
Mr. William Glen	Dept. Energy and Forestry P.O. Box 2000 Charlottetown, P.E.I., C1A 7N8

Dr. A.G. Gordon	Ont. Tree Improv. and Forest Biomass Inst. Min. Natural Resources Box 490 Sault Ste. Marie, Ontario, P6A 5M7
Mr. Richard Greenwood	Program Forester Timmins Regional Office OMNR and Energy 60 Wilson Street Timmins, Ontario, P4N 2S7
Dr. J.P. Hall	Canadian Forestry Service Newfoundland Forestry Centre P.O. Box 6028 St. John's, Newfoundland, A1L 5X8
Dr. Charles M. Harrison	Dept. For. Res. & Lands Herald Building P.O. Box 2006 St. John's, Newfoundland, A2H 6J8
Mr. J.C. Heaman	Research Branch B.C. Ministry of Forests 1450 Government Street Victoria, B.C., V8W 3E7
Mr. Clare Hewson	B.C. Ministry of Forests Red Rock Nursery R.R. #7 Prince George, B.C., V2N 2J5
Dr. R.H. Ho	Ont. Tree Improv. and Forest Biomass Inst. Min. Natural Resources Maple, Ontario, L0J 1E0
Mr. J.V. Hood	Forest Resources Branch Min. Natural Resources Parliament Buildings Toronto, Ontario, M7A 1W3
Mr. P. Janas	Canadian Forestry Service Petawawa National Forestry Institute Chalk River, Ontario, K0J 1J0
Mr. B. Jaquish	Vernon Research Centre B.C. Ministry of Forests 3401 Reservoir Rd. Vernon, B.C., V1B 2C7

Mr. Ingemar Karlsson	B.C. Ministry of Forests Cowichan Lake For. Exp. Stn. Mesachie Lake, B.C., V0R 2N0
Dr. C.T. Keith	Forintek Canada Corp. 800 Montreal Road Ottawa, Ontario, K1G 3Z5
Dr. R.M. Kellogg	Forintek Canada Corp. 6620 N.W. Marine Dr. Vancouver, B.C., V6T 1X2
Dr. M.A.K. Khalil	17 Diefenbaker Street St. John's, Newfoundland, A1A 2M2
Mr. G.K. Kiss	Vernon Research Station B.C. Ministry of Forests 3401 Reservoir Rd. Vernon, B.C., V1B 2C7
Dr. J.I. Klein	Canadian Forestry Service Northern Forestry Centre 5320-122 Street Edmonton, Alberta, T6H 3S5
Dr. Margaret H. Knowles	School of Forestry Lakehead University Thunder Bay, Ontario, P7B 5E1
Mr. J. Konishi	Silviculture Branch B.C. Ministry of Forests 1450 Government Street Victoria, B.C., V8W 3E7
M. Yves Lamontagne	Ministère de l'Energie et des Ressources Service Pépinières et Reboisement 200B Chemin Ste. Foy, Québec, G1R 4X7
Dr. Jack Maze	Univ. of British Columbia Dept. of Botany #3529-6270 Univ. Blvd. Vancouver, B.C., V6T 2B1
Dr. M.D. Meagher	Canadian Forestry Service Pacific Forestry Centre 506 West Burnside Road Victoria, B.C., V8Z 1M5

Mr. W. Moore	Great Lakes For. Prod. Ltd. P.O. Box 430 Thunder Bay, Ontario, P7C 4N3
Dr. E.K. Morgenstern	Dept. of Forest Resources Univ. of New Brunswick Bag No. 44555 Fredericton, N.B., E3B 6C2
Mr. T.J. Mullin	Tree Breeding Centre Dept. of Lands and Forests P.O. Box 190 Debert, Nova Scotia, BOM 1G0
Dr. Gordon Murray	Canadian Forestry Service Petawawa National Forestry Institute Chalk River, Ontario, KOJ 1J0
Mr. Bryan Nicks	E.B. Eddy Forestry Ltd. Station Road Espanola, Ontario, POP 1C0
Dr. M. Pandila	Saskatchewan Dept. of Park & Renewable Resources Forestry Division P.O. Box 3003 Prince Alberta, Saskatchewan S6V 6G1
Dr. Y.S. Park	Canadian Forestry Service Maritimes Forestry Centre P.O. Box 4000 Fredericton, N.B., E3B 5P7
Dr. William H. Parker	School of Forestry Lakehead University Thunder Bay, Ontario, P7B 5E1
Dr. Louis Parrot	Faculté de forestière et de Geodesie Université Laval Québec, Québec, G1K 7P4
Dr. R.P. Pharis	Dept. of Biology University of Calgary 2920 24th Ave. N.W. Calgary, Alberta, T2N 1N4
Mr. Jack A. Pitel	Canadian Forestry Service Petawawa National Forestry Institute Chalk River, Ontario, KOJ 1J0

Dr. J. Poliquin	Faculté de foresterie et de Geodesie Université Laval Québec, Québec, G1K 7P4
Dr. G.R. Powell	Dept. of Forest Science Univ. of New Brunswick P.O. Box 4400 Fredericton, N.B., E3B 6C2
Mr. W.E. Raitanen	Min. Natural Resources 60 Wilson Avenue Timmins, Ontario, P4N 2S7
Ms. Rose Marie Rauter	Forest Resources Branch Ontario Min. of Natural Resources Parliament Buildings Toronto, Ontario, M7A 1W3
Mr. S. Robertson	Canadian Forestry Service Newfoundland Forestry Centre P.O. Box 6028 St. John's, Newfoundland, A1C 5X8
Ms. Diane Roddy	Prince Albert Pulpwood Ltd. P.O. Box 1720 Prince Albert, Saskatchewan, S6V 5T3
Dr. S.D. Ross	B.C. Ministry of Forests Research Branch 4300 North Road Victoria, B.C., V8Z 5J3
Mr. John Russell	B.C. Ministry of Forests Cowichan Lake Res. Station P.O. Box 335 Mesachie Lake, B.C., VOR 2N0
Dr. R. Savidge	Dept. of Forest Resources Univ. of New Brunswick Bag No. 44555 Fredericton, N.B., E3B 6C2
Ms. Janet Schilf	Alberta Forest Service Energy & Natural Resource P.O. Box 634 Smokey Lake, Alberta, T0A 3C0
Mr. H. Schooley	Canadian Forestry Service Petawawa National Forestry Institute Chalk River, Ontario, K0J 1J0

Mr. William Schroeder	PFRA Tree Nursery Indian Head, Saskatchewan, S0G 2K0
Mr. R. Seabrook	Great lakes For. Prod. Ltd. P.O. Box 430 Thunder Bay, Ontario, P7C 4N3
Mr. S. Segaran	Forestry Branch Dept. of Natural Resources 300-530 Kenaston Blvd. Winnipeg, Manitoba, L3N 1Z4
Mr. Dale Simpson	Canadian Forestry Service Maritimes Forestry Centre P.O. Box 4000 Fredericton, N.B., E3B 5P7
Mr. D.A. Skeates	Ont. Tree Improvement and Forest Biomass Institute Min. Natural Resources Maple, Ontario, L0J 1E0
Mr. R.F. Smith	Canadian Forestry Service Maritimes Forestry Centre P.O. Box 4000 Fredericton, N.B., E3B 5P7
Mr. A. Stipanivic	Ministère de l'Energie et des Ressources Complexe Scientifique Ste. Foy, Québec, G1P 3W8
Dr. O. Sziklai	Faculty of Forestry University of B.C. 207-2357 Main Hall Vancouver, B.C., V6T 1W5
Dr. Gilles Vallée	Ministère de l'Energie et des Ressources Complexe Scientifique Ste. Foy, Québec, G1P 3W8
Mr. B.S.P. Wang	Canadian Forestry Service Petawawa National Forestry Institute Chalk River, Ontario, K0J 1J0
Mr. Ronald G. Wasser	J.D. Irving Co. Ltd. Sussex Tree Nursery R.R. #4 Sussex, New Brunswick, EOE 1P0

Mr. Patrick Wearmouth	Procter & Gamble Ltd. Cellulose Ltd., Postal Bag 1020 Grande Prairie, Alberta, T8V 3A9
Mr. Victor Wearn	Northern Forest Devel. Group Timmins Regional Office Min. Natural Resources Timmins, Ontario, P4N 2S7
Dr. D. Webb	Queen's University Biology Dept. Kingston, Ontario, K7L 3N6
Dr. J.E. Webber	Research Branch B.C. Ministry of Forests 4300 North Road Victoria, B.C., V8Z 5J3
Mrs. A. Wood	P.O. Box 57 Newcastle, Ontario, L0A 1H0
Mr. J.H. Woods	Cowichan Lake Res. Stn. B.C. Ministry of Forests P.O. Box 335 Mesachie Lake, V0R 2N0
Dr. A. Yanchuk	Refor. & Rec. Branch Alberta Forest Service 9915-108 Street 8th Floor Mail Cage Edmonton, Alberta, T5K 2G9
Dr. C.W. Yeatman	Canadian Forestry Service Petawawa National Forestry Institute Chalk River, Ontario, K0J 1J0
Dr. F. Yeh	Research Branch B.C. Ministry of Forests 1450 Government Street Victoria, B.C., V8W 3E7
Dr. Cheng Ying	Research Branch B.C. Ministry of Forests 1450 Government Street Victoria, B.C., V8W 3E7
Mr. B. Yuill	Scott Paper Co. Ltd. P.O. Box 549D New Glasgow, Nova Scotia, B2H 5E8
Dr. L. Zsuffa	Faculty of Forestry University of Toronto Toronto, Ontario, M5S 1A1

Hugh George MacGillivray

George MacGillivray died in Fredericton, N.B. on August 31, 1984. George was born in Sydney, Nova Scotia in 1920 where he received his primary and secondary education. He enlisted in the Canadian Armed Forces (Royal Canadian Artillery) in 1939 the day after Germany invaded Poland and eight days before Canada officially entered World War II. He subsequently served with distinction in the West Nova Scotia Regiment. He was seriously wounded in 1944 crossing the Lamone River in Italy.

George entered the University of New Brunswick in 1946 and was awarded a BSc Forestry degree in 1949. He obtained his Masters of Forestry degree from the University of Michigan in 1950. In June 1950 he joined the Canadian Forestry Service, Maritime District, where he was employed until his retirement in December 1976.

Essentially all of George's professional career was devoted to research and development in forest genetics and tree improvement. He pioneered research in this field in the Maritimes where he succeeded in laying the foundation for a valuable research program despite difficult obstacles. George established numerous species and provenance trials throughout the Maritimes Region in close cooperation with Mark Holst at P.N.F.I. and many provincial and industrial representatives in the Region. He planted replicated trials of black, red, white, and Norway spruces, jack and red pines, balsam fir, Douglas fir, Japanese, European and native larches and yellow birch as well as numerous other species. His foresight in establishing these trials and in maintaining detailed records over a period of almost 25 years has left the Maritimes a legacy of valuable materials and information as a basis for current tree improvement activities.

George was an active member of the C.T.I.A. throughout his professional career and upon his retirement was elected as an honorary member. He maintained a strong and continuing interest and served in positions of responsibility in several organizations including the Royal New Brunswick Rifle Association (life member and past president), and the Fredericton Rifle Club (president). Throughout his life he maintained a keen interest in Scottish affairs and at the time of his death he was Honorary President of the Fredericton Society of Saint Andrew.

George will long be remembered by numerous friends and colleagues for his ability to overcome severe physical handicaps and to contribute to his fellow man with his knowledge, skills, generosity and friendship. He is survived by his life companion, friend and wife, Dr. Ellen MacGillivray.

HONORARY MEMBER
MEMBRE HONORAIRE

Dr. W.H. Cram



Dr. W.H. Cram

Dr. W.H. "Bill" Cram was born at Morden, Manitoba in 1913. He completed his highschool education to grade 12 at Morden in 1932 and graduated from the University of Manitoba in 1939 with a B.S.A., majoring in Plant Science and Horticulture. From 1934 to 1938 Bill was employed seasonally by the Experimental Farm at Morden, as a labourer and student assistant in the Pomology Section for propagation and breeding work. From 1939 to 1941, he was employed at the University of Manitoba as a summer supervisor of vegetable trials and also as a lecturer and laboratory instructor for Horticulture. From 1941 to 1942, Bill was employed with the Dominion Forest Nursery Station at Indian Head, Saskatchewan, as a tree planting supervisor. Bill joined the R.C.A.F. in 1942, where he served in Canada and Europe until 1945. Upon his return from war service, Bill returned to Indian Head, where he was employed at the Experimental Farm as a Horticulturist. During this time he also attended the University of Manitoba, from where he graduated in 1948 with his M.Sc. in Plant Breeding and Biometrics. In 1947 Bill again began work at the Forest Nursery Station in Indian Head as a Tree Breeder and conducted related propagation research. During this time, Bill also attended the University of Minnesota, where he obtained his Ph.D. in Plant Breeding and Genetics in 1950.

From 1947 to 1958, Bill was actively involved in a tree improvement program and had many papers published related to his work at the nursery. His extensive work with caragana and his promotion of this species earned him the title of "Caragana Bill".

In 1958 Bill was appointed Superintendent of the Canada Agriculture Nursery Station at Indian Head, and served in this capacity until his retirement in December of 1977. Although his duties as Superintendent reduced the time available for research, he continued to supervise an extensive and diverse program of applied research and equipment development which resulted in the nursery changing from a manual operation to one where herbicides and machines were of considerable importance.

After his retirement in 1977, Bill was rehired by the Prairie Farm Rehabilitation Administration (PFRA) Tree Nursery on a part time basis, to write up research projects which had been done during his tenure at the nursery.

Perhaps Bill's greatest contribution to prairie forestry and horticulture has been his great enthusiasm in promoting tree plantings, as well as his unending desire to improve the plant material available for prairie planting.

BUSINESS MEETING MINUTES
COMPTES RENDUS DE LA RÉUNION D'AFFAIRES

BUSINESS MEETING - MINUTES

Dr. A. Corriveau chaired the 20th Business Meeting of the CTIA/ACAA held in Pavillon De Koninck, Université Laval, Quebec City, on Tuesday, August 20, 1985.

227. MINUTES OF THE LAST MEETING

Motion: That the minutes of the 19th business meeting be approved as published.

Moved by D.P. Fowler, seconded by B. Cheliak. Carried.

228. CHAIRMAN'S REPORT

Dr. Corriveau commented on the busy term in office. Of particular interest was the Forest Research Advisory Committee of Canada meeting and their request for forest genetics research priorities from the CTIA. Recently the chairman has pursued incorporation of the CTIA and redesigning the letterhead. The CTIA received a Canada At Work grant to employ 3 students for 5 months to organize this meeting.

229. 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 \$9,274.48 in the association's account as of August 16, 1985.

Motion: That the financial statement be accepted as presented.

Moved by G. Vallee, seconded by F. Yeh. Carried.

C.W. Yeatman stated that the CTIA should have their financial statement audited - particularly if the CTIA desires to become incorporated.

Motion: That the CTIA/ACAA have their financial statement audited and the cost be borne by the CTIA.

Moved by C.W. Yeatman, seconded by W. Baker. Carried.

230. EDITOR'S REPORT

C.W. Yeatman reported that the Proceedings of the 10th meeting were produced and distributed rather tardily due to not receiving camera ready versions of papers.

The CTIA accepted the resignation of C.W. Yeatman as Editor.

Motion: To thank Kit Yeatman for the excellent services provided as Editor of the CTIA during the past several years.

Moved by G. Vallee. Carried.

231. MEMBERSHIP

a) Honorary Member

Dr. William H. Cram was proposed by C.W. Yeatman and seconded by W. Schroeder, A. Gordon and D. Fowler.

Dr. Cram has been a breeder of spruce and Caragand for many years and head of PFRA, Indian Head Nursery, Saskatchewan.

Motion: That Dr. W.H. Cram be elected Honorary Member. Carried.

b) The following were nominated as new active members:

Dr. J.J. Balatinecz	Univ. of Toronto, Faculty of Forestry
Mr. L. Bennett	Ontario Paper Co., Timmins, Ontario
Mr. D. Brophy	Ontario Paper Co., Thorold, Ontario
Mr. J. Dojack	OMNR, N.C.R., Thunder Bay, Ontario
Dr. R. Gambles	Univ. of Toronto, Faculty of Forestry
Mr. K. Greenwood	OMNR, N.R., Timmins, Ontario
Dr. C.T. Keith	Forintek Canada Ltd., Eastern F.P. Lab.
Dr. R.M. Kellogg	Forintek Canada Ltd., Western F.P. Lab.
Mr. W. Moore	Great Lakes For. Prod. Ltd., Thunder Bay, Ontario
Mr. B. Nicks	E.B. Eddy Co., Espanola, Ontario
Dr. J. Poliquin	Université Laval, Faculty of Forestry
Mr. J. Russell	B.C. Ministry Forest, Dept. For. Resources
Dr. R. Savidge	Univ. New Brunswick, Dept. For. Resources
Mr. W. Schroeder	PFRA Tree Nursery, Indian Head, Sask.
Mr. R. Seabrook	Great Lakes For. Prod. Ltd., Thunder Bay, Ontario
Mr. V. Wearn	OMNR, N.R., Timmins, Ontario
Mr. P. Wearmouth	Proctor & Gamble Ltd., Grande Prairie, Alberta
Dr. D. Webb	Queens Univ., Biology Dept., Kingston, Ontario
Dr. A. Yanchuk	Alberta Forest Service, Edmonton

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

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

C.W. Yeatman stated that 33 new corresponding members were added to the list along with 12 Institutions. There were 11 deletions and 60 address changes.

232. BUSINESS ARISING FROM PREVIOUS MEETINGS

a) Education Committee (E.C.)

J. Begin stated that five of the six universities sent students to this meeting in response to offer of travel expenses by CTIA.

Since the last meeting, the E.C. had pursued scholarship funds from industry and received pledges for about \$3000. Some concern was voiced that this had been done without the authority of the membership.

Motion: That the approximately \$3000 received from industry for graduate student scholarship be invested immediately with a view to beginning a scholarship as soon as funds permit and that further solicitations to industry take place after this meeting and subsequent incorporation of the CTIA/ACAA.

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

Some discussion ensued on the difficulties involved in administering such a scholarship.

b) Forest Gene Resources

C.W. Yeatman attended a Plant Gene Resources meeting and presented a paper. Forest genetic resources are retained more readily than is the case with domesticated agricultural crop species. Gene resources will be maintained by the new planted forests and in wild stands designated and regenerated as genetic resource areas.

c) Forest Tree Seed Act

D. Pollard stated that with the CFS move from Environment Canada to Agriculture Canada there is no need to revise Canada Tree Seed Act to accommodate forestry concerns. Completion of the Forest T.S. Act has been delayed by the necessity to having the act in 2 languages and the constant legal review this requires. Once completed, approval will come by Order-In-Council. Pollard reported that no reports from the CTIA committee have been received and that the CTIA must take an active role in drafting the appendices to the Act.

The CFS has inspected and certified 3 orchards in B.C.

G. Vallee raised concerns about Plant Breeders Rights. Pollard suggested that because of extreme controversy and resistance the Plant Breeders Rights Act may not be passed.

d) Tree Seed Working Group

B. Wang reported that during the business portion of yesterday's meeting the Tree Seed W.G. had elected Y. Lamontange as chairman and H. Schooley as editor of newsletter.

233. NEW BUSINESS

a) Forest Research Advisory Committee of Canada

A. Corriveau reported that FRACC requested CTIA prioritize forest genetics research.

Motion: That the CTIA/ACAA form a standing committee to advise and recommend research priorities on Forest Genetics in Canada to FRACC and that the 85/87 Chairman appoint a minimum of 3 active members to the committee for a 2 year term.

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

b) Biotechnology Working Group

W. Cheliak reported that some months ago forest biotechnology scientists met in Saskatoon and formed the Canadian Association for Conifer Biotechnology and recommend that no further action be taken by the CTIA but that the CACB would gladly report progress to the CTIA.

c) Wood Quality Working Group

See attachment #2.

Motion: That a Wood Quality Working Group be established within the CTIA and that the Treasurer provide the Group with up to \$500 for operating expenses if needed.

Moved by R. Kellogg, seconded by D. Fowler. Carried.

d) Incorporation of CTIA/ACAA

A. Corriveau reported it would be easier for CTIA/ACAA to attract corporate and government funding if the association was incorporated.

Motion: That an ad hoc committee be formed by the new executive to investigate the necessary procedures and proceed toward incorporation within a one year period.

Moved by W. Cheliak, seconded by A. Gordon. Carried.

e) Letterhead Revision

A. Corriveau presented a new design.

Motion: That the new design as proposed by A. Corriveau be adopted as presented.

Moved by C.W. Yeatman, seconded by W. Cheliak. Carried.

f) Cost of Publishing Proceedings

D. Winston expressed a CFS concern that the cost of publishing the proceedings (Parts 1 and 2) - borne by the CFS - was escalating beyond reason.

Motion: That the CTIA attempt to reduce the costs and paperwork involved in the production and distribution of the Proceedings and Members' Reports.

Moved by D. Winston, seconded by D. Fowler. Carried.

The new executive will appoint an ad hoc committee - chaired by the new editor - to address the motion.

g) Business Meeting Schedule

Motion: That all future business meetings be held during the late afternoon so that attendees can lieisurely enjoy the culinary fantasies of the cities involved.

Moved by J. Coles, seconded by W. Cheliak. Carried.

234. FUTURE MEETINGS

a) Location of 1987 Meeting

The chairman called to attention the resolution passed by the 19th meeting (item 223b) which stated that the 21st meeting be held in Nova Scotia. T. Mullin of NS Dept. L & F confirmed that Nova Scotia would host the meeting and that the new executive would determine a theme.

b) Location of 1989 Meeting

An invitation was received from the Alberta Forest Service to host the 22nd meeting in Alberta.

Motion: That the CTIA/ACAA hold its 1989 meeting in Edmonton, Alberta.

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

c) Location of 1991 Meeting

An expression of interest was received from Petawawa National Forestry Institute.

235. ELECTION OF OFFICERS

The nominating committee chairman, D.P. Fowler, proposed the following slate of officers for election:

Chairman	T.J. Mullin
Vice-Chairman - Symposium	E.K. Morgenstern
Vice-Chairman - Arrangements	H. Frame
Executive Secretary	J.F. Coles
Treasurer	C.W. Yeatman
Editor	T.J.B. Boyle

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

Motion: That the slate of officers proposed be elected.

Moved by D.P. Fowler, seconded by G. Murray. Carried.

236. ADJOURNMENT

Motion: That members of the CTIA/ACAA thank the executive committee for a well-organized and thought-provoking meeting.

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

Motion: That the 20th business meeting of the CTIA/ACAA be adjourned.

Moved by N.K. Dhir, seconded by W.M. Cheliak. Carried.

Financial Statement, 1983-85 - Attachment #1

Canadian Tree Improvement Association/
Association Canadienne pour l'Amélioration des Arbres

August 20, 1985

Balance 17th August 1983	\$5,125.58
Income (19th Meeting plus interest)	\$8,403.01
Expenses	<u>\$4,254.11</u>
Balance	\$9,274.48

WOOD QUALITY WORKING GROUP - Attachment #2

Considering the interest in wood quality in Canadian tree improvement programs it would be desirable to create an organization through which communication can take place between tree improvement workers and wood scientists. The purpose of the organization would be to stimulate, support and coordinate wood quality activities in Canadian tree improvement programs. Specifically, the group would:

1. Serve as a source of technical information on wood quality required by tree improvement programs.
2. Standardize and coordinate methods of sampling and measuring wood quality characteristics in order to insure compatibility and comparability of measurements.

It is suggested that the logical form for this important national activity would be the Canadian Tree Improvement Association. It is hereby requested that a Wood Quality Working Group be established within the C.T.I.A. to carry out these proposed activities. The following individuals have agreed to serve as the initial executive body of the Wood Quality Working Group.

Chairman: Robert M. Kellogg, Forintek Canada Corp.
Vice-Chairman: Alvin Yanchuk, Alberta Forest Service
Secretary: Jean Poliquin, Laval University

R.M. Kellogg
20/8/85

POSTER SESSION ABSTRACTS
RÉSUMÉS DES AFFICHES PRÉSENTÉES À LA SÉANCE

POSTER SESSION - TITLES, AUTHORS & ABSTRACTS¹

LE VERGER À GRAINES DE C.I.P. À HARRINGTON

M. Jacques Bégin
C.I.P. Inc. Montréal, Québec

En 1984, la compagnie C.I.P. Inc. inaugurerait le premier verger à graines industriel au Québec. Le verger, d'une superficie de 50 ha, est établi sur une ancienne terre agricole dans le canton Harrington près de Lachute au Québec. La production du verger à maturité est estimée à 22 millions de semences annuellement. Elle comprendra de l'épinette noire et du pin gris ainsi qu'un volume appréciable de graines d'épinette de Norvège et d'épinette blanche.

L'emplacement du verger comprend également un arboretum pour chacune des essences principales soit l'épinette noire et le pin gris.

Des tests de famille pour chacune des essences indigènes sont établis dans la région où s'est effectuée la sélection des arbres-plus.

COLLECTION OF BRANCHES, CONES, AND FOLIAGE FROM TALL TREES IN NEW ENGLAND

Petr R. Brym and Robert T. Eckert
Department of Forest Resources
University of New Hampshire, Durham, N.H.

Forest tree needles, leaves, cones, or seeds are used for various purposes in forestry, including monitoring of pollution and pest damage, genetic population structure analysis, and tree propagation. The desired items can be easily obtained from tall trees in tree orchards with the help of specially equipped bucket trucks, but collections in natural stands in Northern New England are hampered by dense, multiple-species forests, and rocky topography. The following poster summarizes approximate costs, effectiveness, advantages, and limitations of eight methods that may be used to collect needles, leaves, or cones in mature forest stands under conditions encountered in New England. The cost estimates vary between regions and organizations, but the information should help in comparing approximate costs of the methods available to workers planning to collect foliage, cones, or branches from tall trees in unmanaged forest stands.

¹For more information, contact authors directly.

TEST DE RÉSISTANCE DU PIN GRIS À LA MALADIE DU CHANCRE SCLÉRODERRIEN

Bussièrès, G.*; Dessureault, M.*; Laflamme, G.**

*Université Laval

**Centre de recherches forestières des Laurentides

Nous testons la résistance de 38 provenances de Pinus banksiana Lamb. à la maladie du chancre scléroderrien.

Le secteur expérimental se situe à environ 110 km au nord-ouest de Roberval, à la limite des régions forestières Laurentides-Onatchiway et Chibougamau-Natashquan. Les semis produits en récipients furent mis en terre au cours de l'été de 1983, dans un jeune peuplement de pin gris où la maladie était présente. Les plants sont établis dans un dispositif à bloc complet avec répétitions réparties au hasard.

Des branches infectées par Gremmeniella abietina (Lagerb.) Morelet ont été utilisées pour inoculer artificiellement les plants au printemps de 1984. le dénombrement des plants infectés permettra d'analyser et de vérifier l'existence de provenances résistantes à la maladie du chancre scléroderrien.

PROGENY TEST OF PLUS-TREE SELECTION

IN WHITE SPRUCE

Katherine Carter

Univ. of Maine, Orono, ME

Twenty-three superior trees of white spruce (Picea glauca (Moench) Voss) were selected in Maine and New Hampshire. Half-sib seedlots gathered from these mother trees in situ were grown in the nursery with "check" seedlots of nursery-run seedlings from the Maine and New Hampshire state nurseries. 3-0 seedlings were transplanted to a field site near Moscow, Maine, in 1974. At age 14, the mean height of 21 out of the 23 selected families is greater than that of the check seedlots. Select families are on average 23% taller than the check trees.

SEED FLOTATION: FACT OR WISHFUL THINKING?

A. Lee Eavy

Univ. of Maine, Orono, ME

Seed flotation, using various fluids, is a common and easy technique for separating sound tree seed from empty or supposedly non-viable seed. Many small-seeded conifers, especially the northern species, are routinely separated in 95% ethyl alcohol (ETOH). Results presented here show that the seeds which sink are highly viable and usually comprise the majority of sound seed. However, a significant quantity of floating seed is also sound and germinates. Therefore, we feel this method is unreliable for the assessment of seed set rates and subsequent selfing ability determinations. As much as 55% of "floated" and supposedly inviable seed have been successfully germinated, and X-ray

results support these findings. X-ray analysis also shows that the ETOH flotation method is very successful at removing Megastigmus-infected seed from floated samples.

SOMATIC EMBRYOGENESIS IN PICEA ABIES (Norway spruce)

Inger Hakman, Sara von Arnold and Tage Eriksson
Institute of Physiological Botany
University of Uppsala
Box 540
S-751 Uppsala, Sweden

Immature zygotic embryos of Picea abies (L.) Karst. were cultured on defined media supplemented with 2,4-D and a cytokinin. Roughly three types of tissue cultures were established within one month. One of these was a translucent and friable white callus containing numerous polarized and organized cellular structures (somatic embryos) intermingled with more unorganized cell clusters. The organized structures consisted of long vacuolated cells extending from aggregates of smaller meristematic cells. The morphology of these organized structures resembled very much the morphology of zygotic embryos, with the two parts representing the suspensor with an embryonal mass of cells. Upon subculture the somatic embryos developed further into plantlets. In the beginning, the somatic embryos terminated in the long suspensor-like cells. Subsequently, the somatic embryos developed further and became seedling-like, with cotyledons, a hypocotyl and a root. Up to 25 plantlets could under suitable conditions be derived from a single callus, which also contained numerous somatic embryos of smaller size. Plantlet formation was followed both in living and sectioned materials and showed close similarity to zygotic embryogeny.

EUCALYPTUS VEGETATIVE PROPAGATION IN ARACRUZ

Yara Kiemi Ikemori
Aracruz Florestal S. A.
29190 - Aracruz - ES - Brazil

Grafting, rooted cutting and in vitro culture techniques have been studied and utilized, as means of propagating both pure species of Eucalyptus and hybrids, for different purposes.

Grafting techniques are utilized to propagate pure species within the long term breeding program, aiming for gene preservation and seed production.

Rooted cuttings are mainly used in propagating highly productive hybrids for routine plantation establishment.

In vitro culture is an alternative propagation technique where the rooted cuttings have been unsuccessful.

**EVOLUTIVE STRATEGY OF THE RECONSTRUCTION OF FORESTS IN HEAVY
AIR-POLLUTED REGION OF THE ORE MOUNTAINS (CZECHOSLOVAKIA)**

K. Kanak

Forest and Game Management Institute

Arboretum Sofronka

Plzen

Power stations near the Ore mountains utilize lignite with a high level of sulphur causing an increased concentration of SO_2 in the atmosphere and resulting in a catastrophic die-back of forests in the zone over 800 m elevation. The greatest damage occurs to spruce, which forms over 90% of the local forests. Of the autochthonous species, only Pinus mugo, Betula spp., Sorbus aucuparia and the highland ecotype of Scots pine (Pinus silvestris) remain. In 1982, on both the Czech and the German side of the mountains, resistant individuals and groups of trees of introduced pine species (Pinus strobus, P. cembra, P. peuce, P. flexilis, P. nigra, P. contorta), aged 45 to 60 years, were located which had survived the spruce. They were not damaged by emissions nor by the poisoned soil and were producing seed.

These conditions enabled a long-term strategy to be developed for the reconstruction of local forests using the results of the catastrophe selection:

- 1) From all fertile groups of pines, seed is being collected for local reforestation.
- 2) From the most resistant trees, ramets are collected for clonal seed orchards or multiclonal plantations,
- 3) In the Sofronka (Plzen) arboretum, individuals of various provenances of resistant species are grafted to establish provenance clonal seed orchards and multiclonal plantations.

**FACTORS AFFECTING THE MICROPROPAGATION OF
CHESTNUT SPECIES IN VITRO**

Roy N. Keys and Franklin C. Jech

West Virginia Univ., Morgantown, W.Y.

Various factors affecting the in vitro production of shoots of juvenile American (Castanea dentata (Marsh.) Borkh.) and hybrid chestnuts were studied. The multiplication rate of juvenile American chestnut was significantly better in a 16-hour rather than a 24-hour photoperiod and on solid (6 g/l agar) rather than liquid medium. A BAP concentration of 1.5×10^{-6} M is recommended for the shoot multiplication stage. Doubling the calcium content and lowering the pH (4.0) of the modified Murashige and Skoog medium (SMM) used for shoot multiplication was not beneficial for multiplication. Hybrid shoots grew well on the SMM medium and on a medium consisting of Greshoff and Doy major salts and Murashige and Skoog minor salts organics. There was a significant clonal effect with the hybrid shoot cultures. Mature American chestnut shoots also grew on the SMM medium, but the multiplication rate is lower than that of juvenile tissue, even after several subcultures.

Rooting of juvenile American and hybrid shoots was accomplished using indole-3-butyric acid (IBA) and the phenylated form of IBA. In a preliminary test, mature American chestnut shoots rooted a very low rate (20%) and only on phenyl indole-3-butyrate.

Tip necrosis occurred in the majority of rooted shoots in all three shoot types. Tests to determine the cause of this tip necrosis indicate that the two-week dark period used for rooting was the prime cause of the tip necrosis. The inability to successfully transfer plantlets to soil was attributed to the weakened condition of any green tips after this dark treatment.

METHOD OF INCREASING SEED PRODUCTION IN CONIFERS BY THE APPLICATION OF BIOREGULATORS

Csaba Matyas
OMNR - U. of T., Toronto

A method of inducing generative primordia in vegetative buds of Scots pine (Pinus sylvestris L.) was developed at the Waldsieversdorf Tree Breeding Centre of the Institute of Forest Science, Eberswalde (East Germany). The method, involving repeated spraying with bioregulators, aims to retard vegetative growth, induce generative (male or female) primordia, decrease the abortion rate and condition the vigour of the trees. The application dates are determined on the basis of developmental phenophases of buds and shoots, respectively.

The response depends on the exact timing of the application. Clones react differently, with increases in flowering ranging from 20 to 150 per cent. Operational application in Hungary resulted in an average increase of 55% of female flowering as compared to the control.

The technology is applied on an operational basis in Scots pine grafted seed orchards in the GDR and Hungary, and may be acquired on a licence from the Institute of Forest Science, Eberswalde. Trials to extend the application to other hard pines are under way in Hungary.

BIOCHEMICAL CHANGES DURING GERMINATION OF TAMARACK (LARIX LARICINA) SEEDS

J.A. Pitel & W.M. Cheliak
Petawawa National Forestry Institute, Chalk River, Ont.

Activities of six enzymes from extracts of separated embryos and gametophytes of Tamarack (Larix laricina (Du Roi) K. Koch) seeds were assayed at various stages of imbibition and germination. On a per seed part basis, activities of 6-phosphogluconate dehydrogenase (6-PGD), glucose-6-phosphate dehydrogenase (G-6-PD), malate dehydrogenase (NAD⁺-MDH), isocitrate dehydrogenase (NADP⁺-IDH), soluble peroxidase (PER) and acid phosphatase (ACP) from both the embryo and gametophyte tissues generally increased slowly following cold stratification for one month and imbibition under germinating conditions for 5 days, but then

increased at a faster rate with emergence of the radicle and subsequent growth of the seedling. The rate of increase of enzyme activity was highest for PER. Soluble protein levels also increased with imbibition and germination, with about three times greater levels present in the gametophyte than in the embryo. Heat inactivation experiments showed that except for G-6-PD, activities were stable up to 40°C. Inactivation occurred at lower temperatures for G-6-PD, while higher temperatures were required for PER. Incubation of extracts for 7 days at 4°C indicated that loss of enzyme activity was greatest for G-6-PD (3.9% remaining) and least for PER and ACP (93.7% and 95.1% remaining, respectively).

AMÉLIORATION GÉNÉTIQUE DE L'AULNE: HYBRIDATION INTERSPÉCIFIQUE

Daniel Prat

École nationale du génie rural des eaux et des forêts
Nancy, France

Le genre Alnus comporte environ 30 espèces réparties surtout dans l'hémisphère nord. De nombreux croisements interspécifiques sont possibles même entre espèces de sections ou de sous-genres différents. Les espèces intéressantes pour la France (A. glutinosa, A. cordata, A. rubra et A. incana) font l'objet de croisements interspécifiques contrôlés. Plus de 500 croisements ont été réalisés sur 20 arbres et plus de 150 lots de pollen différents. Les graines de chaque croisement sont récoltées et semées; le succès du croisement n'est appréciable que lors de la germination. Les autofécondations sont infructueuses. Il apparaît que certains croisements interspécifiques sont plus difficiles à réaliser que d'autres et que les effets individuels et/ou réciproques sont importants. Ceci peut être dû en partie au décalage phénologique entre les différentes espèces. La production du pollen doit être forcée à avancer ou à ralentir pour des durées variables selon le croisement considéré.

Le suivi des plants au cours de leurs trois premières années sur deux stations différentes (terrain hydromorphe, terrain sec à calcaire superficiel) montre un bon comportement des hybrides interspécifiques (A. cordata x A. inca sur les terrains sec et hydromorphe, et A. rubra x A. glutinosa et A. glutinosa x A. incana sur le terrain hydromorphe). Dans chaque station, certains plants hybrides ont une croissance plus forte que les plants des espèces pures associées.

Le taux de succès souvent faible des croisements (0,1 à 15,0 plants obtenus par strobile récolté) et la variabilité des descendances amènent à sélectionner les individus les plus performants et à les multiplier végétativement pour les diffuser sous forme de variétés clonales à l'issue de tests clonaux. Les études s'orientent également vers l'étude de la diversité génétique de diverses espèces d'aulne afin de guider la sélection des géniteurs.

**POLLINATION AND SEED QUALITY IN YOUNG
PLANTATIONS OF LARIX LARICINA**

Kathleen J. Tosh

Univ. of New Brunswick, Fredericton, N.B.

Tamarack (Larix laricina (Du Roi) K. Koch) is one of four tree species included in the New Brunswick Tree Improvement Program. To meet the demands for reforestation, the procurement of good quality seeds on a regular basis is necessary and seed orchards are being established throughout New Brunswick for this purpose. This study was initiated in 1983 to identify factors that may be affecting seed set in young seed orchards. Three plantations of tamarack, established in 1978, on three sites at the Provincial Forest Nursery at Kingsclear NB, were used.

One of the main objectives was to relate pollen production to the success of seed production over a two-year period. Estimates of pollen production and dispersal patterns were made from pollen traps in 1983 and 1984. Pollen shedding occurred during the last part of April and early May in both years. The period of peak pollen shedding lasted 3 to 7 days and was closely associated with the weather conditions. The amount of pollen shed increased significantly in 1984 and was more frequently caught on the west side of pollen traps. Seed-cone receptivity and peak pollen shedding were synchronized.

Seed cones were collected at the end of August in 1983 and 1984, from each plantation. The seed cones were dissected, measured, and the seeds extracted. The mean number of full seeds increased significantly in 1984. The increase in seed quality was directly attributable to the increase in pollen availability. It can be estimated that the total full seed for the 90 trees assessed was 103,860 in 1983 and 492,660 in 1984.

**UTILISATION DU PILODYN POUR ÉVALUER LA DENSITÉ DU BOIS DANS DES
TESTS DE DESCENDANCE**

Michel Villeneuve

Univ. of New Brunswick, Fredericton, N.B.

Le classement de familles de pins gris en fonction de la densité du bois a été fait à l'aide du Pilodyn. La corrélation entre la densité du bois juvénile et celle du bois mature était suffisante vers l'âge de 15 ans. L'échantillonnage de 2 ou 3 arbres par parcelle dans 5 ou 6 répétitions d'un seul test de descendance donnerait une estimation fiable de la densité moyenne d'une famille.

**OPTIMIZATION OF SHOOT FORMATION BY EMBRYONIC
EXPLANTS OF PINUS STROBUS L. IN VITRO**

D.T. Webb & B. Flinn

Dept. of Biology

Queen's Univ., Kingston, Ont.

Horizontally oriented Pinus strobus embryos produced shoots on SH medium containing cytokinin. Benzylaminopurine (BA) and 2-isoheptyladenine (2iP) induced caulogenesis, but BA was more potent. Shoots developed principally from swollen-yellow cotyledons. The duration of BA exposure did not significantly alter the final shoot number, but longer exposures led to more callus formation. A 2-4 week exposure was near-optimal for whole embryos. Contrary to prior results (Minocha, 1980) a cytokinin was required for caulogenesis, and neither auxins nor triiodobenzoic acid induced or markedly enhanced shoot formation. Seed preincubations at 5° or 27°C did not affect caulogenesis, but cotyledons from cultured embryos were more caulogenic than those isolated from seeds hydrated overnight. Upside-down embryo orientation increased the uniformity of the caulogenic response by whole embryos and reduced the BA-exposure time to 7 days. Cotyledons from UD embryos performed better than those from hydrated seeds. Timing experiments showed that a 50% response was achieved by cotyledons after 5 days exposure to BA. SH medium was superior to MS medium for shoot induction. The macronutrients accounted for this difference, and NH_4 was the controlling factor.

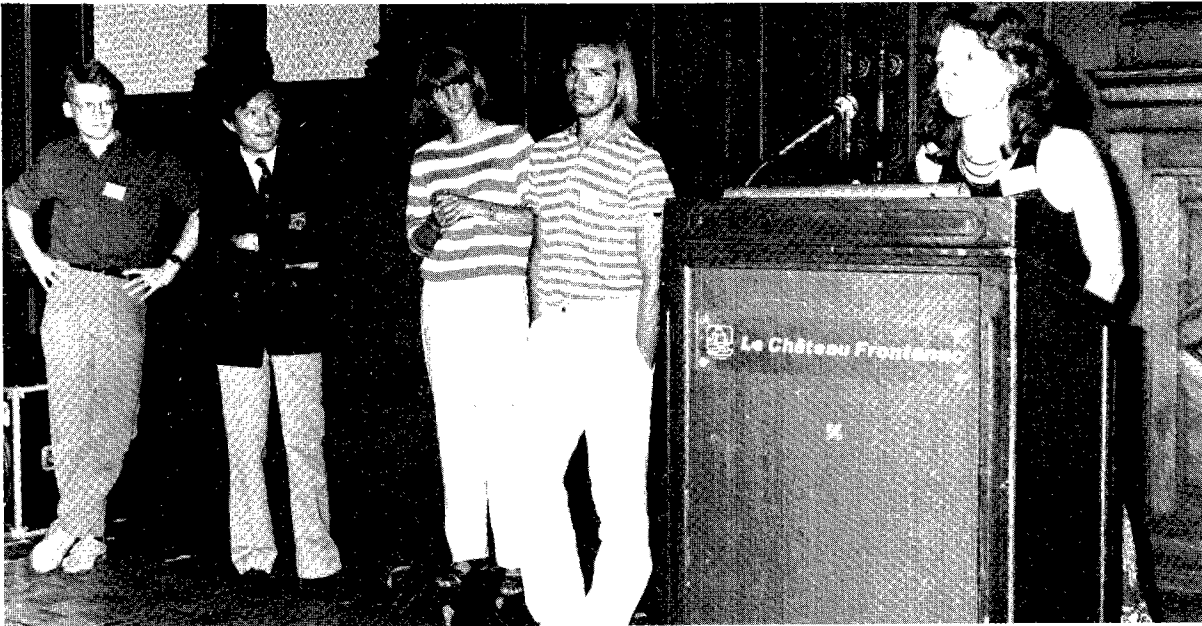
JACK PINE SEED ORCHARD RESEARCH

C.W. Yeatman, T.C. Nieman, and P. Copis

Petawawa National Forestry Institute, Chalk River, Ont.

A model breeding population of jack pine (Pinus banksiana Lamb.) was initiated in 1978 in cooperation with the Ontario Ministry of Natural Resources, Algonquin District. The population will provide fully pedigreed seed and trees for advanced-generation research and will quantify gains achieved by pursuing alternative procedures in selection, breeding and seed production within seedling and clonal orchards of jack pine.

SYMPOSIUM, BANQUET AND FIELD TOURS - PHOTOS
SYMPOSIUM, BANQUET ET TOURS DES LIEUX - PHOTOS



Francis Yeh, président du comité d'éducation (deuxième à gauche), et les étudiants Adalsteinn Sigurgeirsson (Univ. de l'Alb.), Beth Beatson (Univ. de Toronto) et Dave Coletelo (Univ. du N.-B.) écoutent Catherine Beale (univ. de la C.-B.) qui remercie l'A.C.A.A. de l'occasion d'assister au symposium.

Francis Yeh, chairman of the education committee (second left), together with students Adalsteinn Sigurgeirsson (U of A), Beth Beatson (U of T) and Dave Coletelo (UNB) listen to Catherine Beale (UBC) thanking the CTIA for the opportunity to attend the symposium.



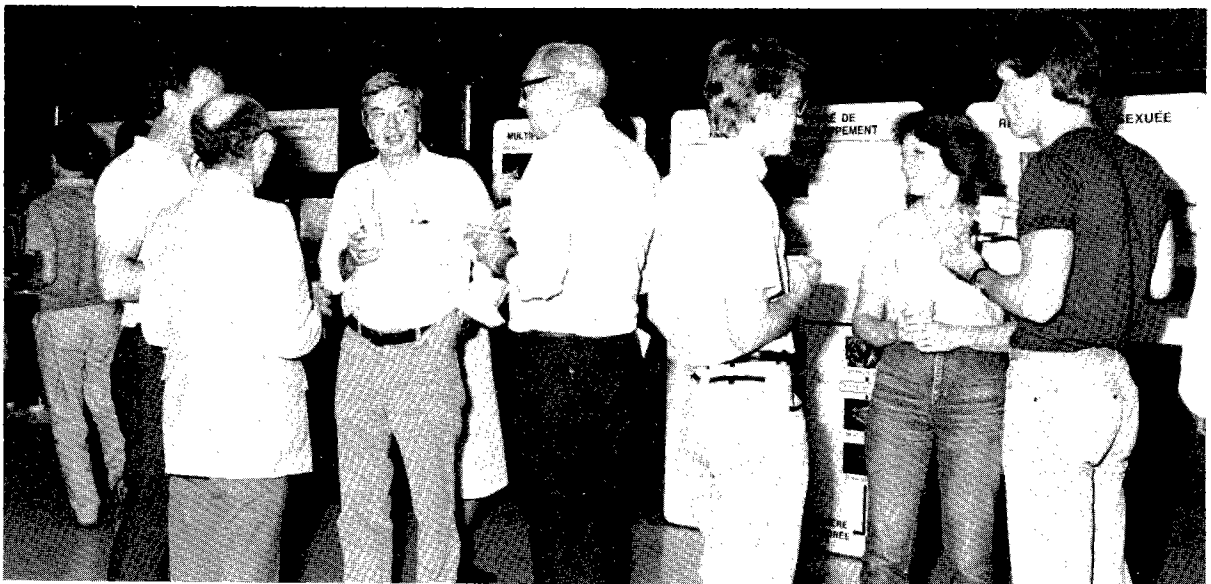
Bob Ackerman, Don Fowler, Francis Yeh, Stan Krugman - Des intellectuels peuvent-ils communiquer sans not dire?

- great minds apparently in speechless communication-thought control?



Les affiches donnent matière à discussion. Gordon Murray, Cathy Carter, Gilles Vallée, John Genys et d'autres participants resoulvent quelques problèmes.

Posters generated much discussion. Here, Gordon Murray, Cathy Carter, Gilles Vallée, John Genys and others come to grips with some problems.



Bob Bouchier et Dianne Roddy présentent leurs idées à un auditoire attentif, y compris Willard Fogal, Jerry Klein et Bob Ackerman.

Bob Bouchier and Dianne Roddy expand their views to attentive audiences, including Willard Fogal, Jerry Klein and Bob Ackerman.

TOUR 1: JEUDI LE 22 AOÛT 1985/THURSDAY, AUGUST 22, 1985

Visite des laboratoires de biotechnologie forestière et de technologie du bois de la Faculté de foresterie et de géodésie de l'Université Laval.

Visit to the forest biotechnology and wood technology laboratories of the Faculty of Forestry and Land Surveying of Laval University.



Visite de Laboratoires des biotechnologie forestière à la Faculté de foresterie et de géodésie de l'Université Laval; Dr. Lalonde explique les travaux en cours.

Visit to forest technology laboratories at the Faculty of Forestry and Land Surveying of Laval University; Dr. Lalonde explaining current research.

TOUR 2: VISITE DU POPULETUM DE VILLEROY ET DE L'ARBORETUM DE LOTBINIÈRE
JEUDI LE 22 AOÛT 1985

- Visite du populetum de Villeroy

Test n° 2 Test de provenance-descendance de Populus deltoides de la vallée du Saint-Laurent (D 80-72-75).

Test n° 8 Test de provenance avec Populus trichopcarpa (D 475-76).

- Visite de l'arboretum de Lotbinière

Test n° 65 Essai de 125 clones de peuplier pour la production de biomasse sur de courtes rotations (2 à 4 ans) (D 568-88).

Test n° 18 Essai de 13 provenances de Larix laricina comprenant respectivement 4, 2 et 1 provenances de Larix decidua, L. Leptolepis et L. sibirica (D 252-74).

Test n° 17 Test de descendance comprenant respectivement 36, 7 et 3 demifratreries de Larix decidua, L. laricina et L. leptolepis (D 251-74).

Test n° 30 Test de provenance de Pseudotsuga menziesii (D 380-75).

Test n° 42 Verger à graines de mélèzes comprenant des demi-fratreries de mélèzes sélectionnés d'Europe, du Japon et laricin (D 457-76).

Test n° 62 Test de provenance sur le pin de Murray (Pinus contorta var. latifolia) (D 570-80).

Test n° 52 Test de 71 provenances de Larix laricina comprenant 8 provenances de 6 espèces exotiques de Larix (D 512-77).

Test n° 21 Test de 180 clones de peuplier. Test clonal de deuxième génération (D 341-74).

Test n° 87 Plantation de démonstration de 77 clones de peuplier en test clonal de troisième génération (D 689-84).

TOUR 2: VISIT TO THE VILLEROY POPULETUM AND THE LOTBINIÈRE ARBORETUM
THURSDAY, 22 AUGUST 1985

- Visit to the Villeroy Populetum

Trial 2 Progeny-provenance trial of Populus deltoides from St. Lawrence Valley (D 80-72-75).

Trial 8 Provenance trial of Populus trichocarpa (D 475-76).

- Visit to the Lotbinière Arboretum

Trial 65 Trial of 125 poplar clones for biomass production on short rotations (2 to 4 years) (D 568-80).

Trial 18 Trial of 13 provenances of Larix laricina including, respectively, 4, 2 and 1 provenances of Larix decidua, L. leptolepis and L. sibirica (D 252-74).

Trial 17 Progeny test including, respectively, 36, 7 and 3 half-sib families of Larix decidua, L. laricina and L. leptolepis (D 251-74).

Trial 30 Provenance trial of Pseudotsuga menziesii (D 380-75).

Trial 42 Larch seed orchard including half-sib families of selected European larch, Japanese larch and tamarack (D 457-76).

Trial 62 Provenance trial of lodgepole pine (Pinus contorta var. latifolia) (D 570-80).

Trial 52 Trial of 71 Larix laricina provenances including 8 provenance of 6 exotic Larix species (D 512-77).

Trial 21 Trial of 180 poplar clones: second generation of clonal trials (D 341-74).

Trial 87 Demonstration plantation of 77 poplar clones of the third generation of clonal trials (D 689-84).



Groupe du tour 2 devant un essai de 125 clones de peupliers évalués pour leur rendement en biomasse.

The group on tour number 2 in front of a test on 125 poplar clones under evaluation for their biomass yield.



A. Stipanivic décrit un test de provenance du mélèze laricin effectué à l'arboretum Lotbinière.

A. Stipanivic giving an explanation of a tamarack provenance trial at Lotbinière arboretum.

TOUR 3: VISITE DES EXPÉRIENCES DE GÉNÉTIQUE FORESTIÈRE ET D'AMÉLIORATION
DES ARBRES À LA STATION D'EXPÉRIMENTATION FORESTIÈRE DE VALCARTIER

Lunch à la Station de Valcartier - Bref historique.

Arrêt 1 Génétique et amélioration du pin blanc.

Arrêt 2 Transfert aux utilisateurs du matériel de qualité
génétique supérieure.

Arrêt 3 Étude de la variabilité génétique des épinettes.

- Hybrides géographiques d'épinette blanche
- Essai de provenances d'épicéa commun d'Europe de l'Est
- Essai de provenances d'épicéa commun de Roumanie et de Tchécoslovaquie
- Banque clonale multiprovenances d'épinette noire
- Essai transdomanial de provenances d'épinette rouge
- Test comparatif du complexe épinette blanche X épinette de Sitka
- Test de descendances d'épinette blanche

TOUR 3: VISIT OF THE FOREST GENETICS AND TREE BREEDING EXPERIMENTS AT
VALCARTIER FOREST EXPERIMENT STATION

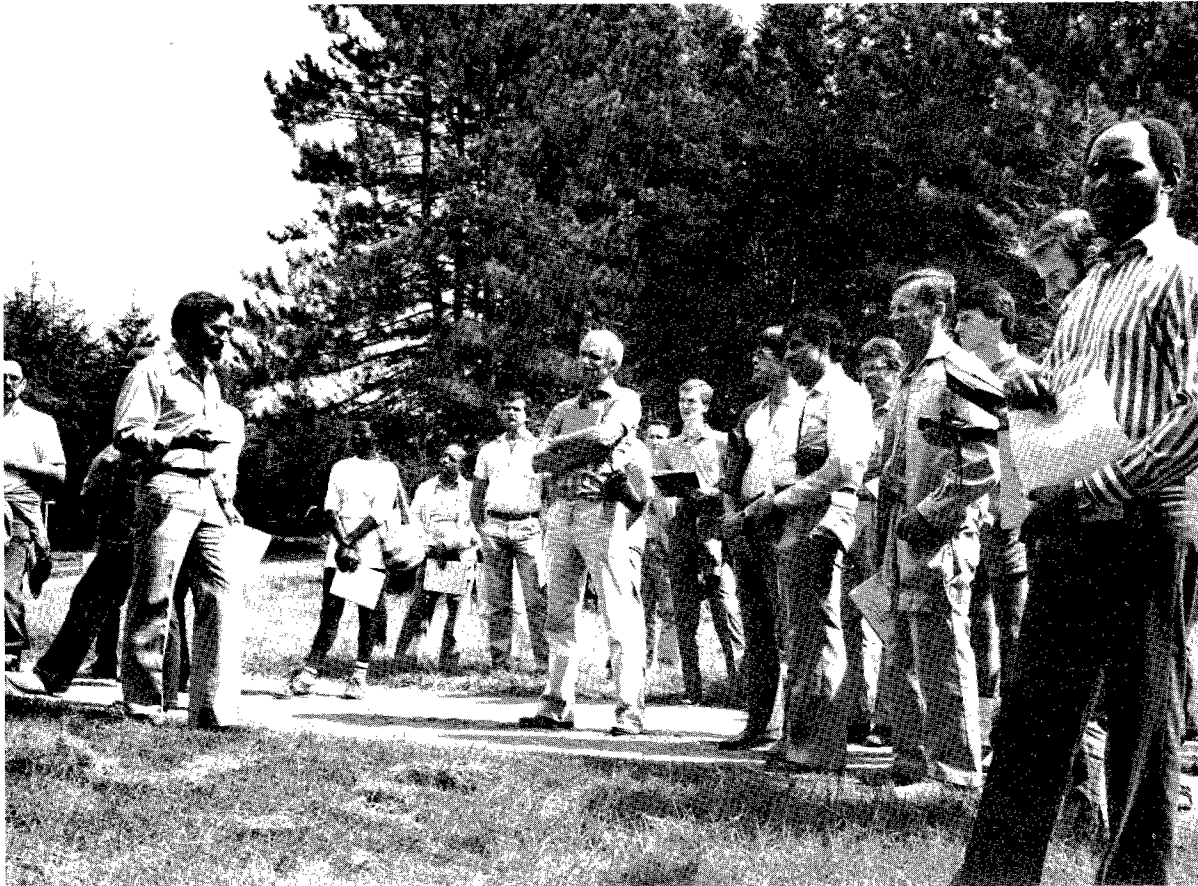
Lunch at Valcartier F.E.S. - Brief historic notes.

Stop 1 Genetics and improvement of Eastern white pine.

Stop 2 Transfer to users of material of superior genetic
quality.

Stop 3 Study of the genetic variability of spruces.

- White spruce geographic hybrids
- Provenance trial of Norway spruce from Eastern Europe
- Provenance trial of Norway spruce from Romania and Czechoslovakia
- Black spruce multiprovenance clone bank
- Range-wide red spruce provenance trial
- Comparative test of white x Sitka spruce complex
- White spruce progeny test



Groupe du tour 3 écoutant attentivement les explications de
Dr. A. Corriveau.

The group on tour number 3 listening to explanations from Dr. A. Corriveau.

NOTES FOR A SPEECH AT THE CLOSING BANQUET OF THE TWENTIETH
MEETING OF THE CANADIAN TREE IMPROVEMENT ASSOCIATION,
CHATEAU FRONTENAC, QUEBEC, AUGUST 21, 1985

Mr. Jean-Pierre Jolivet

*Minister responsible for forests,
Ministère de l'Énergie et des ressources,
Gouvernement du Québec*

To begin with, I would like to thank Mr. Armand Corriveau, President of the Canadian Tree Improvement Association. I was very happy to accept his invitation to speak at your convention. Its theme, "New Avenues in Forest Genetics" ties in well with the government's objective of "Building a Forest for the Future".

Indeed, both these themes, and both these objectives, are part of the same vision of the future, and your convention here in Quebec City coincides with the beginning of a period of change in which all tree improvement specialists are called to play an important role.

Québec is a land of forests. The forest section of the ministère de l'Énergie et des Ressources, for which I am responsible, manages the vast resources of the public forests and encourages the development of private resources and of the forest industry. As such, it is a major force in Québec's forest sector. Consequently, the new forestry policy which I made public last June 11 is a significant event for the entire forestry sector in Québec. I will therefore take a few minutes to outline the major thrusts of the new policy.

Based on its analysis of the forest sector's problems, the gouvernement du Québec has formulated an action program featuring five major elements:

- protection of the intended production use of the forest territory;
- changes in the way the public forests are managed;
- production from private forest property;
- joint action to adapt the structure of the processing industry to the characteristics of Québec's forests, and
- direction of research and development activities towards these.

To begin with, the forest generates several resources and supports various activities which contribute to the quality of life in Québec. Forest areas must be utilized in a rational way that is consistent with respective potentials and conforms to a master plan that will enable the entire community to draw maximum benefits from the forest.

The commitment requires that all the agents involved make whatever efforts are needed to recognize, protect and improve the various resources, while at the same time being conscious of the ecological diversity of Québec's forests.

From the economic standpoint, wood is without doubt the most important resource produced by the forestry world. The new policy specifies that from now, forest resources, public and private, will be managed and utilized on a sustained yield basis. This implies significant changes compared to the way public forests have been managed.

Another significant aspect of the orientation of the new forestry policy is the recognition that research is an essential tool for improving and managing the resource so that a bright future is ensured for Québec's forest sector. The government will make a significant effort to support an active and dynamic research program within both the public administration and other research organizations. In addition to these efforts, particular attention will be paid to disseminating research results, so that the scientific and technical information gained is used as fully as possible.

These few elements give you a very general idea of the major thrusts of the new forestry policy.

I would now like to deal in greater detail with an aspect which, I am sure, interests all of you: restoring cutover or damaged areas to production.

Under the new policy, it is now mandatory that forest operators provide for the regeneration of areas they have harvested, using artificial reforestation if necessary. In addition, the Ministry is committed to restoring normal yield levels to areas which are currently unproductive, as a result of past harvesting or damage. There again, reforestation will be necessary in a good number of areas. To put it briefly, there will be no harvesting without regeneration.

In this regard, the reforestation program is an essential component of the forestry policy. Beginning in 1988, the program calls for 300 million saplings to be planted each year. This is an ambitious project, with significant consequences both from an economic and a forestry standpoint, and will generate activities such as the production of seeds, production of saplings using different techniques, and ground preparation.

The government has decided to be responsible for the production of all the saplings needed for reforestation, both in public and private forests. Since reforestation is so important for the future of the forest sector, and in view of the costs involved, the government is thus ensured of obtaining saplings of the highest possible quality.

The program covering the establishment of seed orchards to provide seeds of the required quality will be stepped up considerably. Whereas 7 or 8 years ago, there were practically no orchards, there are now a little more than 300 hectares established and the objective is 1 900 hectares by the end of the decade.

In addition, since two-thirds of the saplings will be produced by private producers or forest companies, the program's success also depends on adequate transfer of knowledge and technology. The concrete involvement of industry and private property owners in the production of seedlings and particularly in establishing and maintaining plantations, the financial participation of the federal government and on-going consultation among the various agents involved in the forest sector, are all vital elements for the program's success.

Before I conclude, allow me to emphasize that the gouvernement du Québec is giving a high priority to research into improving the genetic qualities of seedlings. In cooperation with other research organizations, the forestry genetics section of the Service de la recherche of the ministère de l'Energie et des Ressources has undertaken research projects and experiments in the genetic improvement of forest trees. Some 650 plantation installations comparing species, provenances, progeny and clones as well as installations for the introduction of species, have been put into operation. A network of 21 experimental sectors for the improvement of forest trees is the key element in the operation of the comparative plantations. In addition, 31 special sectors have been created to meet particular needs.

The Service de la recherche is also undertaking research projects into advanced techniques such as propagation by cuttings and IN VITRO culture.

Finally, in a field as specialized as forestry genetics, attention must be paid to communication between researchers and diffusion of scientific and technical information gained. In addition to more research, the new forestry policy suggests that a cooperative organization be formed which would bring together all those interested by work being done in the genetic improvement of trees.

I trust that this 20th meeting has been fruitful for all of you and I hope that you will continue your work so that the quality of our forest resources will improve in the years to come.

Thank you for your invitation.

NOTES POUR UNE ALLOCUTION LORS DE LA 20^E RENCONTRE BIENNALE DE
L'ASSOCIATION CANADIENNE POUR L'AMÉLIORATION DES ARBRES,
UNIVERSITÉ LAVAL (QUÉBEC),
LE 20 AOÛT, 1985

M. Jean-Claude Mercier

*Sous-ministre associé (Forêts),
Gouvernement du Canada*

Mesdames et Messieurs,

Il me fait plaisir de prendre la parole aujourd'hui à l'occasion de la vigtième rencontre biennale de l'Association canadienne pour l'amélioration des arbres (ACAA).

I am very pleased to be representing the honourable Gerald Merithew, Minister of State, Forestry, and the Canadian Forestry Service. Since the federal election in 1984, the government has done many things to advance and enhance the forestry sector in Canada. For example, the CFS now enjoys a status within the government that it has not had in the past twenty years. And the CFS has actually undergone it's first expansion in the last fifteen years, resulting from new responsibilities in the negotiation and management of federal-provincial agreements. These agreements are now in place for all provinces except Newfoundland and that one is now being considered. Another new activity is that of job creation programs in forestry.

La plupart d'entre vous savez que le Service canadien des forêts est le symbole de la recherche forestière au Canada: un organisme réputé pour sa stabilité, son intégrité de même que la qualité de ses programmes de recherche. Au cours des dernières années, plusieurs facteurs ont réduit la capacité du Service canadien des forêts à régler efficacement les problèmes rattachés à la recherche forestière de même que ceux touchant le transfert des connaissances techniques. Il s'avère plus important que jamais que la recherche scientifique soit entreprise avec l'objectif de bénéficier tant au secteur public que privé. À cet effet, nous faisons en sorte que toutes les ententes fédérales-provinciales appuient les efforts de recherche et que la diffusion des résultats de ces recherches contribue à l'aménagement forestier.

L'objectif primordial de ces programmes de recherche découle de l'importance que revêt la ressource forestière pour le Canada, aussi bien du point de vue social qu'économique. Si nous voulons assurer un avenir prospère à l'industrie forestière, il nous incombe dès aujourd'hui de régénérer et d'administrer adéquatement la totalité de nos terres

forestières disponibles. D'autre part, nous devons reconnaître qu'il est notre responsabilité de voir à la protection, à la promotion et à la sauvegarde de notre richesse forestière pour bon nombre d'autres motifs.

C'est en tenant compte des diverses parties intéressées que les gestionnaires de la ressources forestière reconnaissent l'importance d'accroître le rendement de nos forêts de façon à suffire aux besoins d'approvisionnements compte tenu des terres consacrées à cette fin.

Canadian foresters are looking to tree breeding, genetics and tree improvement as a major means of accomplishing this goal. Traditionally, tree breeding has been a relatively slow process, particularly when dealing with our northern boreal conifers. Nevertheless, research by CFS scientists and by colleagues with other agencies, in effect, you, the members of the CTIA, is starting to show dividends. For example, all provinces now have identified seed zones and regulations for seed transfer as a result of provenance trials conducted by tree breeders. While this may sound quite elementary now, it is only a few years ago that seed zones became normal operating procedure.

Also, some other very important findings have derived from these long-term provenance trials. I am thinking especially of the identification of the Upper Ottawa Valley seed sources providing superior seed for growing white spruce in eastern Canada; the identification of the Baskatong source of jack pine which is resistant to scleroderris canker; and the identification of lodgepole pine as being particularly susceptible to sweet fern blister rust when moved to jack pine sites in eastern Canada. As a result of this latter finding, the transport and planting of lodgepole pine seed and seedlings into eastern Canada will be restricted under the tree seed regulations of the seeds act, which is expected to be enacted by the end of this year.

Comme je l'ai mentionné plus tôt, je crois qu'il est essentiel que les résultats en recherche forestière puissent être mis en application. Il me fait plaisir de constater que les spécialistes en amélioration des arbres font figure de pionniers dans ce domaine. Par l'entremise des rencontres de l'Association canadienne pour l'amélioration des arbres et par leurs études, les activités de recherche en amélioration génétique des arbres et leurs résultats sont mis à la disposition des techniciens forestiers, des spécialistes en amélioration des arbres ainsi que des gestionnaires forestiers.

D'autre part, la communauté scientifique a participé à la formation de coopératives fédérales-provinciales et industrielles chargées de l'amélioration des arbres, dont le rôle est de mettre sur pied des vergers à graines et des stratégies de gestion de récoltes de graines pour ses membres en utilisant les connaissances scientifiques les plus avancées. De telles coopératives sont maintenant en voie de réalisation en Colombie-Britannique, au Nouveau-Brunswick, en Nouvelle-Écosse et plus récemment en Ontario.

Il me fait plaisir de souligner que les programmes pour l'amélioration des arbres ont reçu une attention particulière dans le cadre de la signature des ententes fédérales-provinciales avec le Manitoba et le Québec. À titre d'exemple, je tiens à souligner le travail de M. Klein, un chercheur du Service canadien des forêts au Manitoba, qui est responsable de l'établissement des vergers à graine qui utilisent du pine gris supérieur pour la reproduction. On prévoit que ce travail d'amélioration des arbres produira un taux de croissance jusqu'à 20 % supérieur à la normale.

Il en est de même pour le Québec où la nécessité d'utiliser du matériel de qualité supérieure pour l'aménagement forestier a été stipulée dans l'entente auxiliaire Canada-Québec sur le développement forestier. Par ailleurs, le ministère de l'Énergie et des Ressources du Québec a réitéré l'importance de ce genre de recherches dans la publication de sa politique forestière rendue publique récemment.

Le gouvernement du Québec se propose entre autres d'établir un organisme dont le but serait de faire avancer la recherche et le développement en matière d'amélioration des arbres. Le Québec considère que l'amélioration des arbres est essentielle si les objectifs de l'aménagement forestier doivent être réalisés tant sur les terres publiques que privées. Le gouvernement fédéral, de même que l'industrie forestière et les universités, seront invités à participer à ce projet.

During the past 10 years, CFS scientists and tree breeders in general have been attempting to develop methods of growing seedlings and trees faster for testing purposes as a means of screening genetic crosses, breeding for resistance and other factors. This work has resulted in the development of many new techniques such as the application of gibberellins and other methods to stimulate cone production, the rooting of coniferous cuttings, the growth of seedlings from embryonic tissue and the development of isozyme analysis as a means of identifying genetic integrity. Research into these genetic methods has provided very powerful tools to promote seed and seedling production.

Also, these developments have heralded the age of biotechnology, the buzzword of the 1980s. Ironically, the CFS initiated this type of research in the 1960s and it was considered too basic and too radical to be continued.

Canadian tree breeders and forest scientists have been at the vanguard of biotechnology for several years. And I believe that the CFS has a vital role to play in its future. Already the CFS has programs launched in micropropagation, genome analysis and quantitative genetics at the Petawawa National Forestry Institute, embryonic tissue culture at the Maritimes Forest Research Centre and vegetation propagation at the Laurentian Forest Research Centre.

In addition, CFS scientists have established close links with the National Research Council of Canada and several Canadian universities to enable sharing of facilities, training in methodology and joint research studies. And, this summer, the first steps have been taken for

CFS scientists to work with ten other nations in biotechnology for the breeding of fast-growing hardwood species under the auspices of the International Energy Agency. As the lead CFS establishment in this field, the Petawawa National Forestry Institute has expanded its scientific expertise and has expanded its provenance research and nitrogen fixation studies to complement the new thrusts in biotechnology that are commencing.

Ces réalisations ne sont que quelques-unes des recherches effectuées dans le domaine. Ainsi, les chercheurs du Centre de recherches forestières du Pacifique étudient dans quelle mesure la biotechnologie peut être utilisée pour résoudre le problème de la rouille vésiculeuse du pin blanc. Par ailleurs, tandis que plusieurs chercheurs étudient les moyens d'améliorer nos forêts par le biais de la technologie et de l'amélioration des arbres, d'autres voient à ce que ces recherches garantissent l'intégrité et la qualité de nos forêts. Je tiens à mentionner qu'en sa qualité de participant au programme de l'OCDE (Organisation de coopération et de développement économique) du commerce international des graines et des plantes, le Service canadien des forêts a enregistré au nom du Canada trois vergers à graines de la Colombie-Britannique.

En terminant, je tiens à vous réitérer mon appréciation pour votre aimable invitation à vous adresser la parole. Le Service canadien des forêts est optimiste quant à l'avenir de la ressource forestière canadienne et je compte sur la participation de nos chercheurs et de leurs collègues de l'Association canadienne pour l'amélioration des arbres (ACAA) en vue d'augmenter le rendement et la qualité de la matière ligneuse.

Ces efforts de recherche constituent une étape importante dans la revalorisation de notre richesse forestière.

Merci.

TREE IMPROVEMENT IN NEWFOUNDLAND AND LABRADOR A PROGRESS REPORT

C. Harrison

*Forest Geneticist
Department of Forest Resources and Lands
Herald Building, P.O. Box 2006
A2H 6J8*

Keywords: Plus-tree selection, progeny tests, exotics, arboretum, seed orchards, seed-production areas, provenance trials.

In 1983, this member's report was titled "Tree Improvement in Newfoundland and Labrador -- A Future Outlook" (Harrison 1984). In that report, it was pointed out that the Provincial Government first became involved in tree improvement in 1979, when the Newfoundland and Labrador Tree Improvement Working Group was formed. A further commitment was made in 1982 when the Province hired a full-time forest geneticist. A number of approaches, which the Province planned to follow over the next several years, were discussed. This paper reports the progress made in the various areas of the improvement over the past two years.

SEED PRODUCTION AREAS

A white spruce (Picea glauca (Moench) Voss) seed production area (s.p.a.) at Grand Lake, in the vicinity of Corner Brook, has been thinned and rogued, and cultural treatments are ongoing. The stand is about 30 years old, and some seed was collected in 1984. This s.p.a. should be in full production by 1990, and should supply the needs of western Newfoundland until genetically improved seed is available from clonal orchards. A similar stand at Frenchman's Pond, southwest of Grand Falls, has been treated to serve as the white spruce s.p.a. for central Newfoundland. Maintenance and cultural work is proceeding on the black spruce (P. mariana (Mill.) B.S.P.) s.p.a. at Carmanville, and larch (Larix laricina (Du Roi) K. Koch) stands near Millertown and Taylor Brook have been tentatively selected as s.p.a.'s.

PLUS-TREE SELECTION

In 1984, a concerted effort was made to locate white spruce plus trees. Seventy were located, counting about 30 that had previously been selected. Ten black spruce and ten larch plus trees have also been

selected. The goal is to have at least 100 of each of these three species. We hope to attain that figure with white spruce and increase the numbers of the other two species significantly in 1985. The bulk of our plus trees are in the central region, but we have also carried out selections in Labrador, the northern peninsula, western and eastern Newfoundland. So far, response to the public participation program has been minimal, but new approaches are being considered.

PROGENY TESTS

After the CTIA meeting in 1983, the author visited various plantations and installations in Québec, and obtained, from Roger Beaudoin of the Ministère de l'énergie et des ressources du Québec, seed from 59 of Québec's black spruce plus trees. These were germinated in the winter of 1983-84, and, after two seasons of greenhouse growth, are to be planted out in progeny tests this summer. The tests will be replicated in the St. George's and Springdale areas, and at a site east of Grand Falls. Each replication will consist of 10 blocks, with each family, plus a Newfoundland source, being represented in each block by a four-tree linear plot. The reason for this design is to facilitate later use of the tests as seedling seed orchards, if these families prove also to be superior in Newfoundland. This approach was adopted because of the impoverished gene pool of Newfoundland spruce and the scarcity of black spruce stands in the 20 to 60 year-old age range, which is the best range for selecting black spruce plus trees.

Seed from our own white spruce plus trees, with a handful of exceptions, were collected in the autumn of 1984. These were germinated in the winter of 1984-85, and, like the Québec black spruce families, will be planted according to the same design, for the same reason. Seed will be collected annually from as many plus trees as possible, and additional progeny tests will be established when seed from sufficient numbers of plus trees of each species is available.

Progeny of selected Ottawa Valley, Ontario, trees will be tested along with that of the Newfoundland white spruce plus trees. Again, the reason is to see if the introduction of genetic material from superior trees outside the province will contribute to our overall genetic improvement programme in that species.

PROVENANCE TRIALS

An all-range provenance trial of Populus trichocarpa Torr. & Gray, located at Villeroy Populetum, Québec, has been replicated at Johnson's Lookout, near Springdale. Cuttings from all trees at Villeroy were obtained from Gilles Vallée in May, 1984, and planted the same month. A 10% sample count in late October, 1984, indicated that 88% had taken root, but 4% subsequently died. Another 13% had sustained frost damage to the growing shoots, leaving 61% apparently healthy with frost damage, if any, limited to the leaves. A full count will be made in the summer of

1985. A new all-range white spruce provenance trial, including more Newfoundland sources than the one established 26 years ago, is in the planning stage.

THE PROVINCIAL ARBORETUM

An arboretum, about 5 ha in extent, is now being established adjacent to the Provincial Tree Nursery at Wooddale. It will consist of two divisions - viz. the exotic division and the genetic division. In the exotic division a small number of individuals of as many species as possible will be planted. Despite the name "exotic division", native species will be present alongside exotic species of the same genus for comparison purposes. Generally speaking, the species will be grouped taxonomically, but exceptions will be made in the case of, for example, those that require special treatment, such as liming. A limited number of warm-climate species, such as Pinus elliottii Engelm. and Acacia melanoxylon Mill., will be located in a display greenhouse, which will be part of the arboretum.

The genetic division will be a repository of all genotypes which we wish to preserve for whatever reason. For example, a ramet of each plus tree will be stored there in case we lose both the original and all ramets in clonal orchards to fire, or another catastrophe. A special section of the genetic division will be the freak gardens, in which genetic aberrants encountered in the nursery or in the field will be planted.

The arboretum will serve several purposes, among which will be educational and scientific aspects. The arboretum will be open to schools, conservation groups, scientists, and individuals who wish to learn more about the trees of the world and tree breeding. A by-product of this will be better public relations. Another benefit will be convenience, in that it will enable our own scientists and those of Canadian Forestry Service to experiment with and to compare material, without travelling to distant parts of the province or even outside the province. Also, only a limited number of exotic species can be tested in formal species trials. Occasionally, a species could surprise us with its performance under Newfoundland conditions. The exotic division will give scores of species a chance to indicate potential, after which larger trials may be established. For example, the great potential of Pinus radiata D. Don for South Africa was discovered by just such a planting of a few specimens near Cape Town, in 1877 (Immelman et al, 1973).

Seed lots of 66 species of exotics were obtained from Petawawa National Forestry Institute, earlier this year. More than one variety of some species were included. These, along with a few other species, seed of which was already available, are now being raised in the greenhouse at Wooddale for planting in the arboretum. Approximately 85 exotic species will be planted in the initial establishment of the arboretum.

EXOTIC SPECIES TRIALS

Besides the Populus trichocarpa provenance trial, a poplar trial was established near Flat Rock, north of St. John's, involving 97 clones of various species and cultivars. Cuttings (5 per clone) were obtained from Lotbinière Arboretum in Québec. Based upon a winter observation in January, 1985, an 80% take was estimated. A full enumeration will be undertaken in the summer or early autumn of 1985.

Several new trials of Japanese larch (Larix leptolepis (Sieb. and Zucc.) Endl.) have been established in various parts of the province. This species has shown promise in several trials in the past. One of the new trials is a 1 km² plantation designed to determine how the species will perform in a pure-stand forest situation, as opposed to small blocks.

Jack pine (Pinus banksiana Lamb.) and lodgepole pine (P. contorta Dougl.) from selected provenances are being grown in the provincial nursery at Goose Bay for trials in Labrador. Siberian larch (Larix sibirica Ledeb.) will also be tried in Labrador, as well as on the island. However, past trials on the island have not been particularly promising. Other exotic species now undergoing initial trials are red alder (Alnus rubra Bong.) and several species of Nothofagus. Species scheduled for initial tests in the next year or two are Corsican pine (Pinus nigra ssp. maritima (Ait.) Melville), giant sequoia (Sequoiadendron giganteum (Lindl.) Buchholz), sweetgum, (Liquidambar styraciflua L.), and western hemlock (Tsuga heterophylla (Raf.) Sarg.). About 35 other exotic species have been planted here in the past, not counting ornamentals.

REFERENCES

- Harrison, C. 1984. Tree Improvement in Newfoundland and Labrador - A Future Outlook. Proc. 19th Meet. Can. Tree Impr. Assoc. Pt. 1, Toronto, Aug 22-26, 1983:34-37.
- Immelman, W., Wicht, C., and D. Ackerman. 1973. Our Green Heritage. Department of Forestry, Republic of South Africa Published by Tafelberg-Vitgewers Beperk, Cape Town: 332 pp.

TREE BREEDING AT THE NEWFOUNDLAND FORESTRY CENTRE 1983-1985

J. Peter Hall

*Newfoundland Forestry Centre
Canadian Forestry Service
Box 6028, St. John's, Nfld. A1C 5X8*

Keywords: Hybridization, inbreeding, selection, specific gravity,
Picea mariana, P. glauca, Larix

Reforestation programs in Newfoundland concentrate on the use of black spruce and white spruce because of a superiority in fibre production and proven adaptability to local conditions. Tree improvement has little effect on reforestation costs but can result in permanently increased productivity. Various exotic species are also being tested for growth and development under Newfoundland conditions.

BLACK SPRUCE (P. mariana)

1. A study of the effects of inbreeding in black spruce was continued with the outplanting of the families obtained in controlled pollinations. Early results in the greenhouse had shown there to be a reduction in seed set and in the growth of selfed compared to outcrossed seedlings (Hall 1984c). The continued development of the various families is being monitored in a replicated field trial.
2. The relationship between growth rate and specific gravity was examined in several natural stands of native conifers. Current plus-tree selection methods are based on rapid growth rates and it is assumed that wood specific gravity is unrelated to growth rate. Results of the study showed a weak relationship between the two and selection based solely on growth rate resulted in a slight reduction in specific gravity. To optimize gains through selection, rapidly growing trees of high specific gravity must be selected and a method for this was suggested (Hall 1984a).
3. The "Pilodyn Tester" was tested on black spruce, white spruce, larch, balsam fir and jack pine to determine its value in selection of trees of higher wood specific gravity. Preliminary results indicate a significant relationship between the inferred specific gravity (Pilodyn) and the measured specific gravity (displacement method).

4. Collection of cones have continued in the demonstration seed production areas established by the NFC. Seed yields are measured annually on selected trees. The proportion of trees flowering, number of cones per tree and number of filled seed per cone are all determined.
5. Two sets of provenance trials have been established in Newfoundland, an all-range trial and a regional trial. In 1984 and 1985 both sets were remeasured at 15 years from seed. Data on height and diameter are currently being analyzed.

WHITE SPRUCE (P. glauca)

1. A provenance trial of 31 sources from the Great Lakes-St. Lawrence Forest Region was remeasured for height and diameter 25 years from seed. The superiority of several Quebec and Ontario provenances was confirmed and a close relationship was found between height at 20 and 25 years ($r = 0.940$). Site conditions are variable within the plantation and this partially confounded the results. Collections of open-pollinated cones were made from the fastest growing provenances in 1984 and 1985.
2. A series of controlled pollinations (both inter- and intra-provenance) have been made on the faster-growing provenances to provide material for selection and to test these various family combinations. In May 1985 seedlings from these crosses were outplanted in western Newfoundland. A replicated field trial of 60 families was also established.

LARCH (larix spp.)

1. Studies of microsporogenesis in native and exotic larches in Newfoundland were completed and a paper was presented at a meeting of the IUFRO Seed Problem group (2.04.00) in Vienna in June 1985 (Hall 1985c). It was concluded that damage induced by low temperatures was not a significant biological impediment to the development of viable seed.
2. Seed quality and quantity were examined in two clones of European larch (L. decidua). Variation was large between and within clones, after inter- and intra-specific hybridization and between the two years sampled (Hall 1985a).

TESTS OF EXOTIC SPECIES

Various species of exotics have been tested in Newfoundland in unreplicated trials, species trials and provenance trials. Most trees are now 20 years old from seed and have been remeasured during 1984 and 1985. To date only Japanese larch (L. kaempferi), European larch, (L. decidua) and Dunkeld larch (L. eurolepis) have been shown to grow faster than native species and still be adaptable to local conditions. A large scale trial of Sitka spruce (12 provenances, 9 plantations) has shown that on average black spruce and white spruce have superior growth rates to Sitka spruce. However some individual trees of Sitka spruce have shown superior growth to black and white spruce.

PUBLICATIONS

- Hall, J. Peter. 1983a. A comparison of the growth of larch with other conifers on reforested and afforested sites in Newfoundland. The Forestry Chronicle 59(1), pp. 14-16.
- Hall, J. Peter. 1983b. Exotic tree species in Newfoundland forestry. NeFRC Woody Points 12(1).
- Hall, J. Peter and C.M. Harrison. 1983. A review of progress in tree improvement in Newfoundland, 67 pages. Paper delivered at Silviculture Newfoundland Symposium, Grand Falls, Nfld., 5-6 April 1983.
- Hall, J. Peter. 1984a. The relationship between wood density and growth rate and the implication for the selection of black spruce plus trees. Env. Can., Can. Forest. Ser., Inform. Rep. N-X-224. 22 p.
- Hall, J. Peter. 1984b. Field test of exotic larches in western Newfoundland. Env. Can., Can. Forest. Ser. Res., Notes, Vol. 4, No. 3, p. 37.
- Hall, J. Peter. 1984c. Genetic improvement of black spruce in Newfoundland. In Proceedings of the nineteenth meeting of the Canadian Tree Improvement Association. Part I. C.W. Yeatman Editor. Can. Forest. Ser., Ottawa, pp. 38-41.
- Hall, J. Peter. 1984d. (in press) Growth and development of larch in Newfoundland. In Sixth International Workshop on Forest Regeneration at High Latitudes. USDA, For. Ser., Gen. Tech. Rep. PNW.
- Hall, J. Peter. 1984e. Certification of Source - Identified Canadian Tree Seed under the O.E.C.D. Scheme. Woody Points, Vol. 13, No. 3.

Hall, J. Peter. 1984f. Northeastern Forest Tree Improvement Conference. Woody Points, Vol. 13, No. 3.

Hall, J. Peter. 1985a. (in press) Variation in seed quantity and quality in two grafted clones of European larch (larix decidua Mill.), Sil. Gen. (34:3).

Hall, J. Peter. 1985b. The role of genetics in forest management. Paper presented at a seminar series "Forestry in Newfoundland". Dept. of Geography, Memorial University of Newfoundland. 19 February 1985. 13 p.

Hall, J. Peter. 1985c. (in press) Effect of pollen development on seed yields in Larix in the boreal forest. IUFRO - Project Group P2.04.00 Seed Problems, 17 p.

Harrison, C.M. and J. Peter Hall. 1983. Tree improvement in Newfoundland - A future outlook, 36 p. Paper delivered at Silviculture Newfoundland Symposium, Grand Falls, Nfld., 5-6 April 1983.

Richardson, J., J. Peter Hall and R.S. van Nostrand. 1984. North Pond: Demonstrations of Forest Research Results. Agric. Can., Can. Forest. Ser., Inform. Rep. N-X-227, 192 p.

COOPERATIVE TREE IMPROVEMENT IN NOVA SCOTIA 1983-85

T.J. Mullin and H.M. Frame

*Tree Breeding Centre
Department of Lands and Forests
P.O. Box 190
Debert, Nova Scotia
B0M 1G0*

Keywords: government-industry cooperation, selection, seed orchards, breeding strategies, genotype-environment interaction.

Tree improvement in Nova Scotia is carried out by a government/industry cooperative known as the Tree Improvement Working Group (TIWG). Established in 1977, the TIWG has representatives from the Provincial and Federal Governments, and the three major pulp companies: Bowater Mersey Paper Co. Ltd., Scott Paper International Inc., and Stora Forest Industries (formerly known as Nova Scotia Forest Industries). The Province and the industry cooperators share the workload of selection and testing, and each maintain major seed orchard installations. The TIWG Management Committee meets twice yearly to review progress and set targets, while day-to-day program direction is handled by the Department of Lands and Forests.

Species of primary interest are black spruce (*Picea mariana* (Mill.) B.S.P.), red spruce (*Picea rubens* Sarg.), and white spruce (*Picea glauca* (Moench) Voss). Some effort is also directed at species planted in smaller numbers: Norway spruce (*Picea abies* (L.) Karst.), white pine (*Pinus strobus* L.) and larches (*Larix* Mill.).

Activities of the TIWG have been reported to the CTIA in earlier members' reports. The present report covers a 2-year period ending in the summer of 1985, and highlights major accomplishments.

Selection

Original selection targets called for 500 plus-trees for species where clonal seed orchards were to be used, and 1500 where seedling seed orchards were planned. For red spruce the TIWG has actually exceeded the 500-tree target. White spruce selection is just short of the 500-tree mark. In both cases field selection has all but curtailed, as additional trees will soon become difficult to phase into the breeding plan.

Black spruce selection remains well below the original 1500-tree target. Poor seed crops and the limited area of black spruce stands in the Province have created problems in building up numbers. Seedling orchards

which have been established to date have included plus-tree selections from other areas, primarily southern New Brunswick, to flesh out the number of families.

Expansion of Orchards

At this point, all cooperators in the TIWG have started major seed orchard installations, and all but one are handling two or more species. A summary of orchards established to date is given below:

<u>Species</u>	<u>Location</u>	<u>Type^a</u>	<u>Approximate area (ha)^b</u>	<u>Managing Agency</u>
Black Spruce	East Mines	S	5.2	Scott
	Aldershot	S	4.4	Stora
High-elevation black spruce	Strathlorne	S	2.8	Stora
White spruce	Debert	C	1.4	L & F
	East Mines	C	3.3	Scott
	Waterville	C	0.9	Stora
Ottawa Valley white spruce	MacQuarrie Lk. Rd.	S	3.6	Stora
Red spruce	Melvorn Square	C	4.2	Bowater
	Waterville	C	2.7	Stora
	Lawrencetown	C	1.6	L & F
White pine	Debert	C	1.6	L & F
Norway spruce	Debert	C	<u>1.8</u>	L & F
Total			33.6	

^aType: C = clonal (grafted), S = seedling

^bArea: exclusive of roadways and unplanted locations

The next few years will be a period of rapid orchard expansion, as most of these sites are preparing to receive large shipments of orchard stock from the Tree Breeding Centre. Orchard design, layout and record keeping is handled by computer.

Seed Production

Nova Scotia, like most parts of eastern Canada had a reasonably good seed year in 1984. The TIWG's first orchard in Lawrencetown, established in 1977, flowered heavily and produced over 2.5 kg of red spruce seed. Although some of the seed has been set aside for testing, most has been put into the production stream, and represents the first major contribution of improved seed to the Nova Scotia reforestation program.

Breeding Strategy

The TIWG program is about to enter a period of evaluation and breeding of selected parents. Approaches to breeding have been discussed for some time, but detailed strategies for each species have only recently been compiled. Don Fowler at the Maritimes Forest Research Centre has prepared a set of strategies which is currently under review, and is expected to form the basis for planning of mating and testing operations which will begin in earnest over the next few years.

Genotype-environment Interactions

The impact GxE interactions on breeding strategy continues to be of interest. An MScF thesis on genotype-nitrogen interactions in black spruce was accepted in 1984 (Mullin, 1984). This work will soon be published in the literature (Mullin, 1985).

Clonal material from the original greenhouse experiment has been propagated by rooted cuttings and established in a series of field tests. A total of 240 clones from 40 full-sib families are represented on each of 4 test sites.

Stand Out-crossing Project on Cape Breton Highlands

Seed from the Highlands of Cape Breton has been in very short supply, as budworm feeding in addition to the harsh environment have all but eliminated flower production. Reforestation stock for this area is required in large numbers (6 million trees annually) and is currently produced as rooted cuttings.

Provenance test results have suggested that the level of inbreeding may be high in the long, narrow stands of black spruce found on the Highlands (Fowler and Park, 1982). Since nursery production is already geared for rooted cutting propagation, it was felt that controlled mating could be used to produce sufficient seed, and would permit a reduction in inbreeding by mating parents from widely spaced stands. A pilot project was initiated in 1984 using pollen from 3 stands to produce outcrossed seed by controlled pollination. The project will likely be expanded in 1985.

PUBLICATIONS AND REFERENCES

- Fowler, D.P. and Y.S. Park. 1982. Range-wide black spruce provenance trials in the Maritimes. Can. For. Serv., Inf. Rep. M-X-137, 25 pp.
- Mullin, T.J. 1984. Genotype-nitrogen interactions in black spruce (*Picea mariana* (Mill.) B.S.P.). unpubl. MScF thesis, Univ. of New Brunswick. 81 pp.
- Mullin, T.J. 1985. Genotype-nitrogen interactions in full-sib seedlings of black spruce. Can. J. For. Res. 15 (in press)

TREE IMPROVEMENT AT NB DEPARTMENT NATURAL RESOURCES

R.D. Bettie, E.D. Stinson

*NB Department Natural Resources
Provincial Forest Nursery
R.R. #6
Fredericton, New Brunswick
E3B 4X7*

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. More recently, Norway spruce is being considered for reforestation and tree improvement work has commenced on this species. Active participation has 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 New Brunswick. Most of these stands are mature and as cone crops develop the better stands or sections of them are cut. To date, 247 kilograms of black spruce seed and 116 kilograms of jack pine seed have come from tested reserve stands.

PLUS TREE SELECTION AND BREEDING

To date, 656 black spruce and 531 jack pine have been selected for use in seedling orchards. A total of 66 white spruce (Picea glauca (Moench)Voss) and 75 tamarack (Larix laricina (Du Roi) K. Koch) have been selected for use in clonal orchards.

ORCHARD ESTABLISHMENT AND FAMILY TEST

To date, 24 hectares of black spruce, 24 hectares of jack pine, 8 hectares of Ottawa Valley white spruce and 3 hectares of tamarack seedling orchard have been outplanted. Five-year measurements of the 1979 black spruce and jack pine family tests were taken. The corresponding 1979 jack pine seedling orchard is beginning crown closure and an initial culling of the poorer families and individuals will take place in 1985.

Grafting of white spruce and tamarack for clonal orchards and breeding orchards has continued. About 4100 white spruce and 4900 tamarack grafts have been done. In 1984, 3 hectares of tamarack clonal orchards were established. Outplanting of 3 hectares each of tamarack and white spruce clonal orchard is planned for 1985.

TREE BREEDING AT THE MARITIMES FOREST RESEARCH CENTRE 1983 AND 1984

D.P. Fowler, J.M. Bonga, Y.S. Park, J.D. Simpson, and R.F. Smith

*Maritimes Forest Research Centre
Canadian Forestry Service
Fredericton, New Brunswick
E3B 5P7*

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 Region. 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.

R.F. Smith returned from educational leave in the summer of 1983, and is currently working in the area of seed orchard research and development. J.F. Coles accepted employment with the Ontario Tree Improvement Council and J.D. Simpson became a permanent member of our tree improvement group in 1984-1985. Mr. Simpson's primary job is to provide technical assistance and advice to the New Brunswick Tree Improvement Council.

HYBRIDIZATION IN PICEA AND LARIX

In 1983, work on species crossability and testing of Picea and Larix was continued. Emphasis in the pollination work was placed on producing hybrids of selected Japanese (Larix leptolepis (Sieb. et Zucc.) Gord.) and European larches (L. decidua Mill.). To this end, 56 different tree x pollen combinations were attempted. White (Picea glauca (Moench) Voss) and black spruce (P. mariana (Mill.) B.S.P.) were again crossed with pollens of Sitka spruce (P. sitchensis (Bong.) Carr.) from selected British Columbia trees (60 tree x pollen combinations). In 1984 over 100 tree x pollen combinations were attempted in Picea. In Larix, 3 sets of 4-tree diallel crosses were attempted with European larch and each of the 12 trees was crossed with 4 selected Japanese larches. Seed yield from most of the Larix crosses was unexpectedly low, possibly due to poor pollen viability.

SPECIES AND PROVENANCE TRIALS

This study was initiated in 1954 and includes a total of 200 replicated experiments and observation plots. Both range-wide and limited range provenance experiments are established over a variety of environmental conditions in the Maritimes. These experiments are maintained, and scheduled measurement, analysis, and interpretation of data are carried out. In 1983-84, four experiments were established or remeasured: tamarack (Larix laricina (Du Roi) K. Koch), black spruce, red spruce (Picea rubens Sarg.), and yellow birch (Betula alleghaniensis Britton).

Tamarack A cooperative range-wide provenance test of tamarack was planted at 10 locations in the Maritimes Region: four in each of New Brunswick and Nova Scotia and two in Prince Edward Island. At each location, 65 provenances covering the entire species range were planted in 8 replicates of 4 tree plots. The seedlings were measured prior to field planting.

Black spruce A cooperative range-wide provenance test of black spruce growing in 10 locations in the Maritimes was remeasured. Ten-year (from planting) height and other observations were recorded and are currently being analysed. At each test location, trees from up to 99 provenances are represented in 6 replications with 8-tree plots.

Red spruce Red spruce provenance data from 10 locations in the Region are being analysed. This test includes a total of 30 provenances from the Maritimes and adjacent Maine and 2 provenances from West Virginia. Preliminary analysis indicates considerable variation among provenances and a correlation between growth and degree of hybridization with black spruce.

Yellow birch A cooperative range-wide provenance test of yellow birch, established in 1963, was remeasured. A total of 45 provenances are represented in 10 replicates of 4-tree plots in only one location in the Region. Data accumulated over the past 20 years are being analysed.

POPULATION STUDIES

The purpose of this study is to elucidate the genetic structure of populations of tree species used for reforestation in the Maritimes and includes work on population structure, inbreeding, progeny testing, and quantitative genetics.

White spruce A white spruce inbreeding study involving five experiments was published in two parts. The first (Fowler and Park 1983) was concerned with the effects of self-pollination on seed set and performance. The results based on 20 trees from three populations up to age 17 years were reported. The most drastic effect of selfing was the increased frequency of empty seeds which averaged over 90%, and was 5 to 22 times higher than from comparable cross pollinations. The average number of embryonic lethal equivalents, although highly variable for individual

trees, averaged 8.0, 9.1, and 12.9 for the three populations. Self-pollination also resulted in slightly lower germination and reduced survival. Seedlings from self-pollination averaged 44.5 and 63.7% less height and diameter growth, respectively than seedlings from unrelated matings at age 17 years.

The second paper (Park, Fowler, and Coles 1984) involved natural inbreeding and relatedness among neighboring trees. Based on percent full seed data from various controlled pollinations, the estimated coefficients of relationship were 0.29 and 0.28 for neighbor and wind pollinations, respectively. Neighboring white spruce trees appear to be related at about the half-sib level. Wind pollination approximates a level of inbreeding expected from trees related at a level well above that of half sibs and differential selection at the pre-embryo to early seedling stage results in progenies again related at the half-sib level. It is suggested that an inbreeding equilibrium exists in natural stands of white spruce and that this equilibrium approximates that expected from half-sib matings. The inbreeding equilibrium is controlled, at least in part, by the frequency of lethal genes in the population.

Black spruce The results of a black spruce inbreeding experiment concerning self-fertility, genetic load, and performance were published (Park and Fowler 1983). Self-pollination resulted in a significant reduction in full seed set and early height growth. The number of embryonic lethals was estimated to be between 5 and 7 for trees in this population. The total number of lethal equivalents acting from time of pollination through age 6 years, ranged from 6 to 8. It was estimated that there are, on average, 1.8 archegonia per ovule in black spruce and polyembryony appears to have an important role in maintaining heterozygosity. Significant differences among female parents with respect to seed weight, percent germination, and 2- and 6-year heights indicated substantial variation due to additive genetic and maternal effects. Relative self-fertility, although generally high, varied widely among parent trees.

A series of black spruce progeny tests at three locations was measured after 5 growing seasons. This experiment includes 130 families from plantations and natural populations. The purpose of the experiment is to provide quantitative estimates of genetic parameters for use in predicting genetic advances and to explore the possibility of converting parental populations into seed collection plantations to provide a moderate level of genetic gain until the time seed orchards are in full production.

Tamarack An open-pollinated progeny test of tamarack from three different populations and planted in four locations was measured at age 5 years from planting. This experiment is designed to provide estimates of additive genetic variance and heritability needed to predict genetic gains through a tree breeding program. The data are currently being analysed.

CONE AND SEED RESEARCH/SEED ORCHARD MANAGEMENT

Over 100 ha of seed orchard have been established in the three Maritime provinces. Numerous problems have arisen associated with both the establishment and management of these orchards. Short-term research projects have been conducted to attempt to solve some of these problems.

Black spruce cone production was successfully enhanced by applying ammonium nitrate at rates of 200 to 300 kg elemental nitrogen per hectare. Six-year results from spacing trials in black spruce plantations have shown that seedling seed orchards planted at 1 x 2 m spacing will have to be rogued to 2 x 4 m by age 15 years otherwise both seed and pollen cone production will be detrimentally affected.

An experimental clonal seed orchard was established at the Acadia Forest Experimental Station to allow Canadian Forestry Service staff to conduct cone induction trials in white, black, and Norway spruce (Picea abies (L.) Karst), jack pine (Pinus banksiana Lamb.) and tamarack.

In 1984, there was a bumper white spruce cone crop. Coinciding with this large cone crop was a high incidence of the spruce needle rust (Pucciniastrum americanum) infecting the cones. This was attributed to the wet weather in the spring and early summer. Several cone collections were made and preliminary results indicated that this rust can seriously reduce or totally destroy seed in heavily infected cones, and therefore could pose a serious problem in white spruce seed orchards.

COOPERATIVE TREE IMPROVEMENT

Technical assistance continues to be provided by the MFRC to the expanding operational tree improvement programs in New Brunswick, Nova Scotia, and Prince Edward Island.

The New Brunswick Tree Improvement Council, composed of 13 cooperators, continues to focus its efforts on black spruce, white spruce, jack pine and tamarack. During the past two years, an additional 350 black spruce plus trees were selected (total 900) and 11 ha of new seedling seed orchard planted (total 65 ha). Jack pine selection progressed steadily with 290 new selections (total 800) and 15 ha of new seedling seed orchards established (total 45 ha). Due to the stage of development of the program, emphasis is now starting to shift to clonal seed orchard establishment. One agency has begun planting clonal orchards of black spruce and jack pine. White spruce and tamarack are receiving more widespread attention with 2 and 12 ha of orchard, planted, respectively. Ninety white spruce and 40 tamarack were selected increasing totals to 260 and 170, respectively. All plus tree selection activities and family test establishment are scheduled to be completed by 1987 at which time emphasis will shift to controlled pollinations and progeny testing.

Family tests and stand tests continue to be measured regularly. The first series of 10-year measurements is scheduled for 1985. Final analysis of five year measurements from all stand tests has identified the best reserve stands of black spruce and jack pine to collect cones from until seed orchards come into full production. Analysis of five-year data from two series of black spruce family tests demonstrated the top ranking families were at least 15% taller than the test averages and the check lots. An EPSON HX-20 portable computer was purchased and developed as a portable electronic data collector.

The first seed was collected from seed orchards in 1984! One agency collected 4.5 kg from a 6-year-old, 5 ha jack pine seedling orchard, another collected 280 g from a 7-year-old Japanese larch clonal orchard.

TISSUE AND ORGAN CULTURE

The present conifer tissue culture program deals primarily with one species, Larix decidua. This species is more responsive in vitro than any of the other conifer species worked with over the years. The major concern is in vitro propagation of mature trees. Techniques to produce adventitious plantlets, either directly from the explant or from subculture callus have been developed. Immature female cones collected in early May, or buds collected in late summer from 30-year-old trees have been used as explants. The plantlets survived transfer to soil for a few months. However, their stems did not elongate, i.e., they remained as rooted short shoots.

Somatic embryogenesis has been induced in subcultured callus from immature megagametophytes. A large number of plantlets were obtained and survived for several months after transfer to soil. These plantlets remained small. This experiment has yet to be reproduced.

PUBLICATIONS

- Bonga, J.M. 1984. Adventitious shoot formation in cultures of immature female stroboli of Larix decidua. *Physiol. Plant.* 62:416-421.
- Bonga, J.M. 1984. Adventitious shoot and root formation in tissue culture of mature Larix decidua. *Proc. Inter. Symp. Recent Advances in Forest Biotechnology*. Traverse City, Mich. June 10-13, 1984. Co-chairs J. Hanover, D. Karnosky, and D. Keathley. pp. 64-68.
- Bonga, J.M. 1984. In vitro propagation of mature conifers. *First Bioenergy Specialists' Meeting on Biotechnology*, Waterloo, Ontario, edited by S. Hasnain, L. Lamptey and M. Moo-Young. pp. 67-69.

- Bonga, J.M. 1985. In vitro propagation of conifers. In Clonal forestry: Its impact on tree improvement and our future forests. Proc. 19th Meet. CTIA (Part 2). pp. 75-83.
- Bonga, J.M. and A.H. McInnis. 1983. Origin and early development of roots in plantlets derived from embryo sections of Larix laricina in vitro. Can. For. Serv. Res. Notes 3:12-14.
- Clare, S.G., B.W. Dykeman, R.F. Smith and J.D. Simpson. 1984. A guide for establishing a permanent sod cover in forest tree seed orchards. Marit. For. Res. Cent., Tech. Note No. 105, 5 p.
- Fowler, D.P. 1983. The hybrid black x Sitka spruce, implications to phylogeny of the genus Picea. Can. J. For. Res. 13:108-115.
- Fowler, D.P. 1983. Exotic softwood trees in the Maritimes: Which ones should we plant? Marit. For. Res. Cent. Tech. Note No. 84. 7 p.
- Fowler, D.P. 1984. Vegetative propagation of forest trees. In Proc. 14th Meet. Study Group on Forest Tree Improvement. N.A. For. Comm., Durango, Mexico, Oct. 9-12, 1984. pp. 58-64.
- Fowler, D.P., and Y.S. Park. 1983. Population studies of white spruce. I. Effects of self-pollination. Can. J. For. Res. 13:1133-1138.
- Fowler, D.P., J.M. Bonga, Y.S. Park, J.D. Simpson, and R.F. Smith. 1985. Tree breeding at the Maritimes Forest Research Centre, 1981 and 1982. Proc. 19th Meet. CTIA (Part I). pp. 193-198.
- Morgenstern, E.K., J.M. Nicholson, and Y.S. Park. 1984. Clonal selection in Larix laricina. I. Effects of age, clone, and season on rooting of cuttings. Silvae Genet. 33:155-160.
- Park, Y.S., and D.P. Fowler. 1983. Inbreeding in black spruce (Picea mariana (Mill.) B.S.P.): self-fertility, genetic load, and performance. Can. J. For. Res. 14:17-21.
- Park, Y.S., and D.P. Fowler. 1983. A provenance test of Japanese larch in eastern Canada, including comparative data on European larch and tamarack. Silvae Genet. 32:96-101.
- Park, Y.S., D.P. Fowler, and J.F. Coles. 1984. Population studies of white spruce: II. Natural inbreeding and relatedness among neighboring trees. Can. J. For. Res. 14:909-913.
- Rohr, R., and J.M. Bonga. 1984. A method to isolate sexual cells of Larix decidua for cytological studies. Can. J. Bot. 62:1651-1658.
- Simpson, J.D. 1983. The New Brunswick Tree Improvement Council's breeding strategy for tamarack. In Proc. 28th Northeast. For. Tree. Imp. Conf. pp. 219-224.
- Smith, R.F. 1983. How early can white spruce cones be collected? Marit. For. Res. Cent. Tech. Note No. 92 2 p.
- Smith, R.F. 1983. Effects of fertilizers and spacing of trees on cone production in young black spruce (Picea mariana (Mill.) B.S.P.) plantations. MSc thesis, Univ. Wisconsin, Madison, 101 p.
- Tidswell, K. 1984. Field grafting of white spruce in the Maritimes. Marit. For. Res. Cent., Tech. Note No. 119, 3 p.

NBIP'S EFFORTS IN NBTIC COOPERATIVE PROGRAM

H. Bitto

*NBIP Forest Products Inc.
Woodlands Division
P.O. Box 1950
Dalhousie, N.B.
E0K 1B0*

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 the Department of Forest Resources, University of New Brunswick.

Seed Orchard

NBIP maintains a 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 covers more than 8.5 ha.

Maintenance during the past two years include fill planting and manual weeding. Weeding releases the planted seedlings and encourages rapid height growth. Fill planting was done to replace losses from rabbit browsing and snow damage.

Test Plantations

As a Council member, NBIP establishes, maintains, and measures test plantations on its crown license. In 1984, 2.2 ha of jack pine and 1.5 ha of Ottawa Valley white spruce family tests were planted. In 1985 2.2 ha of black spruce family test was planted. To date, total test areas by species are: black spruce (14.5 ha = 6 tests), jack pine (7.7 ha = 4 tests), and white spruce (3.0 ha = 2 tests).

Regular inspections are made on these tests and maintenance activities are carried out as needed. Measurements at age five were done on two tests in 1984 and will be done on one test this fall.

Plus Trees

During the past two years, NBIP has collected five white spruce, two jack pine and four black spruce as plus tree candidates.

REFERENCES

ANON. 1982 Five Year Report 1977-1981. N.B. Tree Improvement Council.

TREE SEED AND FOREST-GENETIC STUDIES AT THE
UNIVERSITY OF NEW BRUNSWICK
1983-1985

G.R. Powell and E.K. Morgenstern

*Department of Forest Resources
University of New Brunswick
Bag Service No. 44455
Fredericton, New Brunswick
E3B 6C2*

Keywords: cone and seed production, genotype-environment interaction, morphogenesis, phenology, tree breeding, vegetative propagation.

The program of education and research related to tree improvement in the Department of Forest Resources, University of New Brunswick, has remained very active. Undergraduate students have continued to contribute to the work of the New Brunswick Tree Improvement Council and to the research endeavours of graduate students and faculty. The following outlines the main activities and findings since our last report (Morgenstern and Powell 1984).

UNDERGRADUATE PROJECTS

As in past years, B.Sc.F. theses have contributed significantly to our knowledge of forest trees. Topics have been diverse but can be summarized under four headings.

Provenance Studies

Linehan (1984, 1985) analyzed the performance of 37 New Brunswick black spruce (*Picea mariana* (Mill.) B.S.P.) provenances at 12 locations. There were significant differences in height as well as significant provenance-location interactions. Similar results were obtained for jack pine (*Pinus banksiana* Lamb.) by Chase (1984), who confirmed the good performance of provenances from eastern New Brunswick. Brown (1985) found significant differences among stands of white spruce (*Picea glauca* (Moench) Voss) even within a relatively small area in Nova Scotia.

Guest (1984) demonstrated the value of computer mapping and trend surface analysis in illustrating variation in growth and phenology.

Family Tests

Large amounts of data are being generated from black spruce and jack pine open-pollinated family tests. Although early results must be interpreted with caution, significance levels, sizes of variance components, and estimates of genetic parameters such as heritability tended to fall within the same range (Taylor 1984, Richards 1985), and therefore are

of value in the development of a data base.

In cooperation with the Petawawa National Forestry Institute, an open-pollinated family test of tamarack (Larix laricina (Du Roi) K. Koch) was analysed at ages from 4 to 13 years. The objective was to determine when juvenile-mature correlations are high enough to make selections. Rank correlations between early and 13-year measurements tended to stabilize at about 9 years from seed. If one grew tamarack in short rotations of about 30 years, a test period of 9 years may be adequate (Smith 1985).

Variation in Crown Development

Using data provided by the Nova Scotia Department of Lands and Forests on over 1000 balsam fir (Abies balsamea (L.) Mill.) saplings, Archibald (1985) showed that large variations existed among various shoot and bud parameters. His results suggested that inter-tree interaction between genetic and environmental factors was high and should be taken into account in selecting trees for Christmas-tree improvement. Vescio (1985) investigated the occurrence and degree of syllepsis (sensu Hallé et al. 1978) in young plantations of tamarack. She found that the proportion of trees producing sylleptic branches and the numbers of sylleptic branches per tree increased over a 5-year period. Despite this, some trees remained nonsylleptic. This demonstrates that the propensity for syllepsis is genetically controlled to some extent, or that trees differ in threshold growth rates required to permit syllepsis to occur.

Reproductive Phenology and Cone Growth

In a study of cone development on 12 white spruce clones in two Nova Scotia seed orchards, variation in timing of receptivity and pollen shedding was related to geographic origin of clones. Limitations in the distance of movement (and hence the size of breeding regions) became apparent (Curtis 1985).

Fraser (1984) found that second-year growth in length and diameter of cones of Scots pine (Pinus sylvestris L.) began in early April (Fredericton, N.B.) peaked in the latter half of June, and was completed in early July. Varying amounts, positioning, and timing of removal of 1-year-old foliated short shoots from the supporting long shoot did not alter this growth pattern; however, removal of all short shoots, or of those on the distal half of the supporting long shoot, before mid-May significantly reduced final cone size (and new-leaf lengths). These findings emphasized the importance of 1-year-old leaves as supporters of new growth, but also showed that effects were local at the individual long-shoot level.

GRADUATE STUDENT AND FACULTY RESEARCH

Fourteen graduate students have been studying in seed-production, tree-improvement or forest-genetic areas at the University of New Brunswick during the two years covered by this report. Five have completed their work, including one (T.J.B. Boyle) who received the first Ph.D. degree in forestry granted by the University. Five more are in the final stages of

thesis preparation. As in the case of undergraduate projects, the work of graduate students, a post-doctoral assistant (W.R. Remphrey), and faculty can best be summarized under separate headings.

Economics of Black Spruce Breeding

Graduate student J.P. Cornelius completed his studies in 1984. He found that black spruce breeding is economic and that the present strategy of the New Brunswick Tree Improvement Council is close to optimum (Cornelius 1984). A journal article has been submitted.

Population Genetics

Graduate students T.J. Mullin and T.J.B. Boyle graduated in 1984 and 1985, respectively. They will report separately in these Proceedings. Studies on genotype-environment interaction by J.M. Wanyancha and R.M. Ricard are continuing (Morgenstern and Powell 1984, Wanyancha and Morgenstern 1985).

Variation, Propagation, Breeding, and Crown Development of Tamarack

We have now studied the rooting of tamarack for five years, and results have been given in several publications (Morgenstern et al. 1984, Pottinger 1985, Morgenstern and Pottinger 1985).

In cooperation with Dr. K. Carter of the University of Maine, a genecological study of tamarack was initiated. This is based on 7 stands x 7 open-pollinated families per stand x 10 clones per family. The resulting ramets from 490 clones were generated through two stages of cutting propagation at the University of Maine. One clonal test of identical design, 2.5 ha in area, was established by each university in the spring of 1985.

Because of the increasing importance of tamarack in reforestation and tree improvement in eastern Canada, it behoves us to understand more of the features which make it morphogenetically so different from other genera used more commonly in the past. To this end, studies of crown-architectural development 'strategies' which permit tamarack to rapidly exploit the space available to it were initiated in 1983. An excurrent crown shape is maintained by mechanisms similar to those in other species (e.g., balsam fir — Powell 1984), but processes are different because shoots may be 'long' or 'short', and if 'long', produced by varying degrees of preformation and neoformation, dependent on position in the crown (Remphrey and Powell 1984a,b,c). Greater height growth is accompanied by an increasing proportion of acrotoneous long shoots which provide for subsequent greater foliage display. The capacity for neoformation provides tamarack with a means of rapidly replacing damaged leaders without appreciable loss of height growth, and a means of growing in height (or length of lateral shoot) for as long as environmental conditions permit (Remphrey and Powell 1984c, Vescio 1985). Vigorous height growth is commonly accompanied by syllepsis, that is, production of branches on the leader as the leader continues to elongate (Remphrey and Powell 1985, Vescio 1985). This additional form of neoformation adds significantly to branch production, and hence to foliage production one year before it otherwise would occur. This, in

turn, leads to greater main-stem diameter growth (McCurdy 1984). Not all trees in a population (or plantation) exhibit syllepsis, thus genetic factors are implicated. Variability in sylleptic production undoubtedly is responsible for variability in commonly used measures of growth (height, dbh) and probably is related to variability in early (at least) cone production.

Cone and Seed Production

The research on cone and seed production in black spruce by G.E. Caron, and in tamarack by K.J. Tosh, reported previously (Powell and Morgenstern 1982) is nearing completion. Caron has shown how first seed-cone and pollen-cone production, build-up in numbers of cones, and periodicity of cone production are intimately interrelated with shoot production in branch-system development (Caron and Powell 1984) and with vigor gradients in the crown as a whole and upon individual branches. This provides greater understanding than hitherto of development to first bearing, phase-change, sex-change, aging and maturation. Tosh has found somewhat similar patterns of seed-cone and pollen-cone production in tamarack, but because of the much greater morphogenetic complexity of branch-system development in tamarack (Remphrey and Powell 1984a,b,c, 1985), and because tamarack cones on young trees occur in two contrasting positions (Powell et al. 1984), relationships are harder to interpret. Tosh has also studied cone morphogenesis, particularly the pollination mechanism, and effects of pollen quantities on seed yield (Tosh 1985). As did Caron (1984) for black spruce, Tosh and Powell (1984) found numerous forms of bisporangiate and proliferated cones in tamarack.

Studies on cone maturation, seed-extraction methods and yield and quality of seeds of Pinus merkusii Jungh. and de Vriese were completed by H. Arisman in 1984. He showed that techniques commonly used in Indonesia were detrimental and suggested means to obtain more uniform seed quality (Arisman and Powell 1985). A student from Kenya, E.M. Kariuki, is investigating seed production in three leguminous tree species indigenous to Kenya, and ways to overcome seed-coat dormancy in those species.

In cooperation with the Ontario Ministry of Natural Resources, M.G. Phelps is investigating clonal differences in phenology of pollen-cone, seed-cone and shoot development in a white spruce seed orchard at Glencairn.

Brief, colour-illustrated accounts of cone development and reproduction were completed for balsam fir (Powell 1983b), red spruce (Picea rubens Sarg.) (Powell 1983a) and black spruce (Powell and Caron 1985).

Variation in Seedling Morphogenesis

Morphogenesis of seedlings of Pinus differs from that of other genera and varies considerably within species (e.g., Thompson 1976, 1981, 1982, Powell 1982). Little definitive information is available in this regard for Canadian species. Variation in first-year morphogenesis of the five native hard pine (Diploxylon) species (two varieties of Pinus contorta Dougl.) is being investigated by S. Silim. He has found differences

between species in several characteristics, has grouped morphological forms into four within-species classes (three in Pinus resinosa Ait.), but has not detected much between-provenance variation.

Juvenile-Mature Wood-Density Relationships

A Pilodyn wood-density tester was found suitable for use on young trees (Villeneuve 1985). Villeneuve (1985) determined from correlations between densities of juvenile and mature wood, that the latter could be reliably estimated for jack pine at age 15 years. Further, reliable estimates of mean wood density could be obtained for families in progeny tests from sampling five or six replications of two or three trees per plot.

ACKNOWLEDGEMENTS

We are grateful for the support of the Canadian-American Center at the University of Maine.

The Tree Improvement Chair at the University of New Brunswick is supported by Acadia Forest Products and Boise Cascade Canada Ltd. (now brought together as Repap Miramichi Forest Products), 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 Maritime 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. The work on crown development and cone production in tamarack has been facilitated by access to plantations at the Provincial Forest Nursery, Kingsclear, granted by N. Kreiberg.

PUBLICATIONS AND REFERENCES

- Archibald, R.A. 1985. An exploratory study of relationships among various parameters in crowns of a young balsam fir population. B.Sc.F. thesis, University of New Brunswick, Fredericton, N.B., 31 pp.
- Arisman, H. 1984. Cone-collection and seed-handling procedures in relation to maturity of cones and quality of seeds of Pinus merkusii Jungh. and de Vriese in Indonesia. M.F. Report, University of New Brunswick, Fredericton, N.B., 164 pp.
- Arisman, H., and G.R. Powell. 1985. Effects of cone colour and seed-extraction methods on yield and quality of seeds of Pinus merkusii in Indonesia. Seed Sci. & Technol. 13: in press.
- Boyle, T.J.B. 1985. The mating system and population structure of black spruce in central New Brunswick and its influence on tree improvement strategy. Ph.D. thesis, University of New Brunswick, Fredericton, N.B., 141 pp.

- Boyle, T.J.B., and E.K. Morgenstern. 1985a. The population structure of black spruce in central New Brunswick. Proc. 29th Northeast. For. Tree Improv. Conf., Morgantown, WV, July 1984, in press.
- Boyle, T.J.B., and E.K. Morgenstern. 1985b. Inheritance and linkage relationships of some isozymes of black spruce in New Brunswick. Can. J. For. Res. 15: in press.
- Brown, A.G. 1985. A test of six white spruce (Picea glauca (Moench) Voss) populations at three test sites in Nova Scotia. B.Sc.F. thesis, University of New Brunswick, Fredericton, N.B., 51 pp.
- Caron, G.E. 1984. Occurrence of sporangiate-vegetative structures and bisexual strobili in young plantations of black spruce. Proc. 19th Mtg. Can. Tree Improv. Assoc., Toronto, Ont., August 1983, Part 1:60.
- Caron, G.E., and G.R. Powell. 1984. Sequential branch development of black spruce saplings. Can. Bot. Assoc. Bull. 17:36 (abstr.).
- Chase, B.R. 1984. Early growth and survival of 25 jack pine provenances at 14 test sites in New Brunswick. B.Sc.F. thesis, University of New Brunswick, Fredericton, N.B., 44 pp.
- Cornelius, J.P. 1984. An economic analysis of black spruce (Picea mariana (Mill.) B.S.P.) breeding in New Brunswick. M.Sc.F. thesis, University of New Brunswick, Fredericton, N.B., 163 pp.
- Curtis, A. 1985. Variation in reproductive bud phenology of white spruce in two clonal seed orchards in Nova Scotia. B.Sc.F. thesis, University of New Brunswick, Fredericton, N.B., 36 pp.
- Fraser, B.W. 1984. Effects of removal of one-year-old needles on development of one-year-old Pinus sylvestris L. cones. B.Sc.F. thesis, University of New Brunswick, Fredericton, N.B., 50 pp.
- Guest, D.A. 1984. Genetic variation patterns in black spruce (Picea mariana (Mill.) B.S.P.) illustrated by computer mapping. B.Sc.F. thesis, University of New Brunswick, Fredericton, N.B., 90 pp.
- Hallé, F., R.A.A. Oldeman, and P.B. Tomlinson. 1978. Tropical trees and forests. An architectural analysis. Springer-Verlag, Berlin, Heidelberg, New York.
- Linehan, B.G. 1984. Early growth and survival of thirty-seven black spruce provenances on twelve New Brunswick test locations. B.Sc.F. thesis, University of New Brunswick, Fredericton, N.B., 61 pp.
- Linehan, B.G. 1985. Early growth and survival of progeny from 37 black spruce stands at 12 locations in New Brunswick. New Brunswick Tree Improv. Council Tech. Rep. No. 2, 35 pp.

- McCurdy, W.D. 1984. Effect of sylleptic branching on diameter growth of Larix laricina. Undergraduate Rep. in Course, University of New Brunswick, Fredericton, N.B., 25 pp.
- McInerney, A.C. 1984. Vegetative propagation of deciduous species: a literature review. B.Sc.F. thesis, University of New Brunswick, Fredericton, N.B., 30 pp.
- Morgenstern, E.K. 1984. Review of "Applied forest tree improvement" by Bruce Zobel and John Talbert. Wiley, Toronto. 505 pp., 1984. For. Chron. 60:312.
- Morgenstern, E.K., and G.R. Powell. 1984. Tree seed and genetic studies at the University of New Brunswick 1981-1983. Proc. 19th Mtg. Can. Tree Improv. Assoc., Toronto, Ont., August 1983, Part 1:61-67.
- Morgenstern, E.K., J.M. Nicholson, and Y.S. Park. 1984. Clonal selection in Larix laricina. I. Effects of age, clone and season on rooting of cuttings. Silvae Genet. 33:155-160.
- Mullin, T.J. 1984. Genotype-nitrogen interactions in black spruce (Picea mariana (Mill.) B.S.P.). M.Sc.F. thesis, University of New Brunswick, Fredericton, N.B., 81 pp.
- Pottinger, A.J. 1985. An investigation of factors influencing the successful propagation of young tamarack stem cuttings. M.F. Report, University of New Brunswick, Fredericton, N.B., 67 pp.
- Pottinger, A.J., and E.K. Morgenstern. 1985. Factors influencing successful propagation of young tamarack stem cuttings. Proc. 29th Northeast. For. Tree Improv. Conf., Morgantown, WV, July 1984, in press.
- Powell, G.R. 1982. A comparison of early shoot development of seedlings of some trees commonly raised in the northeast of North America. Proc. Northeast. Area Nurserymen's Conf., Halifax, N.S., July 1982, pp. 1-24.
- Powell, G.R. 1983a. Red spruce. In Reproduction of conifers: a handbook for cone crop assessment. Can. For. Serv., For. Tech. Rep. 31, pp. 35-36.
- Powell, G.R. 1983b. Balsam fir. In Reproduction of conifers: a handbook for cone crop assessment. Can. For. Serv., For. Tech. Rep. 31, pp. 37-38.
- Powell, G.R. 1984. Patterns of development in balsam fir crowns. Can. Bot. Assoc. Bull. 17:43 (abstr.).
- Powell, G.R., and G.E. Caron. 1985. Black spruce. In Reproduction of conifers: a handbook for cone crop assessment. Can. For. Serv., For. Tech. Rep. 31, in press.

- Powell, G.R., K.J. Tosh, and W.R. Remphrey. 1984. Occurrence and distribution of cones borne laterally on long shoots of Larix laricina. Can. J. Bot. 62:771-777.
- Remphrey, W.R., and G.R. Powell. 1984a. Shoot preformation and neoformation in relation to crown architecture patterns in Larix laricina saplings. Can. Bot. Assoc. Bull. 17:44 (abstr.).
- Remphrey, W.R., and G.R. Powell. 1984b. Crown architecture of Larix laricina saplings: quantitative analysis and modelling of (nonsylleptic) order 1 branching in relation to development of the main stem. Can. J. Bot. 62:1904-1915.
- Remphrey, W.R., and G.R. Powell. 1984c. Crown architecture of Larix laricina saplings: shoot preformation and neoformation and their relationships to shoot vigour. Can. J. Bot. 62:2181-2192.
- Remphrey, W.R., and G.R. Powell. 1985. Crown architecture of Larix laricina saplings: sylleptic branching on the main stem. Can. J. Bot. 63: in press.
- Richards, M. 1985. Five-year height and survival of black spruce in nine family tests in New Brunswick. B.Sc.F. thesis, University of New Brunswick, Fredericton, N.B., 40 pp.
- Smith, G.P. 1984. Juvenile-adult height correlations in 36 tamarack (Larix laricina (Du Roi) K. Koch) families at 5 ages. B.Sc.F. thesis, University of New Brunswick, Fredericton, N.B., 39 pp.
- Taylor, C.S.J.J. 1984. 1979 black spruce family tests in New Brunswick - 5-year results. B.Sc.F. thesis, University of New Brunswick, Fredericton, N.B., 33 pp.
- Thompson, S. 1976. Some observations on the shoot growth of pine seedlings. Can. J. For. Res. 6:341-347.
- Thompson, S. 1981. Shoot morphology and shoot growth potential in 1-year-old Scots pine seedlings. Can. J. For. Res. 11:789-795.
- Thompson, S. 1982. Environmental control over the shoot growth of pine seedlings. In Proc. Can. Containerized Tree Seedling Symp., Toronto, Ont., September 1981, COJFRC Symp. Proc. O-P-10, pp. 177-181.
- Tosh, K.J. 1985. Pollination and seed quality in young plantations of Larix laricina. Poster at 20th Mtg. Can. Tree Improv. Assoc., Québec, P.Q., August 1985.
- Tosh, K.J., and G.R. Powell. 1984. Aberrant cone production in tamarack. Can. Bot. Assoc. Bull. 17:46 (abstr.).

- Vescio, S.A. 1985. An investigation of sylleptic branching and its possible relationship to main-stem leader elongation in Larix laricina. B.Sc.F. thesis, University of New Brunswick, Fredericton, N.B., 42 pp.
- Villeneuve, M. 1985. Use of the Pilodyn tester to estimate wood density in progeny tests. Poster at 20th Mtg. Can. Tree Improv. Assoc., Québec, P.Q., August 1985.
- Wanyancha, J.M., and E.K. Morgenstern. 1985. Genetic variation in nitrogen concentration, accumulation and utilization efficiency in 20 Larix laricina families. Proc. 29th Northeast. For. Tree Improv. Conf., Morgantown, WV, July 1984, in press.

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

R. Beaudoin, A. Stipanivic et G. Vallée

*Ministère de l'Énergie et des Ressources
Complexe scientifique
Sainte-Foy, Québec
G1P 3W8*

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

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

À ce jour, un total de 1 995 clones ont été sous observation au Service de la recherche du ministère de l'Énergie et des Ressources du Québec. De ce nombre, 650 clones ont été sélectionnés dans les peuplements naturels au Québec, 928 dans des plantations comparatives d'hybrides et d'espèces et 417 sont des clones introduits surtout d'Europe et d'Ontario.

Compte tenu du potentiel de P. trichocarpa, tous les arbres du test de provenances installé au populetum de Villeroy en 1976 ont été clonés dans le but de reproduire le test dans d'autres régions du Québec. D'ailleurs, 4 collections de boutures représentant chaque arbre du test ont été distribuées à d'autres organismes dont 3 au Canada et 1 aux États-unis. Ces organismes sont: Fast Growing Hardwoods Group of Ontario Ministry of Natural Resources, Ontario Tree Improvement and Forest Biomass Institute, Newfoundland Department of Forest Resources and Lands, North Central Forest Experiment Station de Rhinelander, U.S.A.

Quatre dispositifs du test clonal de 3^e génération ont été établis dans différentes régions du Québec. Le bilan des dispositifs des tests clonaux de 1^{re} et 2^e générations âgés de 10 ans et plus a permis la recommandation des clones suivants pour la populiculture au Québec: clones de P. x euramericana n° 36, 131, 205, 3020, 3021, clones de P. x interamericana n° 3026, 3027, 3052, 3053, 3054 et 3055 et clones de P. x jackii n° 22, 45, 1009, 1012, 1013, 1078, 1080, 1083. Les clones de P. x jackii sont recommandés pour les zones de la forêt boréale (climax de la sapinière et de la pessière) ainsi que pour le climax de l'érablière à bouleau jaune, tandis que les clones de P. x euramericana et P. x interamericana sont valables pour les climax des érablières laurentienne et à caryer.

Les croisements suivants ont été faits et ont produits des semis: P. x jackii x P. trichocarpa, P. x jackii x P. deltoïdes, P. x jackii x (P. balsamifera x P. nigra), P. x jackii x P. deltoïdes et le réciproque, P. x euramericana x P. x jackii, P. x jackii x (P. alba x P. grandidentata), P. x jackii x P. grandidentata et (P. deltoïdes x P. trichocarpa) x P. x jackii.

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

Mots-clés: Larix Mill., test de provenances, test de descendance, croisements.

Plantations comparatives

Nos efforts sont présentement concentrés sur l'installation de dispositifs qui nous permettront d'estimer la valeur génétique, comme source de graines, des plantations de mélèze déjà établies au Québec. Ainsi, en 1984, nous avons mis en marche un test comprenant 101 descendance, surtout de mélèze d'Europe, dans l'arboretum de Villeroy (région forestière L.3). D'autres tests semblables sont prévus pour l'avenir.

Nous avons aussi mis en marche un test de descendance de mélèze laricin dans le but d'étudier l'héritabilité de la flexuosité de la tige et de l'angle d'insertion des branches. Ainsi, 60 descendance récoltées sur les arbres sélectionnés pour ces caractéristiques de phénotype ont été semées et les plants se trouvent présentement dans la pépinière.

L'analyse des données recueillies dans deux de nos dispositifs âgés de 5 ans et installés dans l'arboretum de Lotbinière (rég. for. L.3) et de Bonaventure (rég. for. L.6) nous a permis de constater la stabilité temporelle et spatiale des classements selon la vigueur de treize provenances de mélèze laricin étudiées. Ainsi, nous avons pu recommander, au moins provisoirement, cinq provenances pour le reboisement au Québec, dans la région forestière des Grands Lacs et du Saint-Laurent. De plus, dans les deux dispositifs de mélèze laricin (un test de descendance et un test de provenances) situés dans l'arboretum de Lotbinière, nous avons effectué une étude concernant la relation entre certains caractères morphologiques de la cime et la croissance à l'âge de cinq ans après la plantation.

Pollinisation dirigée

Les premiers essais de pollinisation dirigée du mélèze ont été effectués dans notre parc à clones en mai 1984. Au total, 12

croisements ont été effectués pour produire des hybrides interspécifiques (10 combinaisons) et intraspécifiques (2 combinaisons). La qualité de graines obtenues et la valeur des croisements seront vérifiées par le test de descendance. Ces travaux avaient surtout pour but de nous familiariser avec la technique de pollinisation dirigée, qui est une voie prometteuse dans l'amélioration des mélèzes et dans laquelle nous planifions de nous engager davantage.

Récolte de graines

La bonne fructification de l'année 1984 nous a permis d'effectuer la récolte sur 900 arbres dans les différentes plantations expérimentales au Québec. Il s'agit surtout des mélèzes d'Europe et du Japon et d'hybrides x eurolépis adaptés à nos conditions climatiques. Le but de cette récolte est de vérifier la valeur génétique des graines produites dans les plantations où le croisement interspécifique et interprovenances est possible.

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

Mots-clés: Pinus banksiana Lamb., test de descendance.

Dans le but de produire de la semence génétiquement améliorée pour le reboisement en pin gris au Québec, le Service des pépinières et du reboisement a continué l'installation de vergers à graines de semis tandis que le Service de la recherche a procédé à l'établissement des tests de descendance correspondants.

Tests de descendance

Au cours de 1983, deux plantations comparatives de descendance ont été établies. Une plantation est située dans la région de l'Abitibi-Témiscamingue (canton de Montreuil) et comprend 347 descendance. L'autre a été réalisée dans la région de Trois-Rivières (canton de Chasseur) avec 246 descendance. Le nombre d'arbres par famille pour chacun des tests est respectivement de 40 et 48. La sélection d'arbres-plus en forêt naturelle a été effectuée localement pour chaque test.

Un test de 322 descendance a été établi au printemps 1984, dans la région de l'Abitibi-Témiscamingue (canton de Lavergne). Le nombre d'arbres par famille était de 48.

PROJET G 78-1. TESTS DE PROVENANCES SUR LE PIN SYLVESTRE
(PINUS SYLVESTRIS L.) PAR R. BEAUDOIN

Mots-clés: Pinus sylvestris L., tests de provenances, vergers à graines de semis.

Le pin sylvestre est une espèce à croissance juvénile rapide, qui se régénère bien et qui pourrait être une option intéressante pour le reboisement de plusieurs sites au Québec. Afin de faire un bon choix de provenances et d'exploiter au maximum la grande variabilité génétique de cette espèce, un programme d'amélioration génétique, qui comprend en premier lieu l'essai d'un grand nombre de provenances dans diverses régions écologiques du Québec, a été mis en place.

Plantations comparatives

L'installation de 15 plantations comparatives de provenances de pin sylvestre a été réalisée dans autant d'arboretums du Québec, en 1983. Ces lots de graines provenaient en partie de certaines plantations déjà réalisées au Québec, mais surtout, par l'intermédiaire de l'IUFRO, de plusieurs pays d'Europe. Ainsi, 70 provenances sur un maximum de 110, semées à la pépinière de Duchesnay à l'automne 1979 et au printemps 1980, ont été testées en dispositifs.

Deux provenances de pin sylvestre (Berthier et Dorvillier) ont été comparées à 6 autres espèces résineuses pour la production de biomasse au populetum de Villeroy, en 1983. Le dispositif a été conçu pour analyser les effets de l'espèce et de l'espacement entre les plants sur la production de biomasse.

Vergers à graines de semis

Deux vergers à graines de semis ont été implantés aux arboretums de Coulonge (45°51' N et 76°34' O) et Mastigouche (46°38' N et 73°13' O). Seize provenances sont comprises dans chacun des vergers et elles ont été choisies en comparant les hauteurs moyennes en pépinière de toutes les provenances, à l'automne de 1982.

Observations en pépinière

Les observations sur le comportement des provenances en pépinière, en automne 1982, ont confirmé la grande variabilité génétique de cette espèce ainsi que ses possibilités d'utilisation pour les productions ligneuse et ornementale au Québec. Les hauteurs moyennes des semis (2-1) des provenances en pépinière variaient de 10 à 70 cm. La coloration des aiguilles était bleuâtre pour trois provenances (France, Angleterre et Belgique).

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

Mots-clés: Picea mariana (Mill.) B.S.P., étude de population, test de descendance.

Plantations comparatives

En 1984 nous avons installé 18 dispositifs comprenant au total 24 provenances québécoises d'épinette noire. Ces tests nous donneront des informations sur le comportement de différentes provenances couramment utilisées dans le reboisement au Québec. Ces dispositifs sont composés de parcelles linéaires de 25 arbres, dans le but de favoriser, au moment de la floraison, la pollinisation interprovenances. Ainsi, ces tests pourront servir aussi comme source de graines améliorées.

Il faut noter aussi la mise en marche de sept tests de descendance en 1983 et 1984, dans le cadre du programme d'établissement de vergers à graines d'épinette noire, dirigé par le Service des pépinières et du reboisement de notre Ministère. Ces tests de descendance, composés du même matériel que les vergers à graines, seront installés sur des sites qui représentent les conditions de terrain à reboiser, et ils fourniront les informations nécessaires pour l'aménagement de vergers à graines. Chacun contient entre 330 et 430 descendance récoltées sur les arbres sélectionnés par les Unités de gestion à l'intérieur de différentes zones de récolte de semences et ils seront plantés sur le terrain durant les années 1985 et 1986.

Pollinisation dirigée

Seuls quelques croisements interprovenances ont été effectués au printemps 1984 et la qualité des graines de même que la valeur génétique des croisements restent à être vérifiés. Par contre, notre parc à clones contient présentement 120 clones sélectionnés dans les régions forestières Boréale et des Grands Lacs et du Saint-Laurent. Nous avons remarqué un début de floraison sur quelques clones; ainsi, nous espérons pouvoir augmenter le nombre de croisements dirigés, surtout dans le cadre de l'étude sur la structure génétique.

Récolte de graines

Comme pour les autres espèces résineuses, la fructification de l'épinette noire a été bonne en 1984. Nous avons récolté 200 descendance à l'intérieur de nos plantations expérimentales. La qualité des graines et des descendance sera examinée dans les tests que nous prévoyons mettre en marche le plus tôt possible.

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

Mots-clés: choix et essais d'espèces, de races, etc., tests de provenances, de descendances et de clones, sélection, hybridation.

En plus des plantations comparatives établies avec des clones de peuplier et de saule, des travaux ont été entrepris sur le frêne blanc (Fraxinus americana L.) et sur différentes espèces d'aulnes (Alnus sp.).

Deux dispositifs d'un test de 44 provenances de frêne blanc représentées par 171 et 209 descendances ont été mis en place à deux endroits dans la vallée du Saint-Laurent.

Un test de 26 provenances d'Alnus rubra représentées par 86 descendances a permis, après deux ans de croissance dans la pépinière de Duchesnay, d'identifier des provenances rustiques qui sont d'Alaska. Le comportement des provenances révèle que les populations d'aulne rouge du sud de l'Alaska et du nord de la Colombie-Britannique devraient être rustiques pour le sud du Québec.

Des tests de provenances-descendances ont été entrepris sur Alnus cordata (Loisel.) Desf. (19 lots de semences), sur Alnus glutinosa (L.) Gaertn. (106 lots de semences) et Alnus incana (L.) Moench (18 lots de semences).

Quelque 94 clones d'aulnes représentant les espèces A. glutinosa, A. incana et A. glutinosa x A. incana sont en collection et reproduits par boutures feuillées pour être testés.

On notera que la principale limitation pour la plantation de A. glutinosa et A. incana est leur susceptibilité au chancre Phomopsis sp.. Par exemple, sur 30 sujets d'aulne glutineux sélectionnés en 1982 dans des plantations ayant 8 ans et plus, la moitié étaient attaqués par le chancre Phomopsis sp. deux ans plus tard. Une sélection de provenances et de cultivars non susceptibles à ce chancre est donc nécessaire.

PROJET G 83-1 MISE AU POINT D'UN SYSTÈME DE PRODUCTION PAR BOUTURAGE
DE SEMIS GÉNÉTIQUEMENT AMÉLIORÉS, PAR G. VALLÉE

Mots-clés: Système de bouturage, tests de descendance, sélection juvénile, relations juvéniles-adultes, variété multiclonale.

L'objectif de ce projet est d'obtenir le plus rapidement possible des plants génétiquement améliorés pour les reboisements de courtes rotations (± 20 ans) par le bouturage de semis, de façon à s'assurer des gains de croissance et d'autres caractéristiques à toutes les étapes de la production: ex.: vigueur des semis cultivés en contenants, vigueur des plants à l'âge juvénile (0 à 10 ans), vigueur des plants à l'âge adulte, résistance ou tolérance aux maladies, qualité des tiges et du bois, etc.

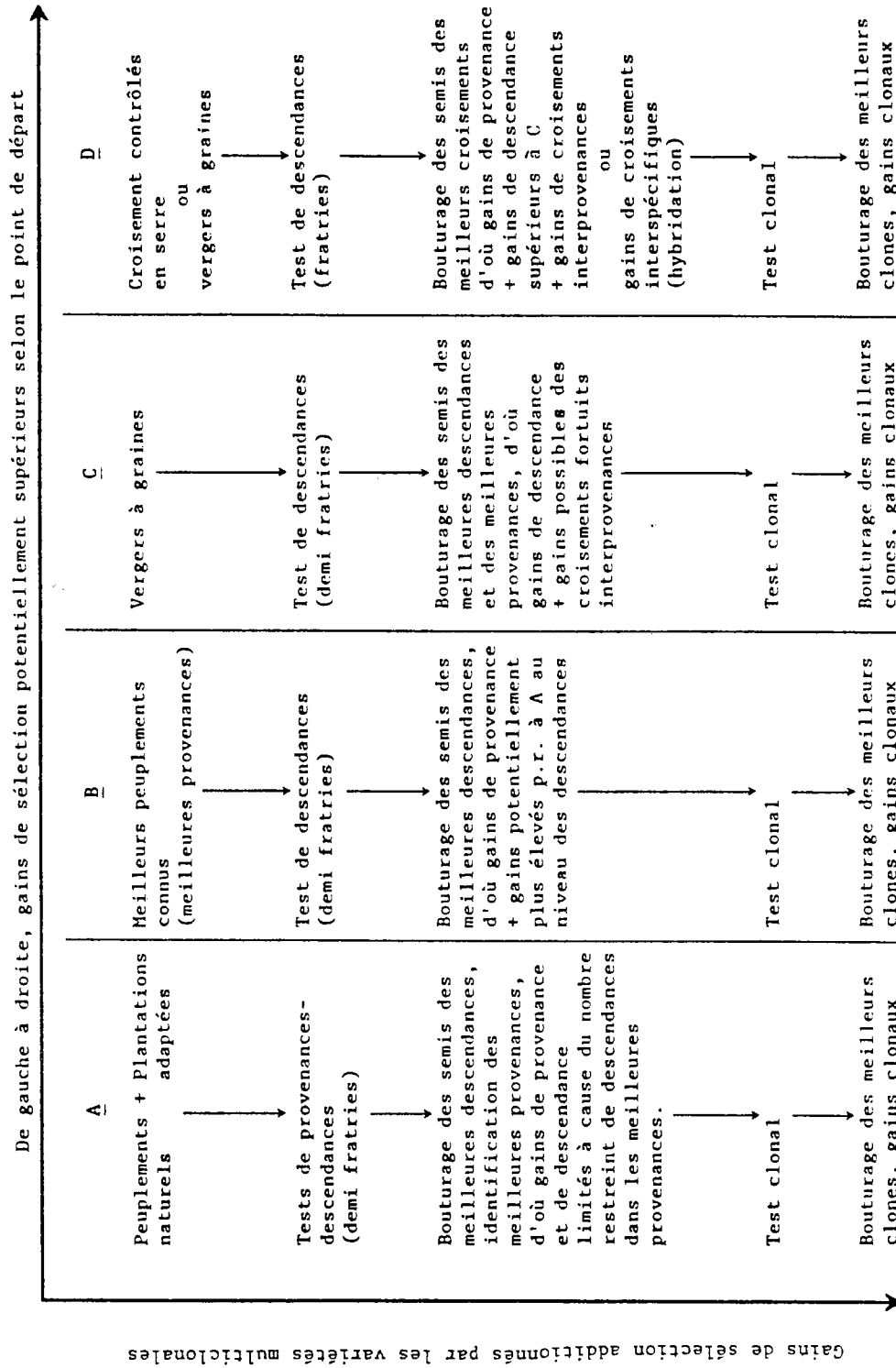
Dans un premier temps, la priorité de sélection sera donnée au caractère croissance, d'autant que le matériel de base, en l'occurrence des descendance (fratries ou demies fratries), proviendra de provenances connues pour leurs performances exceptionnelles et d'arbres sélectionnés pour leur qualité de fût et exempts de maladies.

Les procédures de développement de variétés multiclones sont décrites au tableau 1. Elles sont basées sur des tests de descendance faits à partir de fratries obtenues de croisements ou demies fratries obtenues d'arbres-mères localisées et protégées en peuplements naturels ou plantations ou verger à graines. Pour une même espèce et sur une base régionale, le processus d'amélioration est continu comme l'indique l'exemple de développement de variétés multiclones présenté au tableau 2. Dans le cas d'hybrides interspécifiques, on se propose de procéder par croisements contrôlés. Pour les espèces feuillues qui peuvent être réjuvenées, la sélection sera poussée jusqu'au niveau des clones, tandis que dans le cas d'espèces résineuses, la sélection s'arrêtera au niveau des descendance en attendant que les problèmes de vieillissement et de réjuvenation soient résolus.

Les travaux réalisés sur ce projet en 1983 et 1984 sont les suivants:

- Mise au point du système fiable de bouturage à partir de petites boutures feuillées (5 cm) de tiges de semis pour des espèces résineuses et de boutures mono-nodales pour les espèces feuillues. Ce système appelé "Bouturathèque" est installé hors serre et est constitué de cases presque hermétiquement fermées qui conservent une humidité relative de $\pm 90\%$. L'activité photosynthétique est

TABIEAU 1
PROCÉDURES DE DÉVELOPPEMENT DE VARIÉTÉS MULTICLONALES

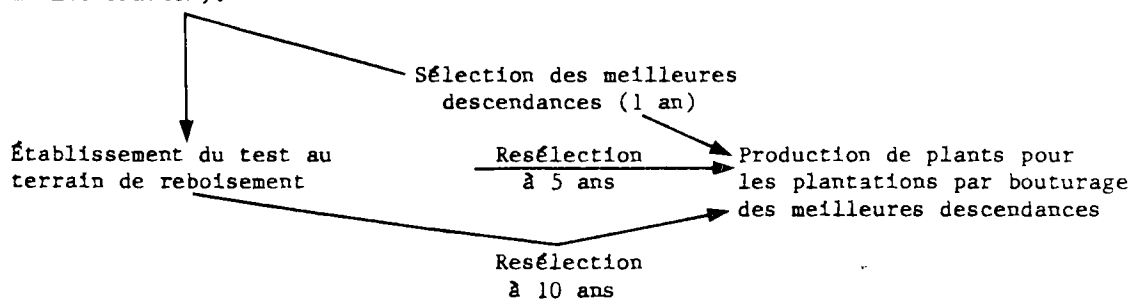


TABEAU 2

EXEMPLE DE DÉVELOPPEMENT DE VARIÉTÉS MULTICLONALES

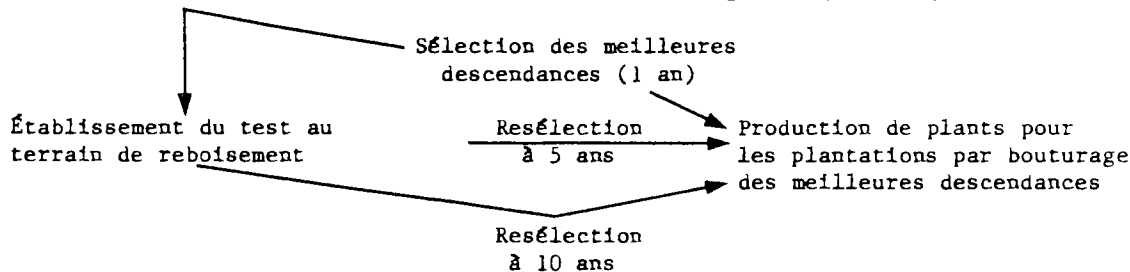
Année 1: 1^{er} cycle d'amélioration

1^{er} test de descendance en serre (\pm 200 descendances par cycle d'amélioration).



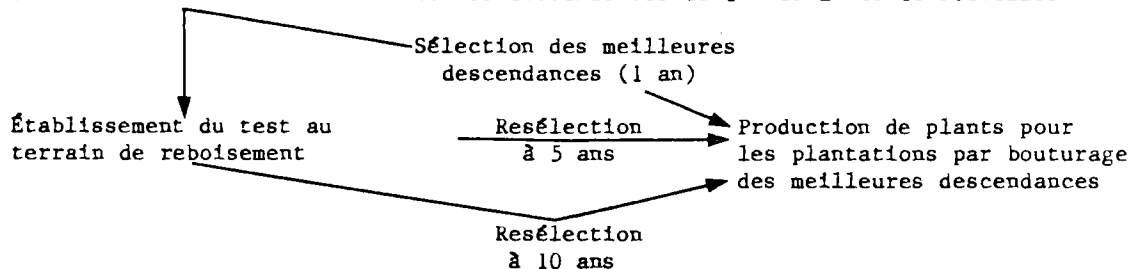
Année 2: 2^e cycle d'amélioration

2^e test en serre avec les meilleures descendances du 1^{er} et de nouvelles



Année 3: 3^e cycle d'amélioration

3^e test en serre avec les meilleures descendances du 1^{er} et 2^e et de nouvelles



maintenue par un éclairage à base de tubes fluorescents (1 tube par 30 cm de largeur de case) et une photopériode de 2 heures de lumière et 1 heure d'obscurité afin de mieux répartir la demande énergétique et la chaleur qui se dégage du système lumineux.

- Des tests de descendances ont été entrepris sur le mélèze d'Europe (Larix decidua Mill.) et l'épinette noire (Picea mariana (Mill.) B.S.P.) à partir de récoltes de semences faites sur des arbres sélectionnés dans les meilleures provenances de deux plantations comparatives de L. decidua et dans 22 peuplements de P. mariana de l'Abitibi.
- Le bouturage de clones de peuplier hybride (Populus L.) de la section leuce et de clones d'aulne (Alnus B. Ehrh.)

RÉCOLTE DE CÔNES ET AMÉLIORATION GÉNÉTIQUE DES ARBRES FORESTIERS AU QUÉBEC

Yves Lamontagne

*Ministère de l'Énergie et des Ressources
Service des pépinières et du reboisement
200B, ch. Ste-Foy
Québec, P.Q.
G1R 4X7*

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

Pour réaliser le programme de régénération artificielle de 300 millions de plants prévu pour 1988, environ 10 mille hectolitres de cônes de diverses espèces sont requis annuellement.

Le Service des pépinières et du reboisement du ministère de l'Énergie 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 et à racines nues.

RÉCOLTE DE CÔNES

En 1983, 10 174 hl de cônes furent cueillis dont les principales essences étaient le pin gris, le pin rouge et l'épinette noire. L'année 1984, avec 53 820 hl de cônes cueillis marque un record sans précédent au Québec. L'épinette blanche, avec 63% du volume récolté, fut la principale essence. Cette récolte aura permis de constituer d'importantes réserves pour les années à venir.

AMÉLIORATION DES ARBRES

Peuplements semenciers

En 1983, des travaux ont été réalisés sur 29,5 ha alors que seulement 5,0 ha ont été traités en 1984. Les espèces considérées sont surtout l'épinette noire, le pin gris et l'épinette blanche. Les travaux ont surtout consisté à nettoyer les peuplements déjà établis, à dégager les arbres choisis comme semenciers, à tailler quelques flèches terminales et à fertiliser pour augmenter la production de cônes. Les peuplements d'épinette blanche, d'épinette de Norvège et d'épinette noire de l'est de la province ont de plus été arrosés contre la tordeuse des bourgeons de l'épinette. La superficie traitée était de 356 ha.

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 4400 arbres, surtout des pins gris, des épinettes blanches, des épinettes noires, des épinettes rouges et des épinettes de Norvège ainsi que des pins blancs, ont été sélectionnés. Le nombre total atteint 15 600. Tous les cônes de pin gris et d'épinette noire sont récoltés sur chaque arbre et des statistiques intéressantes en sont tirées. Ces graines sont conservées jusqu'à leur utilisation dans les vergers de semis et dans les tests de descendance, de provenances, etc. La récolte de greffons sur les autres essences se fait selon les possibilités de greffage pour les vergers clonaux.

Afin de ne pas retarder l'implantation des vergers dû aux mauvaises années semencières, à l'absence de production de graines par les arbres sélectionnés ou à l'absence de pousses causée par la tordeuse des bourgeons de l'épinette, la sélection se pratique actuellement en fonction de la présence de cônes et de belles pousses. En d'autres termes, seulement les arbres sur lesquels la fructification est évidente et ceux qui permettent la récolte de greffons de qualité, en plus des autres caractéristiques propres à chaque espèce, sont sélectionnés.

Vergers à graines

Au cours des deux dernières années, l'entretien des vergers déjà établis s'est poursuivi. 110 ha de nouveaux vergers ont été implantés et 170 ha de terrain ont été préparés pour de futurs vergers. Les essences impliquées sont l'épinette noire et le pin gris.

En 1983, 18 500 greffes d'épinette blanche ont été réalisées avec un taux de reprise de 62%. Pour 1984, ces chiffres sont respectivement 18 650 greffes et 61%. L'épinette blanche et l'épinette rouge ont été greffées en 1984.

L'implantation de vergers de 1^{re} génération, de vergers de semis surtout, ira en augmentant jusqu'en 1987 pour décroître par la suite.

ACTIVITÉS DE RECHERCHE DU S.C.F. EN GÉNÉTIQUE ET AMÉLIORATION DES ARBRES FORESTIERS AU QUÉBEC

A. Corriveau, J. Beaulieu, G. Daoust

Service canadien des forêts
1055, rue du Peps
C.P. 3800
Sainte-Foy, (Québec)
G1V 4C7

Mots clefs: Pinus strobus, Picea glauca, Picea abies, génétique forestière, amélioration des arbres, propagation

Au cours de la période de 1983-1985 le Service canadien des forêts a conduit, en collaboration avec le ministère de l'Energie et des Ressources du Québec des travaux de recherche sur la génétique, l'amélioration et la multiplication végétative de l'épinette blanche, de l'épicéa commun et du pin blanc. Les populations naturelles et artificielles de ces espèces furent échantillonnées et des tests génétiques précoces furent conduits sous culture intensive puis dans différents milieux forestiers. La sélection de phénotypes supérieurs a été poursuivie tandis que des croisements dirigés étaient effectués en parc d'hybridation et que des propagules étaient mis à la disposition du MER pour la réalisation de vergers à graines clonaux. Des recherches sur la qualité du bois de l'épinette blanche ainsi que sur la production et la sélection in vitro de clones résistants au froid étaient conduites à contrat par des chercheurs de l'Université Laval.

GÉNÉTIQUE ET AMÉLIORATION DE L'ÉPINETTE BLANCHE

Entrepris en 1976, les travaux de recherche et d'amélioration des caractéristiques qualitatives, d'adaptabilité et de productivité de l'épinette blanche ont été poursuivis tel que prévu dans le plan de travail initial.

Grâce à une année exceptionnelle de fructification survenue en 1984 il nous a été possible d'intensifier l'échantillonnage génique des populations naturelles d'épinette blanche d'origine québécoise. Pour ce faire, des semences de quelque six cents individus représentant cent-vingt populations furent récoltées, traitées et entreposées en vue de besoins futurs de recherche et de la préservation de la variabilité génétique de l'espèce.

Des observations d'ordre phénotypique furent effectuées dans des tests de descendance/populations conduits sous culture intensive. Ils nous ont permis d'évaluer l'importance de la variabilité génétique et l'héritabilité des caractéristiques de croissance juvénile de l'épinette

blanche. Des analyses multifactorielles ont été conduites sur des données biologiques et géoclimatiques recueillies en tests génécologiques dans le but d'élucider les principaux facteurs et sources de la variation et de l'adaptation de l'espèce. Poursuivant le même objectif, des superficies forestières furent préparées et quatre plans expérimentaux furent établis. Ils complètent à onze, une série de tests génécologiques, comptant quelque trois cent cinquante demi-fratries, répartis dans la région forestière des Grands Lacs et du St-Laurent. Nous serons ainsi en mesure d'identifier et de recommander les meilleures sources et génotypes pour les programmes d'amélioration et de reboisement régionaux.

Une étude de la variabilité de l'infradensité du bois et de la productivité volumique de l'épinette blanche, 25 ans après plantation a été complétée et est en voie de publication. Des différences significatives entre les populations furent observées. Cependant, la majorité de la variation de l'infradensité du bois se situe entre les arbres de la même population. Il ressort de cette étude que des gains substantiels en poids de matière sèche produite peuvent être obtenus par la sélection, dans un premier temps des populations à croissance rapide et dans un deuxième temps, de la sélection d'individus possédant un bois de densité supérieure, à l'intérieur de ces populations.

Une seconde étude, conduite cette fois à partir d'échantillons prélevés en forêts naturelles nous a permis de confirmer les observations précédentes. Aucun gradient de variation de l'infradensité de l'épinette blanche parallèle aux gradients géographiques n'a pu être décelé. Cependant, certaines régions de provenances expriment des caractéristiques particulières de densité de bois significativement plus faible ou plus élevée que de l'ensemble des populations échantillonnées. Un contrat de recherche accordé à un groupe de chercheurs de l'Université Laval, dans le cadre du programme PRUF et portant sur l'étude des caractéristiques intrinsèques du bois de l'épinette blanche est actuellement à sa deuxième année de réalisation. Des résultats très intéressants ont été obtenus à ce jour.

Dans le but de surmonter l'handicap majeur, à l'obtention rapide de gains génétiques, qu'est la tardiveté de reproduction sexuée chez l'épinette blanche nous avons entrepris la mise en pots de clones âgés de 4 à 7 ans. Les clones empotés seront placés sous enceintes plastiques et induits à la fructification par pulvérisations hormonales et stress environnementaux divers.

Afin d'élargir la base génétique de l'amélioration de l'épinette blanche des sélections ont été effectuées en tests comparatifs et les ortets ont été multipliés par greffage et inclus dans le parc d'hybridation de l'espèce. Suite à une saison de fructification abondante le synchronisme de floraison des clones d'épinette blanche en parc d'hybridation a pu être évalué. Des croisements dirigés, selon un plan diallèle complet ont été réalisés bien que la faible quantité de pollen produite ait limité l'ampleur du programme. Il a pour but d'évaluer la valeur en croisement des clones, leur aptitude à la combinaison ainsi que les variances génétiques additives et de dominance des caractéristiques d'intérêt économique.

De plus, nous avons participé au programme d'implantation de vergers à graines du ministère de l'Énergie et des Ressources du Québec en mettant à la disposition de cet organisme un grand nombre de clones sélectionnés et un programme informatique "MIMOSOL" permettant la réalisation de plans de vergers à graines.

GÉNÉTIQUE ET AMÉLIORATION DU PIN BLANC

Une réévaluation de l'incidence de la rouille vésiculeuse (*Cronartium ribicola* J.C. Fisch.) dans les plantations et forêts naturelles de pins blancs du Québec méridional a stimulé l'initiation des travaux de recherche et d'amélioration génétique de l'espèce en fonction des conditions écologiques des zones d'incidence de la rouille.

Depuis, près de cent cinquante populations d'origine québécoise ont été échantillonnées et des semences furent récoltées sur quelque cinq cent phénotypes possédant des caractéristiques de croissance et forme désirables. À la suite d'échanges effectués avec des organismes de recherche canadiens et étrangers, notre banque de gènes comprend maintenant plus de huit cent cinquante lots de semences d'ascendance distincte représentant cinq espèces dont quatre partiellement résistantes à la rouille vésiculeuse.

Deux tests génétiques précoces comptant 300 demi-fratries issues de quelque 170 populations distinctes ont été conduits sous serre et poursuivis en pépinière. Des observations relatives à la croissance juvénile, à l'aoûtement et au débourrement des différents groupes génétiques furent effectuées. Des différences significatives entre les populations et familles furent constatées, cependant aucun gradient de croissance parallèle aux gradients géographiques ne fut décelé. Une étude en laboratoire de la résistance au froid et au dessèchement des populations de pin blanc fut conduite selon les gradients longitudinal et latitudinal de la distribution naturelle de l'espèce. Une augmentation de ces caractéristiques avec la continentalisation des populations a été décelée cependant que la variation dans la sensibilité des populations du gradient nord-sud semble davantage liée à des conditions climatiques locales.

Quelque cent soixante descendances de quarante populations de quatre espèces de pin haploxylon furent également produites en serre. Il s'agit de *P. griffithii*, *P. koraiensis*, *P. sibirica* et *P. peuce*, espèces possédant un bon degré de résistance à la rouille vésiculeuse. Elles constitueront une source génique importante lors de la conduite des hybridations interspécifiques. Ces lots furent repiqués à la pépinière forestière de Harrington en vue d'un premier test de rusticité.

Cent cinquante phénotypes supérieurs de pin blanc furent sélectionnés en forêts naturelles, avec emphase dans les populations de belle venue du lac des Araignées, du lac Brome, du lac Balsam, de la rivière Schyan afin de constituer la base génique du programme d'hybridation infraspécifique de l'espèce. La majorité de ces phénotypes furent multipliés par greffage et implantés en parc d'hybridation.

De plus un verger à graines de pin blanc a été établi dans la région de Montréal en collaboration avec le MER. Le plan du verger a été réalisé à l'aide du programme informatique "MIMOSOL". Les phénotypes sélectionnés furent greffés en champ sur des sujets préétablis.

AMÉLIORATION DE L'ÉPICÉA COMMUN

L'épicéa commun (Picea abies L. (Karst)) est l'un des exotiques les plus prometteurs pour la production de bois à pâte et de charpente dans la région forestière des Grands Lacs et du St-Laurent au Québec. Planté sur les loams frais et sur les loams sablonneux son rendement y est supérieur à celui des épinettes indigènes.

Plus de cent provenances d'épicéa commun ont été testés au Québec de 1957 à 1980 dans quelque quarante essais distincts. De ce nombre quinze provenances furent sélectionnées sur la base de leur productivité, rusticité et tolérance apparente au charançon du pin blanc (Pissodes strobi (Peck)). Un relevé des plantations commerciales de plus de quinze ans a été effectué et chacune fut évaluée en tant que source potentielle de gènes pour l'amélioration de l'espèce. Cent phénotypes supérieurs furent sélectionnés dans les meilleures provenances testées et dans les plantations commerciales de belle venue. Ils furent multipliés par greffage en vue de la mise sur pied d'un parc d'hybridation requis à la conduite des croisements dirigés et des buissons de multiplication destinés à produire une partie des propagules nécessaires à la réalisation par le MER des quelque 90 ha de vergers à graines clonaux prévus.

Grâce à l'excellente saison de fructification de 1984, l'échantillonnage génique des plantations commerciales de belle venue et des populations exotiques en essais a pu être entrepris. Plus de trois cents lots de semences furent récoltés, traités et entreposés en vue de besoins futurs de recherche et de préservation du bassin génique de l'espèce au Québec. Également cent cinquante descendance de populations polonaises particulièrement intéressantes ont été obtenues de l'Institut de recherche forestière de Varsovie. Elles seront ensemencées sous peu et testées dans différentes régions du Québec méridional afin de permettre de nouvelles sélections et l'élargissement de la base génétique pour l'amélioration de l'épicéa commun en fonction des conditions climatiques et pédologiques particulières de ces régions.

CLONAGE, TRANSFERT TECHNOLOGIQUE ET PROBLÈMES SPÉCIFIQUES

Outre les travaux et recherches sur la génétique et l'amélioration proprement dit des essences mentionnées précédemment, la recherche sur la variabilité et la productivité de quelques-unes des principales espèces résineuses et l'identification des sources supérieures a été poursuivie. Les observations phénotypiques et les traitements sylvicoles nécessaires ont été effectués à intervalles réguliers dans les essais en place.

Un résumé des travaux en cours de réalisation, des résultats obtenus des recherches poursuivies et des recommandations sur les sources et génotypes désirables pour les reboisements actuels et la mise sur pied d'un réseau de vergers à graines fut rédigé en collaboration avec le Service de la recherche et le Service des pépinières et reboisement. Ce travail a fait l'objet d'une publication conjointe, de la part des différents services en cause et est intitulée: "Amélioration génétique des essences résineuses au Québec: recherche et développement".

Les travaux sur le clonage des phénotypes supérieurs et d'âge avancé dans le but d'optimiser les gains génétiques obtenus de la sélection et de l'hybridation ont été poursuivis. Une analyse des résultats obtenus de différents traitements; température, milieux de racinement, taille de rajeunissement, a été effectuée et un document de synthèse a été préparé.

Dans le but de faciliter la création de plans de vergers à graines dans lesquels l'inbreeding est minimisé et l'hétérofécondation favorisée, assurant ainsi la production de semences de qualité, un programme informatique interactif a été développé. Le programme MIMOSOL est écrit en langage FORTRAN et facile à utiliser. Il a déjà été utilisé avec succès pour la création de plans de vergers à graines par le MER et la CIP Inc. MIMOSOL est disponible sur demande auprès des auteurs.

Deux contrats de recherche attribués à des professeurs-chercheurs de l'Université Laval sont maintenant à leur deuxième année. L'un porte sur l'étude des caractéristiques intrinsèques du bois de l'épinette blanche, tandis que le second porte sur la culture de tissus et la sélection pour la résistance au froid de clones d'aulnes et de mélèzes. Les rapports d'étapes produits indiquent que des progrès sensibles ont été accomplis.

RAPPORTS ET PUBLICATIONS

- Archambault, L.; Beaulieu, J. 1984. Réduction de la croissance en volume occasionnée au sapin baumier suite à la défoliation par la tordeuse des bourgeons de l'épinette. For. Chron. 61(1) 10-13.
- Beaulieu, J.; Corriveau, A. 1985. Variabilité de la densité du bois et de la production des provenances d'épinette blanche, 20 ans après plantation. Journ. Can. Rech. For. (sous presse).
- Beaulieu, J.; Corriveau, A.; Daoust, G. 1985. Alex; système informatisé de gestion d'un répertoire de référence bibliographique. Rapport GA-85- 06, 45 p.
- Bousquet, J. 1984. Variabilité infraspécifique de certaines caractéristiques juvéniles de l'épinette blanche. Thèse de finissant U.L. Avril 84, 150 p.

- Cormier, D. 1985. Variabilité de la tolérance à un gel tardif en fonction de la source géographique chez le pin blanc. Thèse de finissant Mars 85, 103 p.
- Corriveau, A. 1985. Génétique et amélioration des arbres forestiers au CRFL. Rapport GA-84-01, 32 p.
- Corriveau, A.; Beaulieu, J.; Daoust, G. 1985. Semex; un système informatisé de gestion des registres de semences forestières. Rapport GA-85-07, 50 p.
- Corriveau, A.; Daoust, G. 1983. CFS forest genetics research and tree improvement in Québec. Proc. Part I. CTIA, Toronto, Ont. Aug. 22-26, 1983.
- Corriveau, A.; Keable, R. 1985. Étude génétique du pin blanc: Tests précoces en culture intensive. Rapport GA-85-02, 55 p.
- Corriveau, A.; Vallée, G., éditeurs. 1983. Amélioration génétique des essences résineuses du Québec: Recherche et développement, Comité d'amélioration génétique des arbres forestiers du Québec. 70 p.
- Daoust, G. 1985. Station d'amélioration génétique des arbres forestiers; un projet. Rapport GA-85-05, 31 p.
- Daoust, G. 1985. Propos sur diverses expériences de bouturage de l'épinette blanche et de l'épinette de Norvège 1982-83-84. Rapport GA-85-04, 70 p.
- Lalonde, M. 1984. Étude sur la régénération des forêts par l'amélioration génétique des espèces chez Alnus et Larix par culture in vitro. Rapport d'étape contrat M.A.S. Environ. OSD83-00081 Mai 84, 15 p.
- Motte, F. 1985. Variation inter- et intra-populationnelle de la densité du bois de l'épinette blanche en forêts naturelles. Rapport interne 20 p.
- Poliquin, J. 1985. Étude de la variabilité intraspécifique de quelques paramètres physico-mécaniques du bois de l'épinette blanche (Contrat PRUF) Rapport d'étape, 10 p. Mars 85.
- Tremblay, F.M. 1985. La culture in vitro du genre Alnus. Thèse de doctorat 76 p. (Contrat PRUF 14SD. KH303-3-C-022).

CIP'S TREE IMPROVEMENT ACTIVITIES

J. Begin
CIP Inc.
1155 Metcalfe Street
Montreal, Quebec
H3B 2X1

A. Dion
CIP Inc.
1053 Ducharme Blvd.
La Tuque, Quebec
G9X 3P9

G. Crook
CIP Inc. (Nature Centre)
R.R. #2
Calumet, Quebec
J0V 1B0

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

In 1979, a first generation tree improvement program was initiated by CIP in Quebec and New Brunswick after two years of experience in cooperative tree improvement with NBTIC in New Brunswick. The objective is to select from Company controlled forests the best trees and grow their progenies to produce genetically superior seed. In Quebec, the selection and testing of plus trees takes place in the Gouin (B-3) boreal region (Rowe 1972) where most Company freeholds are located. In New Brunswick, NBIP Forest Products, a CIP Inc. subsidiary, participates in the Province's cooperative program (NBTIC). Within this program, members are expected to select plus trees and share or exchange the breeding material with other NBTIC members. Testing and orchard establishment is done regionally with the material made available through NBTIC. CIP's program focuses on three native species, black spruce (Picea mariana (Mill) BSP), jack pine (Pinus banksiana Lamb.) and white spruce (Picea glauca (Moench) Voss). A few promising exotics have also received at least some work. They are the Japanese larch (Larix leptolepis (Sieb & Zucc) Gord.), European larch (Larix decidua (Mill)) and Norway spruce (Picea abies (L.) Karst).

CIP'S PROGRAM IN QUEBEC, BY J. BEGIN AND A. DION

Black Spruce and Jack Pine

Black spruce and jack pine are the most important reforestation species, totalling nearly 2.2 million planted seedlings per year at this time on CIP freeholds in the St-Maurice area.

To assemble the breeding stock, extensive selection has been carried out for the past six years using a rapid ocular procedure. Trees are chosen at a rate of one per half hectare or less, in young stands located on Company controlled forests.

During the 2-year period under review, we have completed our

selection program of 500 trees per species by adding some 220 jack pine and 370 black spruce to the breeding stock.

Candidate trees are felled during the cold season. Cones and scions are gathered from the tree tops and kept in cold storage until processed or grafted. Scions are grafted to dormant stock and outplanted in the nursery where they develop for two years before they are sent for planting in the arboretum at the orchard site. We are currently experimenting with large (6 litre) pots where the ramets can be held for two growing seasons without intermediate transplanting in the nursery.

With most of the genetic material on hand we were able to officially open CIP's Harrington Seed Orchard in the spring of 1984. After a careful study of all possible sites, it was decided that the seed orchard would be located on an old farm near CIP's Nature Centre. It is expected that the southerly location, the long growing season and the good quality of the site will stimulate the development and the production of the orchard.

Concurrently with the establishment of the orchard is the testing of plus tree families. These test plantations are established on typical planting sites, usually 1 to 2 years before each family is planted in the orchard.

The family tests for each species are planted in two different locations, replicated 13 times on one test site and 4 on the other. Each 1 hectare replication has the configuration of a matrix made up of 550 linear plots. Individual seedlings of the four-tree plot have a 2 m x 2 m spacing.

The planting layout was established using a computer program (REPAL) developed by MER in Quebec. In this particular application of the program, we set to 15 m the minimum spacing for the progeny of plus trees originating from the same stand. All 17 replications of the test were planted using the same computer-generated layout.

Planting of the test was started in 1982. Since then more than 370 black spruce and 220 jack pine have been selected. Establishment of the jack pine family test was completed this summer.

The final roguing of the orchard will take place 10 to 15 years after planting based on the performance of the families in the tests.

Norway Spruce

The Norway spruce program operates on a rather limited scale. The use of clonal orchards is dictated by the late age at which this species starts producing seed. Most of the scions were from the best selections made by the Laurentian Forest Research Centre (CFS) in Quebec and by PNFI in Ontario. Grafting started in 1980 and by 1984 we had grafted 160 clones. One fourth of the orchard has already been planted

and the establishment of both the orchard and the arboretum will be completed by 1986.

Exotic Larches

Larch improvement also started as a cooperative program. In 1979 the Petawawa National Institute (CFS) initiated a project to test the hardiness of 79 Japanese larch seedlots in the Great Lakes and St. Lawrence forest region (Rowe 1972). CIP agreed to plant one of the three test plantations on its private land in the St. Lawrence Valley. The test layout was designed with the idea of eventually using the plantation as a seed orchard.

After five growing seasons, the trees had reached an impressive size. As was expected, larger differences in height showed at the individual tree level than at the seedlot level. During last winter, the plantation experienced severe damage from field mice which girdled 30% of the trees. Plans are to remove the girdled trees and to thin the plantation to 50% of its actual density based on the phenotype of individual trees within each seedlot. Measures will be taken to prevent the recurrence of the mice problem.

In May 1980, scions from selected clones in the European larch and Japanese larch plantations of CIP 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.

ESTABLISHMENT OF CIP SEED ORCHARD COMPLEX BEGINS AT HARRINGTON, BY G.CROOK

SEED ORCHARD COMPLEX

In the fall of 1983, CIP purchased a farm in the vicinity of the Harrington Nature Centre as the next step in the tree improvement program begun in 1979. In 1984 the first ramets and seedlings destined to make up the CIP Seed Orchard were planted.

The establishment activities accomplished in 1984-85 may be summarized as follows:

Jack Pine

The 5 blocks of the 3 ha clone bank were laid out and 905 ramets were transferred from the holding area in the bare-root nursery at the Nature Centre. Five ramets from each plus tree are to be established

in each block using a systematic and 3 x 4 m spacing design. The clone bank will serve as the base population for development of the second generation orchard, as well as an open pollinated seed source.

The 48 blocks making up the seedling seed orchard were laid out and planted over a two-year period, one half each year. The 23,000 seedlings required for the orchard were produced in multipot containers and each seedling identified with a self-adhesive numbered tag. Planting was done using a dibble, with the seedlings spaced in row pairs 2 m x 1,5 m apart. Each pair of rows is 3,5 m apart to allow for an access corridor. Each orchard block covers 2,400 m². Planting will be completed this year.

Black Spruce

The same work was accomplished as for the jack pine clone bank. Each of the 5 blocks covers 0,45 ha and ramets are spaced at 3 m x 3 m. A total of 495 ramets have been transplanted from the nursery.

In the seedling seed orchard, 95 blocks were laid out and half of each block planted. Here again the 22,000 seedlings were grown in multipot containers and identified with numbered tags. The seedlings are planted in single rows, at a 0,95 m spacing. Each block covers 1,680 m².

Norway Spruce

The layout of the 9 blocks was done for this clonal orchard. Two of the blocks will serve as a clone bank to hold the 160 clones which were selected from provenance tests planted in several locations in Quebec as well as from plantations at PNFI. The 7 other blocks will contain the breeding population of 120 clones, 1 ramet from each clone planted at a 4 m x 5 m spacing following a computerized controlled random pattern generated by a program developed at LFRC. A total of 312 ramets were transplanted from the nursery holding area, representing over 25% of the total number to be established. Tree improvement in this species has been carried out in cooperation with the CFS.

OTHER IMPROVEMENT ACTIVITIES AT THE CIP NATURE CENTRE

Grafting

During the period under review, more than 9,150 grafts have been made by personnel at the Nature Centre with an overall survival in excess of 70%.

In 1984 the Company began its grafting program in white spruce, making 740 grafts with scions collected from plus trees in New Brunswick. These grafts represent about a third of the program to establish a 6 ha clonal orchard for this species at Harrington by 1988. The seed produced from this orchard will be used by NBIP Forest Products Ltd. at Dalhousie,

N.B. in its reforestation program.

In addition to this, 1,000 white spruce grafts were made on contract for the MER in Quebec.

The grafting program for three other species has also been completed between 1984-85. Some 720 Norway spruce scions have been grafted in 1984. Another 3,400 black spruce and 2,770 jack pine grafts have also been made from scions removed from plus trees.

In European and Japanese larch, 300 grafts were made using scions collected from local CIP plantations of these species. The ramets will be added to the Company's 0.5 ha clonal seed orchard established at the Nature Centre

Scion Collection

The Petawawa National Forestry Institute collected scions from plus trees in the Japanese larch plantation at the Nature Centre as well as in plantations of several European larch provenances at Avoca, southwest of Harrington.

The Quebec Ministry of Energy and Resources collected cones from the same European larch provenances at Avoca for use in their genetic research program. The Avoca plantation contains several German and Polish provenances that were planted in 1960 in cooperation with PNFI.

REFERENCE

- Rowe, J.S., 1972. Régions forestières du Canada, Envir. Can., Serv. Can. For. Publ. 1300F. 172 p.

RESEARCH IN TREE SEED, SEEDLING GROWTH, AND POLLINATION, 1983-85

G.E. Caron

Université du Québec en Abitibi-Témiscamingue
42, rue Mgr Rheaume est, C.P. 700
ROUYN, Québec
J9X 5E4

Keywords: Picea mariana, Picea glauca, pollination-drop production, seed-cone production, tree spacing, seed-germination test, seedling etiolation.

During the period covered by this report, my Ph.D. studies at the University of New Brunswick entered their final stages. These included activities related to tree-seed production at the University of Victoria and at the Petawawa National Forestry Institute (20 weeks). This report contains an outline of those activities, and also of research on seedling growth initiated in 1985 since my move to the Université du Québec en Abitibi-Témiscamingue.

BRANCH AND SEED PRODUCTION IN BLACK SPRUCE

My Ph.D. dissertation, "Development of branch patterns and seed production in young black spruce (Picea mariana (Mill). B.S.P.)", has been submitted to the University of New Brunswick. Some of the findings of that work have been briefly described (Powell and Morgenstern 1982; 1985; Caron 1984b; Caron and Powell 1984; Morgenstern and Powell 1984) and a related study reported (Caron, 1984a).

POLLINATION AND CONE INDUCTION

At the University of Victoria, I was involved with Dr. J.N. Owens in investigations of pollination-drop production in Picea glauca (Moench) Voss and cone induction in Tsuga heterophylla (Raf.) Sarg. The investigations on P. glauca were initiated to establish the sequence of, and to verify the influence of relative humidity on, the pollination-drop formation. The investigation on T. heterophylla was designed to test effects on differentiation of GA_{4/7} application at specific periods during shoot development.

CONE PRODUCTION AND SEED GERMINATION

At the Petawawa National Forestry Institute, I used procedures developed in my Ph.D. research to investigate with Mr. H.O. Schooley the influence of tree spacing on seed-cone production of P. glauca and P. mariana. Thirty-year-old, plantation-grown, trees at 1.2, 2.4, and 4.9 m cone production per living P. glauca tree was 730, 5200, 11400 at each higher spacing; whereas, that for P. mariana was 340, 1500, and 2100, respectively.

A second study was initiated with Mr. B.S.P. Wang to determine the effect of early extraction on the germination of stratified and non-stratified P. glauca seeds. The seeds extracted early after cone collection had poor and unstable germination for the unstratified experiment; stratified seeds had slightly better germination percentages. The seeds extracted four to six weeks after cone collection had good but unstable germination; stratified seeds had high and stable germination. Variation in germination percentages was observed among trees in each of the two sets.

BLACK SPRUCE ETIOLATION

Rapid growth of P. mariana seedlings in greenhouses, especially during winter, results in considerable seedling etiolation by the thirteenth week, and many seedlings become horizontal. A few weeks later, as the growth in diameter of the mainstem continues and lignification occurs, seedlings begin to recover. At first, 3 to 5% of the seedlings develop strong malformations and are of unacceptable quality for reforestation; however, about 50% of the seedlings have lesser malformations of the mainstem. Generally, many of these malformations are rectified by planting time. However, about 30% of the seedlings are considered unsuitable for planting and are rejected. This problem, which is common in provincial and private nurseries in Quebec, results in high financial loss. However, there is no proof that the malformations will have a significant negative influence on subsequent growth. A project has been initiated at the Université du Québec en Abitibi-Témiscamingue in collaboration with Mr. Fernand Miron of the Serres de Guyenne and the Ministère de l'Energie et des Ressources du Québec to establish whether this is the case.

REFERENCES AND PUBLICATIONS

- Caron, G.E. 1984a. Occurrence of sporangiate-vegetative structures and bisexual strobili in young plantations of black spruce. In Proc. Nineteenth Can. Tree Improv. Assoc., Toronto, August 1983, Part 1. p. 60.
- Caron, G.E. 1984b. Patterns of seed-cone and pollen-cone build-up and distribution and the associated seed yield in young black spruce (Picea mariana (Mill) B.S.P.) trees. In 1st Annual NE For. Graduate Student Conf., Univ. of Maine, Orono, ME, April 1984. p. 14.

- Caron, G.E. 1985. Development of branch patterns and seed production in young black spruce (Picea mariana (Mill.) B.S.P.). Ph.D. dissertation, Univ. of New Brunswick, Fredericton, NB. In preparation.
- Caron, G.E. and G.R. Powell. 1984. Sequential branch development of spruce saplings. Can. Bot. Assoc. Bull. 17:36. Can. Bot. Assoc. Mtg., Fredericton, NB, June 1984.
- Morgenstern, E.K. and G.R. Powell. 1984. Tree seed and genetic studies at the University of New Brunswick. In Proc. Nineteenth Mtg. Can. Tree Improv. Assoc., Toronto, Ont., August 1983. pp. 61-67.
- Powell, G.R. and G.E. Caron. 1985. Black spruce. In Reproduction of conifers: a handbook for cone crop assessment. Can. For. Serv., For. Tech. Rep. 31. 2 pp. In press.
- Powell, G.R. and E.K. Morgenstern. 1982. Forest genetics, tree improvement, and related work at the University of New Brunswick 1979-1981. In Proc. Eighteenth Mtg. Can. Tree Improv. Assoc., Duncan, BC, Part 1. pp. 204-209.
- Powell, G.R. and E.K. Morgenstern. 1985. Tree-seed and forest-genetic studies at the University of New Brunswick 1983-1985. In Proc. Twentieth Mtg. Can. Tree Improv. Assoc., Quebec PQ, August 1985, Part 1. 9 pp. In press.

TREE IMPROVEMENT PROGRESS IN ONTARIO'S NORTHWESTERN REGION 1983-1985

W.D. Baker

*Ontario Ministry of Natural Resources
Northwestern Region
Kenora, Ontario
P9N 3X9*

Keywords: Seed orchard management, tree improvement co-operative, wood quality, breeding orchard.

Considerable progress has been made in Ontario's Northwestern Region tree improvement program. Program activities have concentrated upon seed orchard management in black spruce (Picea mariana (Mill.) B.S.P.) and white spruce (Picea glauca (Moench) Voss) and the initiation of a jack pine program (Pinus banksiana Lamb.).

BLACK SPRUCE

At the present time, eleven black spruce seedling seed orchards and their corresponding family tests have been established throughout the Northwestern Region. Each black spruce orchard is based upon 320 unique family selections, replicated 50 times on 5 hectare sites. One additional black spruce orchard site has been selected and site prepared in Red Lake District, with establishment scheduled for 1988.

Seed orchards have been established on intensively prepared (root raked, disked) sand and sandy loam sites in order to have the capacity of manipulating nutrient and moisture regimes. Much of the work over the past several years has concentrated on developing appropriate seed orchard management techniques for these sites. These have included cover crop establishment, mulching, fertilization, irrigation and insect control.

The establishment of cover crops to improve moisture retention and prevent erosion on these coarse textured soils has met with limited success. Cultivars of several grass and legume species (fescues, clovers, bluegrass) alone and in mixtures have been sown. Many of the sites have been invaded by a member of the sedge family (Cyperus schweinitzii), which has provided a suitable natural cover crop.

Mulching the root zone surface area has been necessary in a number of orchards in order to retain soil moisture and inhibit weed competition. Various mulch materials including woven black plastic, sawdust, and burlap have been employed.

Fertilization is being utilized to promote vigorous vegetative growth which appears to be a prerequisite for abundant cone production. Soil nutrient availability is low due in part to the removal of the organic layer during root raking. Corrective nutrient scheduling has been based largely on foliar analysis. Black spruce foliar nutrient values have averaged 1.43 N, 0.15 P and 0.47 K % available in the orchards. Fertilizer prescriptions have concentrated on maintaining and/or improving nitrogen levels in early spring with an application of 75 to 125 Kg N/ha followed by a mid-summer application of phosphorous and/or potassium plus a limited amount of nitrogen. The fertilization program has been based upon a granular application applied either in a spot or cluster application.

A soil moisture deficit situation in Northwestern Region has led to all black spruce orchards being equipped with a volume gun irrigation system. The intent of the irrigation program is to ensure optimum survival during the establishment phase as well as promoting vegetative growth during the growth phase. Soil moisture conditions are monitored through a series of tensiometers. These are an important aid, but fall short of providing all the information needed for an irrigation schedule which should contain a forecast of the time and amount of water to apply to each section of the seed orchard.

For this reason, a nutrient-moisture study has been established to examine specific fertilization-irrigation scheduling in seed orchard management. The intent of this program can be generally defined as the problem of determining the timing and amount of irrigation water and fertilization to be supplied to the orchard trees. The main aim of the irrigation scheduling model is to provide an estimate of water utilization by the trees and to minimize the length of time during which the trees experience water stress during the growing season. A climate based model has been developed by the Atmospheric Environment Service of Environment Canada for scheduling irrigation when the soil moisture drops below several predetermined levels. The amount of irrigation water applied is calculated utilizing the climate inputs for the period since the last calculations and the forecasted precipitation for the day.

Due to the high permeability of these soils and the lack of organic material, many of the nutrients are lost through percolation and have to be supplied on a regular basis. Nutrient studies based on N-P fertilization at a rate of 0 to 300 Kg N/ha in split applications are being undertaken in conjunction with foliar analysis to provide a firmer basis for fertilization recommendations.

Protection measures have been taken to control problems with spruce budworm (Choristoneura fumiferana (Clemens)), white pine weevil (Pissodes strobi (Peck)), various sawflies (Diprionidae), and grasshoppers (Acrididae). Potential insect problems and population levels are monitored by both Ministry of Natural Resources and the Forest Insect and Disease Survey (F.I.D.S.) Unit staff. Control measures using the insecticides dimethoate, acephate and malathion have been required to date.

WHITE SPRUCE

White spruce plus tree selections are continuing to complete the white spruce clonal seed orchard program. Five white spruce orchards are in various stages of completion, with a sixth orchard to receive its first clones in 1986. The white spruce orchards are being phased in over a four to five year period, since our annual grafting capability is limited to approximately 6,000 grafts. Winter greenhouse grafting with white spruce has produced extremely good results, averaging 83% successful grafts. Selections should be complete by 1988.

Heavy insect damage particularly from spruce budworm have made plus tree selections somewhat difficult, as many potential individuals will be eliminated. Reduction in vigor from budworm attack has also posed problems for the grafting program.

After outplanting in the orchards, the white spruce grafts have performed well. A heavy frost in June 1985 has been responsible for mortality of 1985 vegetative growth in several orchards.

JACK PINE

The jack pine program in Northwestern Region is in the initial phase of development. A production seedling seed orchard strategy which includes a clonal breeding orchard has been selected for jack pine. The program concentrates on selecting and improving jack pine for stem form, crown and branch form, wood quality and height growth. Initial selections have taken place in Ignace and Kenora Districts. Grafting for the jack pine breeding orchard began this past winter. This first attempt at winter greenhouse grafting with jack pine resulted in 67% survival.

Development of the jack pine program in the Northwestern Region will be done in conjunction with the Ontario Tree Improvement Council. Through the auspices of the Council, Boise Cascade Canada Limited, Great Lakes Forest Products Limited and the Northwestern Region of O.M.N.R. will co-operatively implement the program. The workload (selection, testing and orchard establishment) will be shared between the three agencies involved, although Boise Cascade will participate mainly in one breeding zone, Great Lakes Forest Products in a second zone, while O.M.N.R. will participate in both.

Wood quality, especially specific gravity, heartwood formation, extractive content and fiber dimensions have been examined in our initial selections. Preliminary data indicates large between-tree differences in these characteristics with ranges of .37 to .46 in juvenile specific gravity, 22 to 62% in heartwood formation, and 2.5 to 3.0 mm in average tracheid length.

FAST GROWING FORESTS
TREE IMPROVEMENT STRATEGY FOR EASTERN ONTARIO

B.A. Barkley

*Fast Growing Hardwoods Program
Ministry of Natural Resources
Brockville, Ontario
K6V 5Y8*

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

The Ontario Ministry of Natural Resources initiated the 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 2000 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. Potential end uses of hybrid poplar range from biomass for energy, to larger diameter material for pulp, wafer-board, and veneer. 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. Once soil types have been delineated, clones can be objectively matched to the site to optimize growth potential of the planting stock. The next step is to site prepare the land for the complete elimination of all weed and grass competition prior to planting.

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 hybrid developed from both exotic and native species.

In addition to the work being carried out with hybrid poplars and other fast growing hardwood genera such as Alnus, Salix and Betula, the program is presently in the process of developing and implementing a tree improvement strategy for conifers in eastern Ontario.

FAST GROWING FORESTS - TREE IMPROVEMENT STRATEGY FOR EASTERN ONTARIO

Statement of Purpose:

To provide for the development and timely deployment of genetically superior coniferous stock within an intensive forest management program in Eastern Ontario. Such a strategy is already in place for Fast Growing Hardwoods.

Tree Improvement in Perspective:

This function is one of four key elements in an intensive forest management program:

- 1) Selection of the best quality sites.
- 2) Use of genetically improved stock.
- 3) Use of improved cultural practices.
- 4) Locating the new forest close to the processing facility.

The development of improved cultural practices and their subsequent successful application in producing Fast Growing Forests is highly dependent upon the immediate availability of genetically improved stock.

GOALS FOR TREE IMPROVEMENT

- 1) Identify the best, currently available materials and begin immediate establishment of fast growing plantations. This will allow: field staff and others to view, first-hand, results of tree improvement in an operational setting; permit the development of associated cultural practices; and provide important feedback to the tree improvement effort when associated with well-designed quality control tests.
- 2) Make full use of all appropriate materials and knowledge produced to date, thereby maximizing the benefit from all relevant past investment in tree improvement and genetics work which has been in progress in Ontario since the 1920's.
- 3) Provide sound basis for an ongoing tree improvement program complementary to, and in support of, the intensive forest management program, in both the long and short term.
- 4) Ensure future options are kept reasonably well open.

THE CLONAL FORESTRY APPROACH

A clonal approach provides an effective and efficient means of realizing these goals. This approach can be effectively applied to both aspects of tree improvement - development and deployment. As shown in the experience of the hybrid poplar program in Eastern Ontario, using a large base of clones in the operational program and establishing quality control tests in association with these fast growing plantations will

minimize risk of any individual clone failure. A gradual and continuous improvement over time will occur in the group of clones available for operational planting. Seed will continue to be used in regular plantations and rooted cuttings reserved for use in fast growing plantations. The following points should be noted in support of the clonal forestry approach:

- Eastern Region's leadership and expertise in successfully using clonal forestry for fast growing hardwoods can be extended to other species for fast growing forests.
- Breeding in breeding halls coupled with nursery clonal hedges will begin producing significant quantities of planting stock much sooner than a seed orchard approach.
- Limited numbers of high quality genetic material can be rapidly multiplied to quantities necessary for deployment in operational plantings and technology development.
- The tree improvement cycle can be shortened resulting in higher gain per unit of time in the development of genetically improved stock.
- Breeding efforts can focus on quality vs. quantity, enabling efficient production and use of hybrid clones.
- Desired genetic traits in the selected trees will be deployed directly to the field without the loss or dilution which usually occurs with sexual propagation.
- Genetic uniformity associated with clones, planted in mosaics of monoclonal blocks matched to site, will result in less variable and higher quality stands.
- Necessary knowledge and experience is sufficiently available for development of satisfactory operational procedures for large scale production in Ontario.
- Program scale of less than 10 million trees is most efficiently served by clonal forestry approach (quality vs. quantity).
- Over time a gradual shift can occur to higher proportions of fast growing plantations in the overall forest management program.

SPECIES PRIORITIES FOR TREE IMPROVEMENT

Focus will be on a limited number of key commercial species as determined by the following criteria:

- Commercial importance, utilization potential, and position within current regeneration program.
- Opportunity for genetic improvement.
- Adaptability to available, productive sites.
- Suitability for intensive forest management i.e. responsiveness to cultural practices.

The species priorities are as follows:

1. White Pine (Pinus strobus)
2. Norway Spruce (Picea abies)
3. Tamarack and the Larches (Larix laricina, L. decidua, L. leptolepis)
4. White Spruce (Picea glauca)

THE GENETIC RESOURCE

An intensive forest management program will produce forests on shorter rotations. Therefore a balance between selections of young, fast growing trees, versus the traditional "large and old" selections will be both justified and important, if these trees are to be harvested at a younger age. Rapid early juvenile growth is highly desirable since this contributes to shorter rotations and results in a much shorter establishment period. During a lengthy establishment period the young crop is at considerable risk and significant reductions in survival, stocking and ultimately yield generally occur in this stage of forest growth. A broad gene pool should be maintained, and enriched through the introduction of new exotics and additional provenances into collection areas. The current genetic base is adequate to initiate a significant improvement program. The available material is most easily considered in 3 categories on the basis of specific tree improvement roles:

1. Natural Stands

- Plus trees will be selected for clonal archives.
- Ultimately the best material will be placed in a breeding hall.
- Good quality stands may also be a candidate seed production areas.
- Seed will be collected from each plus tree for testing purposes.
- Young selections are important given anticipated short rotation forests of the future.

2. Plantations

- Plus trees will be selected for clonal archives.
- Ultimately the best material may be placed in a breeding hall.
- Plus trees will be selected from young plantations when available for clonal hedges.
- Good quality plantations may also be candidate seed production areas.
- Seed will be collected from each plus tree for testing purposes.

3. Trials and Collections

- Best individuals will be selected for establishment of clonal hedges.
- Best material will be placed in clonal archives and eventually a breeding hall.
- Trials and collections are important both as a source of material and information in establishing the breeding hall and clonal archives.
- Additional exotics and provenances should be acquired and placed in collection areas.
- Relevant materials and information from adjacent jurisdictions will be assessed.

TIME FRAME

The tree improvement activities represent a continuum of events. The relative importance of activities will change over time. Initial efforts will focus heavily on selection activities. Gradually there will be an increased emphasis placed on breeding to produce better quality replacement clones. Monitoring of trials, collections and quality control tests, will refine the breeding effort and provide information to improve the quality of clones used in fast growing plantations. Using the clonal forestry approach will allow immediate deployment of genetically improved stock as early as the first year.

FOREST GENETICS AND TREE IMPROVEMENT RESEARCH AT MAPLE 1983-1985

George P. Buchert

*Ontario Tree Improvement and Forest Biomass Institute
Ministry of Natural Resources
Maple, Ontario
LOJ 1E0*

The forest genetics program at Maple has undergone significant changes due to personnel movement. L. Zsuffa, former principal scientist and unit leader, resigned from the Ontario Ministry of Natural Resources to head the forest genetics program at the Faculty of Forestry, University of Toronto. J.V. Hood, quantitative geneticist at Maple, is now technical coordinator of forest genetics and tree improvement at the Tree Seed and Genetics Unit, Forest Resources Branch, OMNR, Toronto. The Forest Genetics and Biomass Section is now composed of seven permanent and three long-term contract research scientists, aided by eleven technical support staff. Current program emphasis reflects current staffing levels, with reduced effort on breeding of poplars and white pine, and quantitative genetic investigations.

A summary of projects accomplished in the Physiological Genetics program follows:

WOOD QUALITY OF JACK PINE

Variation Within Trees

A study was conducted in cooperation with Abitibi Price and the University of Toronto to ascertain the amount of variation in selected wood quality parameters within jack pine trees, and to give guidelines for wood character sampling. Ten trees from each of two stands near Chapleau, Ontario, were sampled and wood parameters were measured from discs at several positions along the bole. Data indicated that there was a strong correlation between specific gravity at DBH and specific gravity at other levels. As a result, specific gravity measurements have been standardized for comparative purposes at DBH. Stem analysis of sections every 30 cm indicated that trees in this sample with high heartwood and extractive content appeared to be less vigorous and had smaller live crowns than those with low heartwood and extractive content.

Variation Between Plus Trees

The Ontario Ministry of Natural Resources has embarked upon a jack pine plus tree selection program, and beginning in 1982, plus tree

selections have been examined for wood quality. In cooperation with the Northern and Northwestern Regions of OMNR and the University of Toronto, the Ontario Tree Improvement and Forest Biomass Institute has analysed 1044 plus trees for several wood quality parameters measured from breast height discs. Included in measurements are: percent moisture content, percent heartwood, juvenile specific gravity (<20 years), mature specific gravity (>20 years), specific gravity at 1/2 cambium, specific gravity at 5, 15 and 25 years, tracheid length at 5, 15 and 25 years and 1/2 cambium. This information is providing baseline data for decisions regarding inclusion of wood quality parameters into selection criteria. High levels of variability are apparent for all measured characters. In addition, it is apparent that percent heartwood shows variation that is independent of tree age. A partial summary of data, expressed by district mean value, is in Table 1.

Table 1. Jack Pine wood quality summarized by district mean value.

	No. of trees	% Heart wood	Juvenile Specific Gravity	Mature Specific Gravity	5 Year Tracheid Lengths	15 Year Tracheid Lengths	25 Year Tracheid Lengths
Kirkland Lk.	104	43.2	.403	.454	1.72	2.85	3.27
Gogama	100	28.9	.397	.440	1.69	2.83	3.29
Ignace	22	37.6	.417	.465	1.69	2.65	3.12
Chapleau 331	126	38.2	.401	.450	1.65	2.87	3.30
Chapleau 431	150	35.3	.396	.442	1.53	2.82	3.29
Hearst	49	36.0	.394	.439	1.93	2.96	3.40
Kapuskasing	25	47.3	.394	.451	1.96	2.90	3.42

ISOZYME STUDIES

Jack Pine Populations and Gene Linkage

Work on isozyme analysis has concentrated on jack pine, white pine and white spruce. Female megagametophyte analysis of 320 jack pine trees from 32 central Ontario stands gave no indication of population substructuring. Only about 5% of the total genetic variability detected could be attributed to among-stand differences. However, the average stand heterozygosity was relatively high ($H=0.15$), indicating a high level of genetic variability among trees within stands. Twenty loci out of 27 loci studied in 13 enzyme systems were polymorphic. Chi-square analysis of doubly heterozygous jack pine individuals indicated measurable linkage between the following pairs of loci:

6 PGD-2/IDH-2; AAT-2,3/DIA-2; PGI-2/AAT-1; MDH-3/DIA-2;
AAT-2,3/AAT-1; 6PGD-3/ACO-1; PGI-2/ADH-1; ACPH-2/DIA-1;
MDH-3/AAT-4; AAT-1/ADH-1.

White Pine Clonal Identification

We used isozyme analysis to determine the clonal identification of ramets in a blister-rust resistant white pine seed orchard. The orchard clones have been selected for form and rust resistance for over 40 years, but identity of materials in the grafted orchard had been confounded. Needles were collected from each ramet and electrophoresed at Maple. Three loci, GOT-2,3, MDH-2 and MDH-3 were found to have diagnostic value. We analysed 1043 ramets and found 52 unique gene combinations. Subsequent computer-generated maps of the orchard plotted ramet positions corresponding to the 52 isozyme genotypes. These maps indicate the potential genetic management problems and give guidelines for roquing, thinning and controlled crossing within the orchard.

White Spruce Seed Orchard Genotyping

The white spruce clones included in the Glencairn Seed Orchard were genotyped by isozyme analysis in order to provide genetic information for pollen flow, pollen grain competition and inheritance studies. Electrophoresis of female gametophyte tissue from 84 clones revealed 13 polymorphic loci useful for future studies, and four monomorphic loci. Subsequent computer sorting indicated a number of clones which were homozygous at enough loci to provide definitive data on pollen competition in pollen mixes.

BREEDING, GENETICS AND GENECOLOGICAL STUDIES
IN SPRUCE FOR TREE IMPROVEMENT
IN 1983 AND 1984, SAULT STE. MARIE, ONTARIO

Alan G. Gordon

*Ontario Tree Improvement and Forest Biomass Institute
Ontario Ministry of Natural Resources
Sault Ste. Marie, Ontario
P6A 5M7*

Keywords: Picea, interspecific hybridization, crossability, variation, 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 genetic and physiological techniques for breeding juvenile trees.

HYBRIDIZATION

In 1983, spruce flowering in Ontario was moderate. We utilized three widely separated breeding areas in Sault Ste. Marie, Algonquin and Simcoe Districts. A total of 266 tree x pollen parent combinations were made, utilizing 365 ramets. Interspecific crosses totalled 36, tri-hybrid crosses four, and hybrid backcrosses two. Tri-hybrid and hybrid backcrossing involved four species and interspecific crossing 19 species.

The resistance of black spruce (Picea mariana) generally to interspecific crossing has been discussed previously (Gordon 1984). Emphasis was maintained on black spruce. Selections were utilized from Geraldton, Thunder Bay and Cochrane, Ontario; from Green River, N.B. and from latitudinal extremities of its range, Moosonee and Lake Erie. Pollen parents were P. asperata, P. abies, P. breweriana, P. engelmannii, P. glauca, P. likiangensis, P. maximowiczii, P. pungens, P. sitchensis, as well as various P. mariana reciprocals. Most of these were, predictably, failures. However, one source from Thunder Bay crossed successfully but with very low crossability with P. engelmannii (Fowler 1980a made the first cross of these species). Some, but not all of the selections from the north-south range extremities, Moosonee and Lake Erie, were successfully crossed with P. sitchensis. Some of these hybrids, including that of P. mariana x P. engelmannii, are strongly heterotic and grow much

faster than the P. mariana x mariana controls. They indicate good potential for tree improvement, are being cloned and will be followed carefully.

After failure of intensive crossing attempts in three previous years, P. mexicana as female parent was successfully crossed for the first time with P. mariana from Cochrane! Crossability was very low and the seedlings will be cloned.

Another new cross successfully made in 1983 was P. omorika x P. farreri. Crossability was moderate. The latter species is an isolated high elevation Burmese species related to P. spinulosa. Its exact specific status is not yet confirmed. Further repeatability was obtained with new selections of P. rubens x P. sitchensis, P. rubens x P. maximowiczii and P. omorika x P. maximowiczii. Crossabilities were all low or very low.

Tri-hybrid and hybrid backcrossing in 1983 involved attempts to increase variation and to detect what its pattern might be. Since P. mariana may be crossed with P. rubens and crosses with great ease with P. omorika, it was assumed there would be no barriers to crossing it with our P. omorika x rubens and reciprocal hybrids. There has indeed proven to be differences in variation both in crossability and growth rates between families. Some hybrids will not accept P. mariana pollen and others accept it freely. No hybrid would accept P. breweriana pollen.

In Ontario, 1984 was a magnificent spruce flowering year, as it was across the country. We carried out our largest crossing to date. A total of 498 tree x pollen parent combinations were attempted with many more ramets. There were 126 interspecific crosses, four tri-hybrid crosses and three hybrid backcrosses. Tri-hybrid and hybrid backcrossing involved seven species and interspecific crossing 18 species.

Small numbers of seedlings were obtained from crosses of high latitude selections of P. sitchensis crossed with northern P. mariana and many more from the much easier crosses with boreal forest P. glauca. P. rubens was also crossed successfully with northern selections of P. sitchensis.

Successful crosses not previously reported were P. glauca x P. likiangensis. The results were very consistent between parents, and hybridity of the seedlings has been confirmed. Results for the new crosses, P. orientalis x P. maximowiczii, were similar. This latter cross is interesting. Both species, one from northern Turkey and the other from Japan, are rather reluctant crossers with a small number of other species, but the crossability between them is extraordinarily high. Another possible new cross is P. orientalis x P. farreri. This has not been confirmed as yet. A number of crosses were successful as expected, in the P. abies x P. asperata group, but there is little yet to report on them.

Successful 'repeatability' crosses confirmed again the low crossabilities of P. orientalis x P. rubens; and P. mexicana x P. omorika, P. engelmannii and P. mariana. (The latter is only the second time we have accomplished this cross. Repeatability crosses also confirmed the moderately high crossabilities of P. mexicana x P. rubens, and x P. sitchensis.

The nature of the new cross P. mexicana x P. mariana in 1983 and 1984 provides further evidence of the genetic separation between P. mariana and P. rubens. In contrast to the crossing behaviour of P. mexicana with P. mariana, P. mexicana crosses freely with, and exhibits little evidence of any crossing barriers against, P. rubens. The first crosses of P. mexicana and P. rubens were achieved in 1978 (Gordon 1980) and easily repeated with other selections in 1980 (Gordon 1982) and in 1984. This contributes further to the contradictory evidence that selections of species from widely separated populations or from where the species ranges do not overlap are amenable to low level crossing.

It also is interesting to note that P. omorika which crosses relatively easily with both P. rubens and P. mariana (Gordon 1976, Fowler 1980b) crosses only very reluctantly with P. mexicana (Gordon 1984 and this report). Similarly, P. likiangensis crosses freely with P. omorika (Gordon 1982), very well with P. rubens (Gordon 1982), moderately with P. mexicana (Gordon 1982), sparingly with P. glauca (this report) and thus far not at all with P. mariana. We crossed P. mariana with P. likiangensis extensively both in 1983 and 1984, all without success.

Finally, in tri-hybrid crossing and hybrid backcrossing in 1984, P. X lutzii (P. sitchensis x P. glauca) was backcrossed successfully with P. sitchensis and out-crossed with P. rubens. P. glauca x mariana (Rosendahl spruce) open-pollinated progeny were successfully backcrossed with both P. mariana and P. glauca, as well as out-crossed with P. rubens. Some of these progeny share morphological characters of P. glauca, some with P. mariana and others are intermediate. All, however, share exactly the same physiological attributes. It has been suggested (Parker and McLachlan 1978) that Rosendahl spruce is simply a white spruce based on material available to them at that time. Evidence here suggests otherwise. Some individual progeny, whether white-like or black-like successfully accept pollen from both white or black spruce and also red, far in excess of what control white or black spruce will accept.

SPRUCE COMPLEXES

In April-May 1983, I made a second visit to Alaska and made a number of further field trips to different forest areas, some on my own and some in company with colleagues of the U.S. Forest Service, Institute of Northern Forestry, or of the University of Alaska. I made two separate trips to southwestern Alaska, the first with Dr. John Hard, forest entomologist with I.N.F., to look at spruce complexes in relation to possible differential attack of the spruce beetle (Dendroctinus rufipennis). There was much current devastation being caused by this beetle.

In the course of this trip, we located a single small bog with a very small number of natural P. mariana x P. sitchensis hybrids. The remaining trees showed no indications of hybridity. A second discovery was a single natural tri-hybrid cross between P. X lutzii (P. sitchensis x P. glauca) x P. mariana. All neighboring trees were P. X lutzii or P. mariana. 'Miles' of further searching in the course of other work in this vicinity and elsewhere revealed no others.

A second field trip to the same area was made with Dr. John Alden, forest geneticist, I.N.F. (and U of A) to show him these discoveries and to look at a single similar bog located quite some distance away in which he had previously located a small number of putative P. mariana x P. sitchensis hybrids. The possibility of their existence had first been pointed out to Alden by Dr. John Zasada, I.N.F. Subsequent isozyme analysis by Alden has confirmed that only a single individual of the trees in the second bog is actually a valid hybrid. Many more similar circumstances in the same general area were examined without finding any evidence of further hybrids even where there are many P. mariana trees in proximity to P. sitchensis. J. Alden and I have collected material: scions, seed, etc. from all these trees and are jointly continuing further work on them.

While alone on another field trip in interior Alaska, I collected an adult 'budworm' in an extensive spruce forest. The insect has proven to be a species new-to-science, not actually a budworm, but very closely related. It is being described at the Biosystematics Research Institute, Agriculture Canada.

OUTPLANTING OF CLONAL INTERSPECIFIC HYBRIDS

Several thousand clonal stock from 35 selections of our remarkably heterotic hybrid P. omorika x P. rubens were outplanted in the spring of 1983 in the Parry Sound District. They were 10 - 15 cm (4 - 6 in.) in height at planting and quite spindly. An intense and widespread early summer drought in 1983 (probably accounting for widespread seed year in spruce in 1984) killed many of these clonal stock. The survivors, about 68% in 1984, have grown remarkably well however, considering their difficult start. Many exceed 60 cm (2 ft.) at the end of their third year.

Other work of this Unit concerns studies of productivity and nutrient cycling dynamics in spruce forest ecosystems (Gordon 1983; Gordon in press).

PUBLICATIONS AND REFERENCES

- Fowler, D.P. 1980a. Tree breeding at the Maritimes Forest Research Centre, 1977 and 1978. Proc. 17th Meet. Can. Tree Impr. Assoc., Pt. 1:81-87.
- Fowler, D.P. 1980b. Hybridization of black spruce and Serbian spruce. Marit. For. Res. Cent. Info. Rep. M-X-112, 30 p.

- Gordon, Alan G. 1976. The taxonomy and genetics of Picea rubens and its relationship to Picea mariana. Can. J. Bot. 54(9):781-813.
- Gordon, Alan G. 1980. Spruce genetics, Sault Ste. Marie in 1977 and 1978. Proc. 17th Meet. Can. Tree Impr. Assoc., Pt. 1:117-121.
- Gordon, Alan G. 1982. Genetics and genecology of spruce, Sault Ste. Marie, Ontario, 1979 and 1980. Proc. 18th Meet. Can. Tree Impr. Assoc., Pt. 1:112-115.
- Gordon, Alan G. 1983. Nutrient cycling dynamics in differing spruce and mixedwood ecosystems in Ontario and the effects of nutrient removals through harvesting. In: Wein, Riewe & Methven (eds.) Resources and Dynamics of the Boreal Zone, p. 97-118.
- Gordon, Alan G. 1984. Genetics, genecology and tree improvement of spruce in 1981 and 1982, Sault Ste. Marie, Ontario. Proc. 19th Meet. Can. Tree Impr. Assoc., Pt. 1:94-97.
- Gordon, Alan G. (in press) "Budworm! What about the forest?" In: Schmitt, D. (ed.) Spruce-fir Management and Spruce Budworm.
- Parker, W.H. and D.G. McLachlan. 1978. Morphological variation in white and black spruce: investigation of natural hybridization between Picea glauca and P. mariana. Can. J. Bot. 56(20):2512-2520.

JACK PINE TREE IMPROVEMENT IN ONTARIO'S NORTHERN REGION

R.B. Greenwood

*Ministry of Natural Resources
Northern Forest Development Group
Northern Region
60 Wilson Avenue
Timmins, Ontario
P4N 2S7*

Keywords: Plus tree selection, seed orchards, family tests, breeding hall, jack pine.

The tree improvement program for jack pine (*Pinus banksiana* Lamb.) has progressed in a rapid but directed manner since it accelerated in the early 1980's. Work has concentrated on the establishment of first generation seedling seed orchards and the associated family tests, but is currently shifting to orchard management and the establishment of a breeding hall program. In addition, vegetative reproduction of jack pine is being examined.

All operational aspects of the regional tree improvement program are managed by the respective district within which each development falls. The jack pine breeding hall and vegetative reproduction programs are managed by Swastika Nursery. The direction, planning and development of the regional program is carried out by the Northern Forest Development Group.

PLUS TREE SELECTION

Extensive selections were carried out between 1981 and 1984 within three of the four breeding zones defined for the region. Cones and scions were collected from the 1,210 selections made. Half-sib seedlings, grown from extracted seed, provided the stock for all seed orchards and family tests. Scions (8 to 10 per plus tree) were grafted at the Chapleau Nursery and will be held in clonal archives for future use in the breeding hall and vegetative reproduction programs.

During the next two winters, 400 additional selections and collections will be carried out to provide seed orchard and family test stock for the fourth and final breeding zone.

SEED ORCHARDS

Due to a concerted operational effort by District staff over the past two years, a 26 ha. orchard in Chamberlain Twp. (Kirkland Lake

District) has been fully established and two other orchards at the Island Lake Tree Improvement Area (Chapleau District), which are currently 75% established, will be completed by summer, 1986. When finished, the Island Lake Tree Improvement Area will be a highly capitalized facility featuring over 80 ha. of jack pine and black spruce (Picea mariana (Mill.) B.S.P.) seed orchards and over 20 ha. of clonal archives.

The fourth and last jack pine seedling seed orchard in the Northern Region is planned for establishment over the next 2 to 3 years as part of the Ontario Tree Improvement Council orchard complex in Playfair Twp., near Ramore, Ontario.

A four tree cluster design (Rauter, 1979) has been utilized for these open pollinated seedling seed orchards. Each orchard is based upon 400 families per replicate, with each replicate divided into four blocks of 25 clusters of four. Each planting location is pre-staked and numbered prior to planting.

With the orchard establishment phase almost complete, plans now include the initiation of orchard management. Determining the most effective vegetation control, fertilization regimes and protection from insects and disease will become the emphasis of the jack pine seed orchard program over the next two years.

It is expected that commercial seed production from seedling orchards will begin replacing the current seed supply (identified seed collection and seed production areas) by 2000, and will be the sole producer of all jack pine seed destined for use in intensive forest management by 2020.

FAMILY TESTS

First generation jack pine family tests are now in place for the completed breeding zone 4 orchard and the partially completed breeding zones 1 and 3 orchards. Two tests were utilized for each orchard except breeding zone 4, for which 3 tests were established. Each test, located on geographically different sites within each breeding zone, consists of a Randomized Block Design utilizing five tree row plots replicated five times. All tests were outplanted either one year prior to, or concurrently with orchard establishment.

Measurements of family tests are expected to provide preliminary family rankings which will determine initial rogueings in the seedling orchards. It is hoped that clonal or full-sib information will be available to determine the appropriate final rogueings of these orchards.

BREEDING HALL

Almost complete at the time of writing is a 855 square metre

breeding hall attached to the Swastika Nursery which will be utilized to accelerate the breeding program in both jack pine and black spruce. Very much in its infancy, this program, over the next two years, will concentrate on determining the most appropriate methods to accelerate the flowering and testing of these two species in the controlled environment of a breeding hall. It is targeted that this facility will by 1990, provide enough improved seed from known crosses to generate small quantities of stock for "elite" management trials.

VEGETATIVE PROPAGATION

Vegetative reproduction of jack pine is an area of the regional program expected to receive some concentration over the next two years. Initial examinations carried out at Swastika Nursery have shown that jack pine can be propagated, albeit at a low success rate, from hard cuttings. It must now be determined whether it is more appropriate to continue with the refinement of a rooted cutting program or to attempt micropropagation of the species.

PUBLICATIONS AND REFERENCES

- Rauter, R.M. 1979. The Development of Sound Genetic Material-Seed Orchards. Pages 82-94 in Tree Development Symposium. COJFRC Symp. Proc. 0-P-7.

CONE INDUCTION AND IN VITRO CULTURE IN SOME FOREST TREE SPECIES

Rong H. Ho

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

Keywords: Picea glauca, P. mariana, P. abies, Pinus banksiana, P. strobus, Populus spp., gibberellic acid, spraying, girdling, root pruning, haploid, embryoid, in vitro vegetative propagation.

Application of gibberellic acid 4/7 (GA_{4/7}), girdling, root pruning and a combination of girdling and root pruning to enhance cone production has been carried out on selected trees in seed orchards or arboreta in black (Picea mariana), white (P. glauca), and Norway spruce (P. abies) for the last 3 to 5 years. The objectives were 1) to establish timing and period of application, 2) to determine the optimal concentration, and 3) to define the effect of repeated application.

In vitro culture, there were 2 projects: 1) haploid plant induction through anther culture in poplars (Populus), and 2) vegetative propagation through explant culture in black spruce, white spruce, jack pine (Pinus banksiana), and eastern white pine (P. strobus). The first project was aimed at production of isogenic pure lines for breeding and the second at development of an in vitro technique for nursery operation.

GA_{4/7} SPRAYING

Forty white spruce trees representing 5 clones were sprayed biweekly with either a control or a treatment solution containing 200 mg/L GA_{4/7}, 15% alcohol, and 0.05% Tween 20 at 2 different periods 1) May, June, and July, and 2) June, July, and August. In 1984, trees sprayed in the first period produced significantly more cones (3051 cones per tree) than the controls (1645 cones per tree) while spraying in the second period was not effective (2749 cones per treated tree vs. 2947 cones per control tree). In both 1983 and 1985, the spraying did not stimulate any cone production. It appeared that the treatment could not guarantee good cone crops.

Four branches from each of the 24 white spruce trees representing 6 clones were sprayed biweekly with 4 different concentrations of GA_{4/7} solution (0, 200, 400 and 800 mg/L) from May to August for 3 years. The concentration of 800 mg/L significantly increased cone

production and resulted in an average of 204 cones per branch in 1984 (149 cones at 0 mg/L, 180 at 200, 187 at 400). Treatment at any of the 4 concentrations was ineffective in both 1983 and 1985.

INTRAVASCULAR APPLICATION OF GA_{4/7}

One hundred µg of GA_{4/7} in 5 ml of 5% alcohol solution was applied weekly to black (4 ramets per clone, 5 clones) and white spruce trees (4 ramets per clone, 6 clones) through branch cut ends at different durations (2, 4, and 8 weeks) in May and June for the last 5 years (1980-1984). Good cone crops occurred in 1984, fair in 1981 and 1982, and poor in 1983 and 1985. In black spruce, an average of 127, 155, and 118 cones per ramet per year was produced on trees treated for 2, 4 and 8 weeks respectively, while the controls were treated with 5 ml of 5% alcohol for 8 weeks and produced an average of 82 cones per ramet per year. In white spruce, the production per ramet per year for trees treated for 2, 4, and 8 weeks, and the controls, averaged 536, 496, 431, and 458 cones, respectively. It appeared that 100 µg of GA_{4/7} per tree per week might be adequate to enhance cone production on small trees (under 2 meters; average height for black spruce was 1.6 meters in 1980 and 2.8 meters in 1984; average height for white spruce was 2.0 meters in 1980 and 4.0 meters in 1984). As trees grow in height and foliage, an escalation of GA_{4/7} concentration in application would be necessary to stimulate cone production. The duration of application may require 4 to 6 weeks, and the treatment should begin at the time of bud scale initiation and end before bud-type differentiation in late June (Marquard and Hanover 1984). According to Owens and Molders (1977), reproductive buds bore significantly fewer bud scales than vegetative buds. Therefore, bud-type determination could have occurred biochemically before or during the process of bud scale initiation. Bud scale initiation could have terminated earlier or could have occurred at a slower pace in the reproductive buds than in the vegetative buds.

GIRDLING AND ROOT PRUNING

Twenty-four white spruce trees representing 8 ramets per clone for 3 clones were selected for the study in which 6 trees were used as controls, and the other 18 trees were either girdled, root-pruned, or both for the last 5 years (1980-1984). Two half-moon overlapping girdles which were opposite each other and placed 30 cm apart were applied to the trunk while in root pruning, roots were severed along the 60 cm radius of the trunk and about 35 cm in depth in early May. An average of 288, 368, 314, and 519 cones per ramet per year were produced from the control, girdled, root-pruned, and girdled and root-pruned trees, respectively. In a good crop year, a combination of girdling and root pruning appeared to be the most effective in stimulating cone crops while in a fair crop year, root pruning would give a good result. However, in a poor crop year, none of the treatments stimulated cone crop.

In 1983, the same girdle treatment was given to one half of 22 Norway spruce trees representing 11 clones. In the following year, production in the treated trees was significantly increased and had an average of 72 cones per tree while the controls produced an average of 34 cones per tree. However, the treatment resulted in chlorosis of foliage and recovery occurred in the year following cone production.

HAPLOID PLANT INDUCTION

Poplar anthers were incubated on a medium in petri dishes when the pollen mother cells in anthers had developed to the mononucleate microspore stage. The medium was based on Murashige and Skoog (MS) medium (1962) and supplemented with 2 mg/L 2,4-D and 1 mg/L kinetin. After 2 months of culture in darkness, the anthers with calli in their cavities were transferred to MS medium supplemented with 1 mg/L BAP and 0.2 mg/L NAA under a 16-hour photoperiod with temperature at 25°C during the day and 15°C at night. In a couple of months, adventitious shoots regenerated from calli and the shoots were rooted in 1/2 strength MS medium containing 0.02 mg/L NAA when they reached 3 cm in height. MS medium supplemented with 0.2 mg/L BAP and 0.2 mg/L NAA was used in the subsequent transfers of calli with adventitious shoots. Plantlets have been produced from P. angulata, P. deltoides, P. nigra, P. jackii, P. x euramericana, and P. maximowiczii x deltoides.

Embryoids have been produced from P. alba. Anthers at the described stage were incubated on MS medium supplemented with 1 mg/L kinetin in petri dishes and the dishes were placed in an incubator in darkness at a constant temperature of 25°C. After 2 months of culture, 3 embryoids were produced. One had 3 cotyledon primordia turned green after the embryoid was exposed to light. The second embryoid had an elongated stem with small leaves and a minute root, and the third was an albino with a couple of leaves. The origin of the embryoids is not known and requires further investigation.

IN VITRO PROPAGATION IN CONIFERS

Open-pollinated seeds of black spruce, white spruce, jack pine, and eastern white pine were germinated aseptically. After the cotyledons had emerged from the seed coats, the germinants were excised into 3 types of explants - epicotyls with intact cotyledons, cotyledon segments, and hypocotyl segments. Explants were incubated on Gresshoff and Doy (GD) medium (1972) supplemented with 10 mg/L BAP and 0.2 mg/L NAA for 40 days. Calli which regenerated from the explants and had primordia of adventitious shoots were transferred to 1/2 strength GD medium containing 1 mg/L BAP, 0.2 mg/L NAA and 1% activated charcoal. After a month of culture, they were transferred to 1/2 strength GD medium for shoot elongation. Adventitious shoots of about 1 cm in height were excised and treated with NAA to promote root primordial formation. The shoots were then rooted in 1/2 strength GD medium without growth regulator. Plantlets have been produced from explants of the 4 species.

Cotyledons of black spruce were most responsive to induction while epicotyls were most responsive for white spruce, jack pine, and eastern white pine.

REFERENCES AND PUBLICATIONS

- Ho, R.H. 1984. Seed-cone receptivity and seed production potential in white spruce. *For. Ecol. Manag.* 9:161-171.
- Ho, R.H. and L. Zsuffa. 1984. Biotechnology in breeding for biomass production. First Bioenergy Specialists Meeting on Bioenergy at the Univ. of Waterloo, Waterloo, Ontario, Oct. 14-17, 1984. Univ. of Waterloo, P. 70-82.
- Raj, A.Y. and R.H. Ho. 1983. Application of tissue and anther culture methods in poplar breeding. XV Internat. Cong. Genet., New Delhi, India, Dec. 12-21, 1983. Oxford and IBH Pub. Co. New Delhi, P. 424.
- Gresshoff, P.M. and C.H. Doy. 1972. Development and differentiation of haploid Lycopersicon esculentum (tomato). *Planta* 197:161-170.
- Marquard, R.D. and J.W. Hanover. 1984. Relationship between gibberellin A_{4/7} concentration, time of treatment and crown position on flowering of Picea glauca. *Can. J. For. Res.* 14:547-553.
- Murashige, T. and F. Skoog. 1962. A revised medium for rapid growth and bioassays with tobacco tissue culture. *Physiol. Plant.* 15:473-497.
- Owens, J.N. and M. Molder. 1977. Bud development in Picea glauca. II. Cone differentiation and early development. *Can. J. Bot.* 55:2746-2760.

RECENT DEVELOPMENTS IN ONTARIO'S PROVINCIAL TREE IMPROVEMENT PROGRAM

R. Marie Rauter & Sandra Stubbart

*Tree Seed & Forest Genetics Unit
Ontario Ministry of Natural Resources
Toronto, Ontario*

Keywords: strategies, staffing, workshops, computers, manuals, support programs.

Tree improvement continues to rapidly advance 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 activities of the Tree Seed & Forest Genetics Unit.

TREE IMPROVEMENT STRATEGIES

In the spring of 1983, a comprehensive draft Tree Improvement Strategy for Ontario was written describing the rationale, some basic principles, breeding approaches for several commercially important species and purposes, and an example of the economic costs and anticipated returns. This document has already provided the basis for the development of policy guidelines for the implementation of tree improvement programs throughout the Province. Not only does the Strategy include policy guidelines for breeding approaches based on clonal and seedling seed orchards, it also includes guidelines for adopting breeding approaches based on clonal forestry for species that have characteristics such as ease of rootability, difficulty in being reproduced by seed, and small regeneration programs.

Copies of the draft were sent out for review in 1983. Regional staff and over 30 forest geneticists from around the world have responded. The review process is nearing completion, and a finished Strategy will soon provide Ontario with long-term guidelines on how tree improvement can help meet forest production targets.

At the Regional level over the past year, tree improvement has taken a larger role in forest management operations. Programs in our major species - black spruce, jack pine, white spruce are underway in

most regions. Ongoing work includes plustree selection, seed orchard establishment and genetic tests.

While an intensive tree improvement program in Ontario continues to develop, there is still demand for high quality natural seed sources to be used to produce stock for existing artificial regeneration programs. Until improved seed is available from orchards, specially selected seed collection areas will fill nursery and greenhouse demands. Almost 16,000 hectares have been identified and reserved for seed collection to date.

STAFFING

The number of individuals assigned to work specifically in tree improvement has increased, both in the field and main office since 1979. In the beginning of 1983, the provincial tree improvement and tree seed program at main office consisted of one permanent staff (Supervisor of the Tree Seed and Forest Genetics Unit), two assistant silviculturalists on contract staff, one two-year tree improvement trainee, and one part-time clerk handling seed orders and inputting data onto TSINOW (Tree Seed Inventory Now). By 1984, a second permanent position, Co-ordinator of Tree Seed and Tree Improvement, was created (replacing one of the assistant silviculturalist positions). There were also additional contract staff, including a summer student, working in the Unit. At the close of 1984 approval was given for a third permanent position, Co-ordinator of Forest Genetics, which was filled January 1, 1985 by Jim Hood, formerly of O.T.I.F.B.I. in Maple, Ontario. Celia Graham, Co-ordinator of Tree Seed and Tree Improvement, is currently on a ten-month maternity leave, but will be returning in late 1985.

At the regional level, there are five tree improvement specialists in the field, three of whom are permanent. These regional specialists provide the much needed guidance and support to field staff and are able to co-ordinate many of the programs at both the Regional and District levels.

The high turnover of contract staff continues to be a problem hampering continuity of program delivery of main office and in the field.

COMPUTER DATA BASE SYSTEMS

The development and use of computer data systems continues to be an integral management and administrative tool in provincial tree improvement at both the field and main office level. The first and latest system TSINOW, is an interactive system developed using FOCUS and is available for IBM mainframes. This system is used to maintain all the records with respect to Ontario's primary seed extraction facility at Angus, Ontario. Data stored on this system includes volumes of cone/fruits received and processed, seed yields, germination tests, and shipment records.

The second major system developed is the TREE IMPROVEMENT SYSTEM. In its entirety, it consists of three systems - PLUSTREE, SEED ORCHARD MAPPING, and PROPAGATION. At present, the PLUSTREE and the SEED ORCHARD MAPPING systems are operational in the field, however, the PROPAGATION system will not be available until the fall of 1985 when final revisions are made. The TREE IMPROVEMENT SYSTEM was developed on the POS operating system for the Digital PRO350. All three systems were created using FORTRAN, EASYENTRY AND DATATRIEVE programs. A brief description of the three systems is given below.

The PLUSTREE system is designed to be used at the regional level to bring together information on the location, description, and disposition of all plustrees selected throughout the province.

The MAPPING system was created to maintain records of plustrees used to establish seed orchards. The system stores, reports and maps seedling and clonal orchards to allow managers extensive analysis of their seed orchards. Modifications to the system in early 1985 will allow information on other plantations such as clonal progeny tests, research plots and other plantations. Currently, the system maps seed orchards in either the permuted neighbourhood design (clonal) or the seedling 4-tree cluster.

And finally, the PROPAGATION system is being designed for the planning and administrative requirements of a clonal forestry approach to management, whereby rooted cuttings are used as stock in artificial regeneration. This system allows for the storing of information dealing with controlled pollinations, clone records for rooted cuttings (e.g. # of ramets per clone), clonal stock production records, and the location and size of plantations established with clonal stock.

WORKSHOPS

Two workshops were conducted over the past two years. The first was held in Toronto to demonstrate the PLUSTREE and SEED ORCHARD MAPPING systems to field staff. The objectives of the workshop were to introduce the new provincial plus tree card, familiarize staff with the DEC Professional 350 microcomputer, especially aspects dealing with EASYENTRY and DATATRIEVE, and demonstrate data entry and report-writing capabilities of both the PLUSTREE and SEED ORCHARD MAPPING systems.

The second workshop, held in November of 1984 in Timmins, Ontario, dealt with genetic test designs. Its objective was to provide regional staff with an update of current tree improvement programs with specific reference to genetic tests. Discussions centered around topics such as test design and efficiency, site selection and planting techniques, estimation of genetic parameters, and genetic gain.

SUPPORT PROGRAMS

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

1. Survey and mapping of tamarack (Larix laricina (du Roi) K. Koch.) in southern Ontario as a preliminary aid for future plus tree selection programs.
2. Survey of Norway spruce (Picea abies (L.) Karst.) plantations for performance data, selection of plus trees from Ontario plantations, and breeding of selected exotic provenances.
3. Irrigation and fertilizer testing in seed orchards to ascertain the best management techniques.
4. Determination of wood quality parameters for a total of 1044 jack pine (Pinus banksiana Lamb.) plus trees in Northern Ontario.
5. Study of spruce flower phenology, conducted at the Glencairn Orchard, to assist in future orchard management.

FIELD MANUALS

The field guide for tree seed crop forecasting, 'Guidelines For Tree Seed Crop Forecasting', was published in 1984 and provides a simple, practical reference for field staff to carry out annual forecasting operations. The field guide covers 62 different species and includes colour plates illustrating cones and fruits of a range of conifer and hardwood species at the time of crop forecasting. This handy pocket-sized manual has been well received in the field and is often requested by foreign agencies.

In an endeavour to provide field staff with a practical guide to the implementation of tree improvement strategies, and the establishment and maintenance of seed orchards in the province, a draft manual of seed orchard management techniques has been completed. Over the next two years, this manual will be expanded into a complete manual for tree improvement and will be co-operatively written by field and main office staff.

NORTHERN REGION'S BLACK SPRUCE TREE IMPROVEMENT PROGRAM

V.H. Wearn

*Ministry of Natural Resources
Northern Forest Development Group
Northern Region
60 Wilson Avenue
Timmins, Ontario
P4N 2S7*

Keywords: Black spruce, seedling orchards, family tests, clonal testing.

The Black Spruce Tree Improvement Program in the Northern Region has made vigorous progress in the past two years. All planned orchards are now in various stages of development with half-sib seedlings growing for both orchard and tests. Also in operation is a private facility producing one million black spruce cuttings per year.

PLUS TREE SELECTION

The region is divided into five breeding zones for black spruce. The target of 400 plus tree selections for each zone is underway. Collections are complete for two of the breeding zones with two others planned for completion in the current year. The final zone should be collected by the end of the 1986/87 season.

SEEDLING ORCHARDS

Four major orchards for black spruce ranging in size from 8 ha. to 56 ha. are in various stages of development. Half-sib seedlings are now growing at Swastika Forest Nursery and will be labelled, packaged and frozen this November for planting in the spring of 1986. These seedlings represent about 25% of the planned orchard program. Completion is scheduled for 1988 for all orchards.

FAMILY TESTS

Rogueing of a seed orchard is largely dependent upon the results of family tests. These tests are planted on well prepared black spruce sites within each breeding zone. There will be three family tests per breeding zone designed in a single tree non-contiguous layout.

CLONAL FORESTRY PROGRAM

A private facility for the purpose of producing one million black spruce annually is in production at Moonbeam (Kapuskasing District). This centre is supplied with enough donor plants to make the required cuttings. Approximately 150 new clones are introduced each year and these clones are used for both production and testing material. The tests are clonal screening/site trials. A single tree plot design is used with a total of ten replications per site on a minimum of six sites across the north part of the region. Controlled crosses in the breeding orchards were made this year to produce more full-sib seed for the clonal program.

We are interested in research conducted at Ontario Universities in the areas of early testing, early flowering and vegetative propagation.

P.N.F.I. GENETICS AND BREEDING:
GENETICS OF JACK PINE: 1984-85

C.W. Yeatman

*Petawawa National Forestry Institute
Canadian Forestry Service
Chalk River, Ontario
K0J 1J0*

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

The Genetics and Breeding Project at the Petawawa National Forestry Institute continues to emphasize studies of genecology, population structure, quantitative genetics and the development of advanced-generation breeding material and concepts. Research attention is focused on the principal commercial conifers of the boreal forest, namely black and white spruce, and jack pine. A new project, Molecular Genetics and Micropropagation, was created under the leadership of Dr. W. Cheliak. This report outlines changes in personnel and facilities during the past two years and presents a summary of the work of the project in general and of jack pine in particular. Other components of the Project are reported separately by Dr. Murray, Dr. Cheliak and Dr. Boyle.

PERSONNEL

Dr. W. Fogal left the Project in 1984 to devote full time to studies of protection of seed and cones from insects. Dr. W. Cheliak, Mr. J. Pitel and Mr. G. Scheer left the Project in April 1985 to establish the new Molecular Genetics and Micropropagation Project. Dr. C.W. Yeatman was granted professional development leave spent at the Australian National University, School of Forestry, for four months in 1984. Dr. T.J.B. Boyle returned to P.N.F.I. in January, 1985 after completing the requirements for his Ph.D. at the University of New Brunswick under the direction of Dr. E.K. Morgenstern. Tim's degree was the first Ph.D. earned within the Faculty of Forestry. Andrew Hurley, Dept. of Biology, Queen's University, continued his pursuit of the red squirrel in pine orchards in a Ph.D. study to be completed in 1985. Taylor Scarr, NSERC Student Scholar, Forestry School, University of Toronto, followed the course of aphid infestations in jack pine progeny tests over the summer of 1985.

CONTACTS AND TECHNOLOGY TRANSFER

Dr. Yeatman joined with Dr. Fowler, Maritimes Forestry Centre, in September, 1983 to explore the potential for seed collection from selected stands of Siberian larch (Larix sibirica Ledeb.) and Scots pine (Pinus sylvestris L.) in southern Siberia. The ground work was laid for a collection trip in fall of 1985 to be made by Dr. Boyle, Mr. W. Schroeder, P.F.R.A., Indian Head, Sask., and Mr. J. Holowacz of C.F.S. HQ acting as interpreter. Close cooperation continued with Regions and Districts of the Ontario Ministry of Natural Resources in the establishment, measurement and maintenance of genetic test plantations of white spruce, black spruce and jack pine. Opportunities for effective technology transfer to government and industrial agencies were enhanced through collaboration with Mr. J. Coles, Executive Director, Ontario Tree Improvement Council. Contacts in Quebec included personnel of C.I.P., Harrington, and Ministère de l'énergie et des ressources, Quebec City, for exchange of breeding material (Norway spruce, Picea abies L.) and technical information. Seed and scions of genetically elite Scots pine Christmas trees were given to the Ontario Christmas Tree Growers Association for distribution to members and inclusion in seed orchards. Staff members collaborated actively with faculty and students of schools of forestry at U.N.B., U. of T., Lakehead U. and U. Alberta in joint research studies and in reviews of proposals and progress reports for research initiated in response to NSERC development grants to forestry faculties.

A number of courses in electronic data capture were held at P.N.F.I. for foresters and technologists from government and industry agencies from across Canada. Under the leadership of Mr. Tom Nieman and with the assistance of Dr. Cheliak, attendees were introduced to data loggers suitable for use in the field and to the associated software and portable computers required for data transfer.

FACILITIES

Financial considerations forced abandonment of plans to construct a new genetics research complex. Specifications for laboratory and office accommodation and a propagation greenhouse and work building were incorporated into a proposed Master Plan for the Institute. A new greenhouse and work building continues to have the highest priority. A portable building was constructed to provide interim office and laboratory space for general use and cold storage for the Seed Bank. Additional storage space was provided at the nursery.

GENETICS OF JACK PINE

A second generation of selected jack pine (Pinus banksiana Lamb.) was initiated by making controlled crosses among the three best phenotypes in the three best families of a progeny test of 32 jack pine plus trees. Selection was again based on stem form, tree vigour and branch angle. Several young jack pine progeny tests were measured,

including a seedling seed orchard at Spoor Lake, a nursery spacing trial, and an accelerated progeny test in the nursery. Seed from a 7 x 7 jack pine diallel cross was sown and seedling development followed in the greenhouse. Photosynthetic and metabolic data were recorded periodically by staff of Dr. T. Blake, U. of T., during the summer of 1975 on a 3 x 3 subset of families growing in the PNFI nursery. Summary analyses of 15-year height data from eight Ontario range-wide provenance tests were made available to Dr. Csaba Matyas (Hungarian Visiting Scientist at U. of Toronto) for a collaborative study of provenance by test location interaction.

PUBLICATIONS

- Yeatman, C.W. 1984a. Introduction: global heritage in jeopardy. Pp. 1-2 in Plant Genetic Resources: A Conservation Imperative. C.W. Yeatman, D. Kafton, and G. Wilkes, eds. Westview Press, Boulder, Colo.
- Yeatman, C.W. 1984b. The genetic basis of jack pine management. Pp. 9-13 in Jack Pine Symposium, C.R. Smith and G. Brown, co-chairman. COJFRC Symp. Proc. O-P-12.
- Yeatman, C.W. 1984c. Production of genetically improved jack pine seed for planting and direct seeding. Pp. 171-177 in Clonal Forestry: Its Impact on Tree Improvement and our Future Forests. Proc. Part 2, 19th Meetg. Can. Tree Improv. Ass., Toronto, Aug. 22-26, 1983. Can. For. Serv., Ottawa.
- Yeatman, C.W. 1984d. P.N.F.I. genetics and breeding: genetics of jack pine: 1982-83. Proc. Part 1, 19th Meetg., Can. Tree Improv. Ass., Toronto, Aug. 22-26, 1983. Can. For. Serv., Ottawa.
- Yeatman, C.W., ed. 1984. Proceedings of the Nineteenth Meeting of the Canadian Tree Improvement Association, Part 1. Minutes and Members' Reports. Toronto, Ont., Aug. 22-26, 1983. Can. For. Serv., Ottawa. 243 p.
- Yeatman, C.W., D. Kafton and G. Wilkes, ed's. 1984. Plant Genetic Resources: A Conservation Imperative AAAS Selected Symposium #87. Westview Press, Boulder, Colo. xii + 164 p.
- Yeatman, C.W., W.H. Fogal, H. Carson and S. Carson. 1985. Inheritance of winter dessication, weevil damage and gall rust infection in Scots pine Christmas trees. Gen. Soc. Can. Bull. 16(2):43 (Abstract).
- Zsuffa, L., R.M. Rauter and C.W. Yeatman, ed's. 1984. Clonal Forestry: Its Impact on Tree Improvement and Our Future Forests. Proc., Part 2, 19th Meetg. Can. Tree Improv. Ass., Toronto, Ont., Aug. 22-26, 1983. Can. For. Serv., Ottawa. 235 p.

BLACK SPRUCE GENETICS, PETAWAWA NATIONAL FORESTRY INSTITUTE
1983-1985

T.J.B. Boyle

*Petawawa National Forestry Institute
Canadian Forestry Service
Chalk River, Ontario
K0J 1J0*

Keywords: Picea mariana, black spruce, provenance, heritability, genetic correlation, population genetics.

For most of the period under review, I was on full-time educational leave at the University of New Brunswick. This report will therefore cover activities at both UNB and PNFI.

POPULATION GENETICS

An investigation, using allozymes, of the population structure and mating system of six populations of black spruce (Picea mariana (Mill.) B.S.P.) in New Brunswick was completed. Multilocus estimates of outcrossing rates ranged from 0.891 to 0.976 with an average over all populations of 0.924. In three populations these estimates were statistically less than 1.0 at the 5 per cent significance level. Genetic differentiation among populations, which were separated by distances of between 1 km and 52 km, was significant, but a very high proportion of the total allozyme variation ($\approx 99\%$) was accounted for by within population variation. There was no evidence for the development of any family structure within the populations.

These results suggest that the current strategy for black spruce improvement in New Brunswick is likely to be genetically efficient. The absence of family structuring may be due to the regeneration strategy of black spruce on upland sites such as those sampled. Typically, following fire, the site is recolonized with seed from surviving groups and surrounding stands, resulting in greater mixing of seed than would result from regeneration in situ. To test this hypothesis, a lowland black spruce population which had clearly not been burnt for several generations, was intensively sampled - seed and vegetative material being collected from about 200 individuals in an area of one hectare. This material is currently being assayed for allozyme variation at 15 loci.

PROVENANCE VARIATION

Ten- and fifteen-year height and survival measurements of the Ontario component of the range-wide black spruce provenance test series were analyzed. Genotype x environment interactions were highly significant for height growth and within site-environmental error was also a major source of variation. Some substantial rank changes are still occurring between ages 10 and 15. However, it appears that provenances from western Ontario generally perform well across the province, even on more southerly sites. A provenance from Nipissing, Ontario was best overall in terms of fifteen-year height growth.

PROGENY TESTS

Ten-year heights from the three series of open-pollinated progeny tests planted in Ontario were analyzed. Narrow sense heritabilities estimated from individual test results ranged from 0 to 0.399 on an individual tree basis and from 0 to 0.896 on a family basis, with averages of 0.169 and 0.663 respectively. Genetic correlations among sites indicated that each of the three site regions (3E, 3W and 4S) should be divided into at least 2 to 3 separate breeding zones.

PUBLICATIONS

- Boyle, T.J.B. 1985. The mating system and population structure of black spruce in central New Brunswick and its influence on tree improvement strategy. PhD dissertation, University of New Brunswick.
- Boyle, T.J.B. 1985. Range-wide provenance tests of black spruce in Ontario. Can. For. Serv. Inf. Rep. (in review).
- Boyle, T.J.B. 1985. Ten-year height growth of open-pollinated black spruce families in Ontario. Can. For. Serv. Inf. Rep. (in preparation).
- Boyle, T.J.B. and D.C. Malcolm. 1985. The reproductive potential and conservation value of a near-derelict Scots pine remnant in Glen Falloch. Scot. For. (in review).
- Boyle, T.J.B. and E.K. Morgenstern. 1985. Population structure of black spruce in central New Brunswick. Proc. 29th Northeast. For. Tree Improv. Conf., Morgantown, West Virginia, 1984: 142-156.
- Boyle, T.J.B. and E.K. Morgenstern. 1985. Inheritance and linkage relationships of some isozymes of black spruce in New Brunswick. Can. J. For. Res. 15. (in press).
- Boyle, T.J.B. and E.K. Morgenstern. 1985. Estimates of outcrossing rates in six populations of black spruce in central New Brunswick, Canada. Silv. Genet. (in press).

- Boyle, T.J.B. and E.K. Morgenstern. 1985. Some aspects of the population structure of black spruce in central New Brunswick. *Silv. Genet.* (in review).
- Boyle, T.J.B., A.J. Pottinger and J.P. Cornelius. 1985. Gwelliant coed yn New Brunswick. *Y. coedwigwr* (in press).

GENETICS OF WHITE SPRUCE, LARCHES AND HARDWOODS, PETAWAWA 1983-1985

G. Murray and W. Cheliak

*Petawawa National Forestry Institute
Canadian Forestry Service
Chalk River, Ontario
K0J 1J0*

Keywords: Provenance, tamarack, isoenzymes

The work of the past two years represents, essentially, a continuation of studies referred to in previous reports from Petawawa National Forestry Institute (PNFI). The range-wide provenance test of tamarack (*Larix laricina* [Du Roi] K. Koch) is now in the field establishment phase, following almost 10 years of effort to assemble a representative seed collection. Field planting of the range-wide provenance tests of white spruce (*Picea glauca* [Moench] Voss) has been completed and measurements of early growth have been collected in many tests. Publication of results of older field tests of white spruce and larch has a high priority as it is recognized that the information is needed to guide those planning operational tree improvement programs and to provide direction for future research activities.

WHITE SPRUCE

Provenance

A provenance test of white spruce was planted at PNFI in May 1985. This was the last of the range-wide tests in the series of range-wide and regional tests (Murray and Cheliak 1984) scheduled for planting in Ontario with the cooperation of the Ontario Ministry of Natural Resources. A total of 6 range-wide and 9 regional tests have been planted in Ontario, but two of the regional tests have been destroyed by fire. In four blocks of the PNFI test, 4 trees of each provenance were planted in random non-contiguous plots in each of two interlocking replicates per block. An equal number of trees was planted in 4-tree row plots in each of 8 blocks in a randomized complete block design. The purpose of this arrangement is to allow evaluation of provenance performance and comparison of row and non-contiguous plots. One interlocking replicate will be removed in thinning at a later date.

Measurement of new and old series of provenance tests has been continued, as scheduled, at 5-year intervals. A paper on results from some of the older tests was prepared by Murray and Skeates (1984). Review

and discussion of all available results of white spruce provenance research will be part of a provenance workshop/symposium being planned for 1986 at PNFI.

Selection, Breeding and Progeny Testing

We have completed selection of trees that will form the breeding population for use in research on advanced generation breeding. An exceptionally heavy cone crop in 1984 made it possible to collect seed from many of the selected trees. However, so few buds were left to produce vegetative shoots that scion collection and grafting could not be done as scheduled in 1985. Open-pollinated seed have already been made available to cooperators for inclusion in family tests.

Isoenzymes were used in the study of inheritance, population structure, mating system, and variance effective population size (Cheliak, Pitel and Murray 1984).

Wood Quality

Under the terms of a PRUF (Program of Research by Universities in Forestry) contract, Dr. J. Balatinecz, University of Toronto, is studying the wood quality of several species, including white spruce. Work done includes observations of Pilodyn penetration in different provenances, and detailed study of wood properties of trees in full-sib families.

LARCH

Tamarack

Although there are still some gaps in the distribution of seed samples collected for the cooperative range-wide provenance test of tamarack, a start has been made with the establishment of field tests. Staff at the Maritimes Forest Research Centre have planted a number of tests and the first of a series of tests in Ontario is scheduled for field planting at PNFI in 1986.

Progress made in the study of geographic variation of isoenzymes in the tamarack seed collected for the range-wide test includes a paper describing the inheritance and linkage of allozymes (Cheliak and Pitel 1985).

Data collected in a tamarack family test planted at PNFI on three different sites were used in an investigation of the correlation between height measurements made between the ages of 4 and 14 years. Results of this investigation are contained in a thesis submitted to the University of New Brunswick by Mr. Graydon Smith as part of the requirements for his degree of Bachelor of Science in Forestry (Smith 1985).

Exotic Larches

Variation in growth and yield of different sources of European larch (Larix decidua Mill.) and a single source of hybrid larch (Larix eurolepis Henry) was evident in recent measurements of 27- and 28-year-old replicated tests at PNFI. The best growth was made by the hybrid larch which reached a mean height of 18 metres in 27 years with mean volume of 286.4 m³/ha (MAI = 10.6 m³/ha/yr). Part of this yield was removed in 1970 (17.6 m³/ha) in a non-commercial thinning, and in 1979 (58.9 m³/ha) when the trees were of marketable size. The European larch giving the highest yield on the same site, a larch of Sudeten origin obtained from a Danish seed orchard, had a total volume of 255.7 m³/ha, while the poorest larch from an unimproved source in Austria produced 144.7 m³/ha.

Scions from European and Japanese (Larix leptolepis [Sieb. and Zucc. Gord.]) larch selected at different locations in Ontario and Quebec have been grafted at PNFI. Some of this material has been included in a seed orchard planted by the Ontario Ministry of Natural Resources in southeastern Ontario. Ramets of most clones will also be planted in a clonal archive at PNFI.

Samples of larch removed in recent thinnings are being used in Dr. Balatinecz's study of wood quality referred to earlier in this report.

HARDWOODS

Work on hardwoods in the past two years has been limited to inspection and tending of existing plantations of green ash and white ash (Fraxinus pennsylvanica Marsh. and F. americana L.).

PUBLICATIONS AND REFERENCES

- Cheliak, W.M. and J.A. Pitel. 1985. Inheritance and linkage of allozymes in Larix laricina. Silvae Genetica [in press].
- Cheliak, W.M., J.A. Pitel and G. Murray. 1984. Population structure and the mating system of white spruce. Can. J. For. Res. 15:301-308.
- Murray, G. and W.M. Cheliak. 1984. Genetics of white spruce, larches and hardwoods, Petawawa 1981-1983. Pages 130-132 in Proc. 19th Mtg. Can. Tree Improv. Assn. Part 1. Toronto, Ontario, 1983.
- Murray, G. and D.A. Skeates. 1984. Variation in height of white spruce provenances after 10 and 20 years in five field tests. Pages 82-89 in Proc. 29th Northeastern For. Tree Improv. Conf., Morgantown, West Virginia, 1983.
- Smith, G.P. 1985. Juvenile-adult height correlations in 36 tanmarack (Larix laricina [Du Roi] K. Koch) families at 5 ages. B.Sc.F. thesis, University of New Brunswick. 39 pp.

MOLECULAR GENETICS AND PLANT TISSUE CULTURE 1983-1985

W.M. Cheliak and J.A. Pitel

*Petawawa National Forestry Institute
Canadian Forestry Service
Chalk River, Ontario
K0J 1J0*

Keywords: Population Genetics, Isozymes, Biochemistry, Molecular Genetics, Plant Tissue Culture, Picea glauca, Picea mariana, Larix laricina, Pinus sylvestris, Picea abies, Alnus spp.

In addition to the above two study officers, two other members were included in the spring of 1985. Both Mr. S.M. Lopushanski and Dr. Francine Tremblay have initiated studies dealing with the plant tissue culture of conifer species as well as with deciduous species such as elm, alder and birch. This realignment of opportunities represents a growth of the genetics effort at the National Institute. With regards to the Molecular Genetics study, the main emphasis in the past 2 years has been with improving extraction protocols, characterization, and quantification of enzyme expression from complex vegetative tissues of coniferous tree species. This work has formed the basis for investigations of population genetics, and pedigree certification of artificial and natural populations of both angiosperm and gymnosperm species. As well, established protocols for analysis of coniferous seeds have formed the basis for studies on the mating dynamics of seed orchards, paternity structure and mating system of several other species.

POPULATION GENETICS

Black spruce

Established methods developed in our laboratory for extracting and characterizing variants of enzymes from needle tissues were used in this study for the analysis of the genetic control of allozyme variants of a 7 x 7 black spruce diallel cross. From this controlled mating scheme, 1,066 progeny were analyzed. Of the many enzymes tested, seven (aspartate aminotransferase, aconitase, glutamate dehydrogenase, leucine aminopeptidase, malate dehydrogenase, phosphoglucosmutase and shikimate dehydrogenase) produced phenotypes that were variable as well as having banding patterns that were of good activity and high resolution. The technique of isozyme analysis also indicated that some progeny of a cross did not have a genotype composition that they were expected to have, given the supposed parent. The use of isozymes as simple genetic markers may thus play a role in maintaining the identity and genetic integrity of breeding stocks.

Scots pine

The experimental results are nearly complete for the isozyme analysis of both embryos and gametophytes obtained from a Scots pine Christmas seed orchard. The trees were planted in the spring of 1966 and then rogued in February 1983. Thirteen clones are involved, for which 6-15 trees were planted for each clone. This resulted in the analysis of 35 seeds for each of the 151 trees in the orchard. A paper detailing the mating dynamics, prethinning, was presented at a IUFRO Population Genetics meeting in Gottingen, Germany in 1984. These results clearly show that there are significant departures from the ideals of panmixia and wide pollen pool distribution in seed orchards.

White spruce

The inheritance of allozymes of 12 polymorphic loci was demonstrated using haploid megagametophytic tissues of viable seed from a total of 47 white spruce trees in one stand. Except for one allozyme of phosphoglucose isomerase, allozymes segregated as expected in a 1:1 ratio. Overall, an excess of heterozygotes was observed in the mature population. However, after 9 years of storage in a seedbank, no more than random selfing could be detected in the viable filial generation. Significant heterogeneity in allele frequency distribution of several loci was observed in the pollen pool in this stand. The calculated ratio of genetically effective males to females in this population was only 0.4. These results were interpreted as evidence for changes in the spatial genetic structure of the population, as well as restricted effective transmission distances of male gametes.

Alder

The thesis work (dealing with the isozyme analysis of various species of Alnus) of a student from Laval University, Jean Bousquet, was supervised by Dr. Cheliak. Some of the results were presented at the CTIA meeting held in Quebec City in August 1985.

Norway spruce

In collaboration with Dr. T. Skroppa of Norway, isozyme analyses dealing with the paternity exclusion and dynamics of pollination during a polycross of Norway spruce has been completed and the data analyzed. Results from several different years of pollination indicate that not all males contributed equally to the filial generation. The implications of these results for the general utility of polycrosses in forest genetics are currently being written.

BIOCHEMISTRY

Changes in the metabolism of six enzymes of both embryo and gametophyte tissues of tamarack seeds were examined during stratification and germination. In addition, some of the characteristics of the enzymes were examined, such as determination of optimal pH and substrate concen-

trations for the spectrophotometric assay of the enzymes, thermal stability studies, and stability with time at 4°C. The enzymes examined included acid phosphatase (ACP), glucose-6-phosphate dehydrogenase (G-6-PD), NADP⁺- isocitrate dehydrogenase (IDH), total cellular NAD⁺-malate dehydrogenase (MDH), soluble peroxidase (PER) and 6-phosphogluconic acid dehydrogenase (6-PGD). On a per seed part basis, activities of all enzymes from both tissues generally increased slowly following stratification at 4°C for one month and imbibition under germinating conditions for 5 days, but then increased at a faster rate with emergence of the radicle and subsequent growth of the seedling. Changes were most dramatic for peroxidase. Levels of soluble protein also increased with stratification and germination, with highest levels being obtained for seeds after 8 days of germination for both the embryo and gametophyte. Activity of glucose-6-phosphate dehydrogenase was not very stable. After 24 h at 4°C, only 20% of the initial activity remained. Experiments using various enzyme stabilizing chemicals such as oxidized nucleotide coenzymes and mercaptoethanol will be examined to help in stabilizing this as well as other enzymes.

Two reports dealing with methods to increase activity of enzymes extracted from needles, bud and bark tissues of white spruce have recently been accepted for publication in Physiologia Plantarum and Canadian Journal of Botany. Enzyme activity was assayed by a spectrophotometer following extraction of the vegetative tissues with various buffers containing enzyme protective agents added singly or in various combinations. A range of concentrations of the chemicals (such as polyethylene glycol, Tween 80, polyvinylpyrrolidone) as well as different pH's of the extraction buffers were tested. The results indicated that unlike needles and bark tissues, enzyme activity of bud tissues (with scales removed) was high even in the absence of any protective agent. Extraction of needle and bark tissues with various combination buffers referred to in the literature clearly indicated that no one extraction buffer was optimal for the six enzymes examined. As needles increased with age on the tree, activities of the dehydrogenases decreased, while that of peroxidase increased.

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 electrophoretic gels. 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.

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.

Changes in the metabolism of basswood seeds during stratification at 4°C and at a control temperature of 20°C (under which conditions dormancy is not released) are being examined. The study includes the assay of the soluble amino acids; total soluble proteins; the spectrophotometric determination of the activity of several enzymes; and the characterization of isozymes by electrophoresis.

Experiments have been initiated to develop protocols for the extraction and characterization of chloroplast DNA from deciduous trees such as alder and poplar as well as from white spruce and jack pine.

PUBLICATIONS

I. Journal articles accepted/published 1983/1985:

- Cheliak, W.M. 1985. Mating dynamics in a scots pine seed orchard. Springer Verlag Lecture notes in Biomathematics (in press).
- Cheliak, W.M. and J.A. Pitel. 1984. Genetic control of allozyme variants in mature tissues of white spruce. *J. Hered.* 75: 34-40.
- Cheliak, W.M. and J.A. Pitel. 1984. Electrophoretic identification and delineation of clones in Populus tremuloides. *Can. J. For. Res.* 14: 740-743.
- Cheliak, W.M. and J.A. Pitel. 1985. Inheritance and linkage of isozymes in Larix laricina. *Silvae Genet.* (in press).
- Cheliak, W.M., K. Morgan, C. Strobeck, F.C.H. Yeh, and B.P. Dancik. 1983. Estimation of mating system parameters in plant populations using the EM algorithm. *Theor. App. Genet.* 65: 157-161.
- Cheliak, W.M., K. Morgan, B.P. Dancik, C. Strobek, and F.C.H. Yeh. 1984. Segregation of allozymes in megagametophytes of viable seed from a natural population of jack pine, Pinus banksiana Lamb. *Theor. Appl. Genet.* 69: 145-151.
- Cheliak, W.M., J.A. Pitel, and G. Murray. 1985. Population structure and the mating system of white spruce. *Can. J. For. Res.* 15: 301-308.
- Cheliak, W.M., B.P. Dancik, K. Morgan, F.C.H. Yeh, and C. Strobeck. 1985. Temporal variation of the mating system in a natural population of jack pine. *Genetics*, 109: 569-584.
- O'Reilly, G.J., W.H. Parker, and W.M. Cheliak. 1985. Isozymes of upland and lowland Picea mariana stands in northern Ontario. *Silvae Genet.* (in press).

- Pitel, J.A., W.M. Cheliak and B.S.P. Wang. 1984. Changes in isoenzyme patterns during imbibition and germination of lodgepole pine (Pinus contorta var. latifolia Engelm.) seeds. Can. J. For. Res. 14: 743-746.
- Pitel, J.A., B.S.P. Wang and W.M. Cheliak. 1984. Improving germination of hop-hornbeam seeds. Can. J. For. Res. 14: 464-466.
- Pitel, J.A. and W.M. Cheliak. 1985. Methods to extract NAD⁺-malate dehydrogenase efficiently from white spruce needles. Physiol. Plant. (in press).
- Pitel, J.A. and W.M. Cheliak. 1985. Effect of protective agents on increasing activity of five enzymes from vegetative tissues of white spruce. Can. J. Bot. (in press).
- Yeh, F.C., A. Brune, W.M. Cheliak, and D.C. Chipman. 1983. Mating system of Eucalyptus citriodora in a seed-production area. Can. J. For. Res. 13: 1051-1055.
- Yeh, F.C., W.M. Cheliak, B.P. Dancik, K.I. Illingworth, D.C. Trust, and B.A. Pryhitka. 1985. Population differentiation in lodgepole pine, Pinus contorta spp. latifolia: a discriminant analysis of allozyme variation. Can. J. Genet. Cytol. 27: 210-218.

II. Papers submitted/in preparation:

- Barrett, J., W.M. Cheliak and P.H. Knowles. 1985. Inheritance and linkage of allozymes in Picea mariana. (submitted Silvae Genet.)
- Cheliak, W.M., F.C.H. Yeh and J.A. Pitel. 1985. Use of electrophoresis in tree improvement programs. (submitted For. Chron.) 22 pp.
- Pitel, J.A. and W.M. Cheliak. 1985. Enzyme metabolism during imbibition and germination of seeds of tamarack. (submitted Physiol. Plant.) 28 pp.
- Pitel, J.A., W.M. Cheliak and J. Barrett. 1985. Inheritance of allozymes in a black spruce diallel cross. (submitted Silvae Genet.) 21 pp.

III. Equivalent to Refereed Publications:

- Cheliak, W.M. and J.A. Pitel. 1984. Techniques for starch gel electrophoresis of enzymes from forest tree species. Envir. Can., Can. For. Serv., Petawawa Nat'l For. Instit. Information Report. PI-X-42. 49 pp.

Nieman, T., W. Kean and W. Cheliak. 1984. An electronic "Notebook" for forestry application. Envir. Can., Can. For. Serv., Petawawa Nat'l For. Instit., Information Report. PI-X-38. 44 pp.

Pitel, J.A. and W.M. Cheliak. 1984. Effect of extraction buffer composition on characterization of isozymes from vegetative tissues of five conifer species: A user's manual. Envir. Can., Can. For. Serv., Petawawa Nat'l For. Instit. Information Report. PI-X-34. 64 pp.

IV. Unrefereed Publications, Posters, and Meeting Abstracts

Pitel, J.A. and W.M. Cheliak. 1984. The effect of some enzyme protective agents in maintaining high activity of malate dehydrogenase extracted from white spruce needles. Abstract presented at the 14th Regional Meeting, Canadian Society of Plant Physiology, Concordia University, Jan. 5-6, 1984.

Pitel, J.A. and W.M. Cheliak. 1984. Methods to improve enzyme activity of white spruce vegetative tissue extracts. Abstract presented at the 26th Annual Meeting of the Canadian Society of Plant Physiology. July 28-Aug. 2, 1984. Whistler, B.C.

Pitel, J.A. and W.M. Cheliak. 1985. Enzyme metabolism of larch seeds during germination. Abstract presented at the Annual meeting of the American and Canadian Societies of Plant Physiology. Brown University, Providence, RI. June 23-28.

NATIONAL TREE SEED CENTRE 1933-1985

B.S.P. Wang, P.S. Janas and H.O. Schooley

*Petawawa National Forestry Institute
Canadian Forestry Service
Chalk River, Ontario
K0J 1J0*

Keywords: cone production, flower stimulation, frost damage, pretreatment, germination, storage, seed-borne fungi, processing, testing, information.

The re-organization of the National Tree Seed Centre into two autonomous projects of research and development, and seed bank and services has been very successful. There has been some changes in the Projects' activities during the reported period. Dr. Rajesh Mittal of India joined our Research and Development as a NSERCC Visiting Fellow in December 1984, and Mrs. Bea Kelley started her technician career with our Seed Bank and Services in May 1985.

RESEARCH AND DEVELOPMENT

Seed Crop Production and Stimulation

A report describing the results of tests of ammonium nitrate fertilizer to stimulate flower, cone and seed production in a young white spruce (Picea glauca (Moench) Voss) seed orchard has been written. Treatments with up to 400 kg elemental nitrogen per hectare significantly increased production by the oldest trees tested (grafts, 9 years from planting), however, even with this stimulation the number of seed produced (2800 per bearing tree) was small. The trees tested were just beginning to bear seed and will probably respond more favourably to treatment when they are a few years older and correspondingly larger in size. The seed from treated trees germinated normally.

Similar seed stimulation tests were conducted in a 30-year-old red pine (Pinus resinosa Ait.) seed production area. Average cone production per tree increased by about 200% with the application of 400 kg per ha of urea or of ammonium nitrate.

Under contract to the CFS, Dr. J.N. Owens and M.D. Blake (1985) of the University of Victoria reviewed the literature on tree seed production and recommended avenues for future research. Their report outlines the reproductive cycle of all important Canadian tree species and for many describes all stages of development of reproductive structures from flower bud initiation to the formation of mature seed. The report contains essential background information needed by everyone concerned with this field of study. It will be published as a PNFI information report.

Studies to characterize the effects of frost on flower production were made between 1979 and 1984 in a red pine seed production area which is partially located within a frost pocket. Complete crop failures as a result of frost damage occurred in 1980 and 1982. A partial failure occurred in 1978 while other years were unaffected. A manuscript describing this work has been submitted to the Forestry Chronicle for publication.

Pretreatment and Germination

Prechilling or cold stratification is commonly used for overcoming seed dormancy and reducing the sensitivity of seed to light and temperature conditions. This results in an increased rate and uniformity of germination (Wang 1985). A cooperative study with N.S. Department of Lands and Forests at Debert examined the handling and processing of white spruce seeds, it was interesting to find that differences in germination of seeds due to different methods of handling and processing can also be partly or completely reduced by prechilling treatment. This is a further indication that white spruce seed should be stratified routinely before sowing or testing.

Studies on the ecology of germination of black spruce (Picea mariana (Mill.) B.S.P.) and red alder (Alnus rubra Bong.) seeds were initiated in 1983. Progress to date indicates that under long photoperiods of 16 and 20 hours, total germination is not affected by cone age (new vs. old), site (upland vs. lowland), and seed source (Gogama vs. Chapleau, Ontario) at all temperature regimes (5 to 35°C) except 35°C. Total germination is greatly reduced at 35°C, although the high temperature effect appears to be modified by the 24 hour photoperiod. Rate of germination, defined as the number of days required to reach 90% of the total germination, is influenced by the germination temperature and the interaction of temperature and photoperiod.

Both the total germination and rate of germination of red alder seeds are affected by germination temperature with the highest and fastest germination at 25°C. Detailed results will be reported later when statistical analyses are completed.

Seed Storage

A new study proposal on storage requirements of white and black spruce seeds was approved and experiments will be started in the fall of 1985. This study will involve a series of experiments using conventional and cryopreservation methods of seed storage.

It was interesting to note that a 1970 collection of lodgepole pine (Pinus contorta Doug.) seedlot from Alberta showed considerable increase in dormancy after 15 year storage at +2°C. A similar increased seed dormancy was reported previously for seedlots stored for 12 years under subfreezing temperature of -18°C (Wang 1982).

Seed-borne Fungi

A study proposal titled "Etiology of seed-borne fungi of white spruce and eastern white pine" was approved and planned experiments will be initiated in the fall of 1985. Preliminary work has indicated that three fungi infecting white spruce seeds of Ontario sources (Alternaria alternata (Fr.) Keissler, Fusarium oxysporum Schlecht., and Penicillium variable Sopp) cause sprouting and cotyledon emergence failure, and top decay of germinants during germination.

SEED BANK AND SERVICES

Seed Extraction, Processing and Testing

In 1984 the Seed Centre's seed extractory processed over 400 single tree and general cone collections of three native alder species collected from 8 provinces. Also processed were 320 lots of white spruce, 253 Scots pine (Pinus sylvestris L.), 197 black spruce, 79 jack pine (Pinus banksiana Lamb.) and 446 miscellaneous seedlots.

A total of 1486 germination tests were conducted as part of the 1984 seed bank inventory. Service and seed bank tests were also performed for moisture content, purity, determination of 1000-seed-weight and assessment of processing injury. The data recording and retrieval systems for seed test results were improved by implementation of computerized interactive database management programs.

Seed Bank and Information Services

The Canadian Forestry Service seed bank currently has an inventory over 3000 lots of 190 species. As a result of the worldwide network of contacts established to procure valuable collections of seed and other reproductive material, over 177 lots comprising 95 species were obtained for the bank in 1984. Of these, 71 lots (24 species) were procured by collections made by project staff, 74 lots (50 species) through seed exchange, and 32 lots (21 species) through seed purchase. In addition,

the ENFOR-sponsored National Alder Collection Project was completed, with collections made in regions not covered in the previous year. As a result, the Bank now contains a comprehensive and well-documented nationwide collection of Alnus crispa (Ait.) Pursh, A. rubra Bong., A. rugosa (Du Roi) Spreng., A. sinuata (Reg.) Rydb., and A. tenuifolia Nutt..

The Seed Centre continues to act as the main clearing house for Canadian tree seed exchange with the People's Republic of China. In 1984, 20 species were received from China in return for seed of indigenous Canadian species.

In response to 89 requests for seed, 759 seed samples of 141 species were dispatched to clients in Canada and 14 other countries in 1984. Computerized files have been implemented for client seed requests, which have markedly improved the efficiency in filling requests and summarizing annual statistics. This file has been linked with the seed bank database so that client seed shipments can be accompanied by computer-generated seedlot information covering provenance information and recent germination test results.

An updated listing of seed available from the Centre's storage facilities was published in the form of an information report (Janas 1984).

In reply to enquiries, information in the form of letters, reprints, maps, and computer inventory listings was sent to 46 clients in 8 provinces and 7 countries. Requests for information now encompass a wide array of topics including seed availability, collection, processing, testing and storage. Technical consultation was also provided to several individuals encountering difficulties in seed extraction and processing.

National Seed Statistics

A report summarizing results of a 1980-81 national survey covering data on seed procurement, processing, utilization and storage was published as an information report (Janas and Haddon 1984). This information will assist provincial agencies in the formulation of general management policies and decisions.

Results of the 1982-83 national survey are currently being compiled and will be published in 1985. This report will also contain a summary of seed storage facilities and conditions used across Canada, using data collected for the International Board for Plant Genetic Resources.

PUBLICATIONS AND REPORTS

Hellum, A.K. and B.S.P. Wang. 1985. Lodgepole pine seed: seed characteristics, handling and use. Pages 187-197 in Proc. Lodgepole

- Pine Symp.: The species and its management. Wash. State Univ., Pullman, WA.
- Janas, P.S. 1984. A list of seed in the Canadian Forestry Service seed bank. Can. For. Serv., Info. Rep. PI-X-39. 63 pp.
- Janas, P.S. and B.D. Haddon. 1984. Canadian forest tree seed statistics: 1980-81 survey results. Can. For. Serv., Info. Rep. PI-X-41. 23 pp.
- Owens, J.N. and M.D. Blake. 1985. Forest tree seed production; a review of literature and recommendations for future research. Can. Forestry Serv., Information Rep. No. PI-X-53. 330 p.
- Pitel, J.A. and B.S.P. Wang. 1984. A review of papers published in the Proceedings of the IUFRO International Symposium on Forest Tree Seed Storage. Commonw. For. Rev. 63(1): 55-66.
- Pitel, J.A., W.M. Cheliak, and B.S.P. Wang. 1984. Changes in isoenzyme patterns during imbibition and germination of lodgepole pine (Pinus contorta var, latifolia). Can. J. For. Res. 14(5): 743-746.
- Pitel, J.A., B.S.P. Wang and W.M. Cheliak. 1984. Improving germination of hop-hornbeam seeds. Can. J. For. Res. 14(3): 464-466.
- Schooley, H.O. 1984a. A comprehensive list of literature on the effects of fertilizers on tree seed production. Internal Report of Study PI-10-050. 20 pp.
- Schooley, H.O. 1984b. White spruce cone crop stimulation by nitrogen. OMNR Contract Report. 56 pp.
- Schooley, H.O., D.A. Winston, and R.R. Macnaughton. 1984. Frost killing of red pine flowers. Manuscript prepared for publication in the Forestry Chronicle. 3 pp.
- Wang, B.S.P. 1982. Long-term storage of Abies, Betula, Larix, Picea, Pinus and Populus seeds. Pages 212-218 in Proc. IUFRO Int. Symp. Forest Tree Seed Storage, Chalk River, Ontario, 1980. Can. For. Serv., Ottawa.
- Wang, B.S.P. 1985. Overview of utilization of improved seed. Pages 193-200 in Clonal forestry: Its impact on tree improvement and our future forests. Proc. 19th Meet. Can. Tree Improv. Ass., Part 2. Can. For. Serv., Ottawa.
- Wang, B.S.P. and F. Ackerman. 1984. Une nouvelle boîte de germination pour les tests de graines d'arbres. Service canadien des forêts, Institut forestier national de Petawawa, Rapport d'information PI-X-27F. 15 pp.

CONTROL AND MONITORING OF SEED AND CONE
INSECTS OF WHITE AND BLACK SPRUCE -- PETAWAWA
1983-84

W.H. Fogal

*Petawawa National Forestry Institute
Canadian Forestry Service
Chalk River, Ontario
K0J 1J0*

Keywords: White spruce, black spruce, seed and cone insects, monitoring, pheromones, systemic insecticides, Beauveria bassiana.

INTRODUCTION

All activities for 1983-84 were concentrated on studies relating to the control and monitoring of seed and cone insects of white spruce, Picea glauca (Moench) Voss, and black spruce, Picea mariana (Mill.) BSP. A study on selection and testing for resistance to insects and diseases was terminated in 1983.

Most data from experiments and surveys that began in 1979 have been summarized and analyzed. In addition, data collection involving yearly assessments on long-term experiments and surveys was continued. Several reports have been written, some are published and others are under review. Findings and conclusions are summarized below.

CHEMICAL CONTROL

a. Foliar application of systemic insecticides

Cone-bearing portions of white spruce trees were sprayed by means of hydraulic sprayers with 1.0 and 1.5 per cent solutions of dimethoate, methomyl, and acephate in a 12-year-old and a 25-year-old plantation. Each insecticide provided highly significant reductions in the incidence of cone damage by coneworm, Dioryctria reniculelloides Mutuura and Munroe, cone maggot, Lasiomma anthracina (Czerny), and cone-axis midge, Dasineura rachiphaga Tripp, and no difference among insecticides was evident. Treatments had no effect on budworm, Choristoneura fumiferana (Clemens) damage.

Dimethoate has been registered for use against seed and cone insects of spruces by Agriculture Canada under the "Minor Use" registration process. Methomyl and acephate should also be considered for registration as foliar sprays against these insects. However data on cone yields, seed yields, seed quality and possible phytotoxic effects are needed.

b. Stem injection or implants of systemic insecticides

Injections of liquid formulations of dicrotophos and oxydemetonmethyl at 1 g AI/cm DBH by means of Mauget® injectors were tested for control of defoliation by spruce budworm, and spruce coneworm, cone damage by insects and for increase of sound seeds in cones of white spruce trees. Implantation of powdered acephate at 0.5 and 1.0 g AI/cm DBH by means of Medicap® capsules was tested for control of cone damage by insects and for increase of sound seeds. Effect of time of injections of liquid dicrotophos at 0.5 g AI/cm DBH on cone damage was also tested.

Dicrotophos and oxydemetonmethyl effectively reduced defoliation by budworm at upper, middle and lower crown levels for two seasons following injection; dicrotophos was more effective than oxydemetonmethyl. Cone damage attributed to budworm was not reduced in the year of treatment unless treatments were made shortly after the peak of flowering; however damage was controlled the year after treatment. Acephate did not control budworm damage to cones. Coneworm damage was not controlled by dicrotophos or oxydemetonmethyl but was controlled by acephate the year after treatment, but not in the treatment year. Spruce seedmoth damage was reduced by dicrotophos and oxydemetonmethyl in the year of treatment but not the year after; acephate was effective both years. Spruce cone maggot and seed-inhabiting insect damage was reduced by dicrotophos and oxydemetonmethyl in the first but not the second year whereas acephate was again effective in both years. Spruce cone axis midge damage was controlled by dicrotophos and oxydemetonmethyl in the first year but not the second, and acephate was not effective in either year. Number of seeds was increased by dicrotophos and oxydemetonmethyl in both assessment years, but in spite of control of insect damage, seed counts were not increased by acephate implants. Treatments did not appear to cause severe toxic stress.

Injection or implantation appear to have merit for eventual use against insects that attack cones and defoliate white spruce plus trees. Protection of white spruce plus trees by this method should facilitate collection of large quantities of seed and healthy scion material for establishment and development of seed orchards. However more work is required to determine how factors such as pollination, size of the cone crop, and stand quality influence the outcome of treatments in terms of seed yields and to determine if treatments have any adverse effects on seed yields and quality or on long term health of the tree. The chemicals tested are not registered for use against seed and cone insects but they should be considered for "Minor Use" labelling.

c. Soil incorporation of carbofuran

Carbofuran was applied to black spruce seed trees by soil incorporation of granular and liquid formulations at rates of 5 or 10 g AI/cm DBH (equivalent to rates of 32 or 64 kg AI/ha of soil surface) on May 14, 1980. Numbers of spruce budworm, spruce coneworm, degree of

defoliation, cone production, percentage of cones damaged by seed and cone insects, numbers of sound seeds per cone slice, numbers of female buds on a sample branch from the cone-bearing portion of the tree, and phytotoxicity were assessed in 1980 and 1981 on all experimental trees.

Treatments provided moderate to excellent protection of black spruce from spruce budworm defoliation. The liquid formulation was effective for budworm control in the year of treatment and persisted the year after treatment; granular carbofuran was not effective in the year of treatment, but it was effective the following year. Rapid and efficient uptake by the tree, to ensure control, is enhanced by use of a liquid formulation applied as a drench rather than incorporation of granules into soil. The toxicant appears to be equally effective at upper, middle and lower crown levels. Treatments did not provide increases in cone or seed yields nor did they protect cones from cone insect damage. A slight phytotoxic effect was evident 2 years after treatment with the liquid formulation at 10 g AI/cm DBH.

There is very little information available about the fate or environmental impacts of carbofuran used on forest soils but evidence suggests that it is persistent, hazardous and should be used cautiously and sparingly. The application rates used in this experiment were similar to those used in seed orchards of southern pines for control of seedbug. However, control of budworm defoliation on black spruce trees requires relatively large quantities of soil-applied carbofuran by comparison with mist blower-applied acephate for example. In addition, it does not appear to provide cone or seed protection of black spruce. Soil-applied carbofuran may not be economically or environmentally acceptable for use on black spruce seed orchards.

BIOLOGICAL CONTROL

All data relating to work on Beauveria bassiana (Bals.) Vuill., has been analyzed. Investigations and findings are summarized below.

Soil around the base of white spruce trees was sampled to determine the vertical and horizontal distribution of cone maggot puparia in a 12-year-old and a 22-year-old plantation. Most of the puparia were found within a 1 m radius of stems in the upper organic soil layers, but some also penetrated to the mineral horizon.

Small samples (25 g fresh weight) of organic soil were inoculated with conidia of B. bassiana to test efficacy of the fungus for control of cone maggots added to soil at two moisture levels (72 or 122 g water per 100 g oven-dry soil). Conidia were formulated with flour or talc carrier (5 g conidia per kg carrier) and mixed with soil at a rate of 25.1 mg conidia per 100 g oven dry soil. After incubation in

closed containers in the laboratory, average mortality of 42 per cent was observed with both formulations in drier soil; there were no differences between formulations. The fungus was not effective in the wetter soil. When larvae were added to reconstituted plantation soil treated with the equivalent of 3.56 kg conidia per ha and incubated under field conditions, mortality averaged 21 per cent for both formulations and again, there was no difference between formulations.

A report outlining a method for producing conidia on solid medium has been prepared. Large quantities of conidia can be obtained commercially, however, their effectiveness against seed and cone insects is unknown. The quality of such preparations can be determined by following the procedures and guidelines presented in the report; rates of application can then be adjusted by comparison with conidia of known quality produced by the method outlined.

EVALUATING LOSSES AND MONITORING INSECTS

Surveys of cone crop size and cone damage by insects in three habitat types of white spruce, were continued. This work will be terminated in 1985 and data will be summarized and analyzed for publication. Evaluation of sex-attractants for use as a monitoring tool for spruce seedmoth was also continued. Results to date are being analyzed for publication.

REPORTS

- Fogal, W.H. and S.M. Lopushanski. 1983. Stem injection of insecticides for control of white spruce seed and cone insects. IUFRO, Cone & Seed Insects Working Party Conference, Athens, Georgia. Pp. 157-167.
- Fogal, W.H. and S.M. Lopushanski. 1985. A test of foliar-applied systemic insecticides to prevent damage to white spruce cones by insects. Submitted to Forestry Chronicle.

FOREST GENETICS RESEARCH ACTIVITIES AT LAKEHEAD UNIVERSITY 1983-1985

P. Knowles, School of Forestry and Dept. of Biology
R.E. Farmer, School of Forestry
W.H. Parker, School of Forestry

*Lakehead University
Thunder Bay, Ontario
P7B 5E1*

Keywords: Larix laricina, Populus balsamifera, Picea mariana, geographic variation, isozyme analyses, provenance test.

The School of Forestry at Lakehead University now has several long term forest genetics projects underway:

Financed by an NSERC Forestry Development Grant a group of five faculty members (Rob Farmer, Peggy Knowles, Alastair Macdonald, Bill Parker, K.C. Yang) are investigating patterns of genetic variation in Larix laricina in northwestern Ontario. The work presently includes long-term provenance tests of material from 13 locations throughout northwestern Ontario, taxonomic studies, evaluation of phenotypic variation in wood properties, isozyme research, and studies of vegetative propagation, seed germination and shoot morphology. Gwen O'Reilly has been employed by the project since its inception to conduct the provenance tests, and Timothy Dickinson, who completed an NSERC post-doctoral fellowship in 1985, has assisted with taxonomic studies. Dennis Joyce will join the group as an NSERC post-doctoral fellow late in 1985. Dan Perry has been employed to supervise the isozyme laboratory commencing October 1985.

Rob Farmer, whose work on genecology of Populus balsamifera is supported by an NSERC operating grant, has recently established a long-term provenance test of clones from northern Wisconsin to Hudson Bay. This test is being supplemented by work on dormancy relations, assimilation rate, rooting characteristics and environmental preconditioning.

During the year 1983/84 P. Knowles initiated several projects focusing on the genetic structure of black spruce. A mating system analysis and inheritance/linkage study of the black spruce portion of the Matawin clonal seed orchard were conducted by a graduate student, John Barrett, in collaboration with Bill Cheliak in Petawawa. The genetic structure of a natural lowland stand was examined by genotyping and mapping a population of 500 trees. The extent of vegetative reproduction and spatial patterning of genotypes is presently being examined using spatial autocorrelation analyses. Finally, the project described in the last report comparing natural and artificially regenerated jack pine was completed and extended to include black spruce. A more detailed description of this project is listed below.

P. Knowles spent the year 1984/85 on study leave at the University of Alberta in association with Bruce Dancik and his post-doctoral fellow, Glenn Furnier. A mating system analysis of Larix laricina was conducted in the laboratory at the University of Alberta as part of the Lakehead NSERC development grant project on the genetics of larch. Finally, an investigation of the genetic structure of populations of Pinus albicaulis was initiated in collaboration with Bruce Dancik and Glenn Furnier.

COMPARISON OF ISOZYME VARIATION AMONG NATURAL STANDS AND PLANTATIONS: JACK PINE AND BLACK SPRUCE

Isozymes from needles of jack pine (Pinus banksiana) and black spruce (Picea mariana) were analysed to test differences among young stands, mature stands, plantations from seed-zone seed collections, a plus-tree clonal seed orchard, and a progeny plantation from the seed orchard. Analyses based on approximately 100 trees per population resolved 7 polymorphic loci for jack pine and 5 for black spruce. For intra-species comparisons, allelic heterogeneity tests indicated no differences between young stands and plantations from seed-zone seed collections. The black spruce clonal seed orchard and mature natural stands were genetically homogeneous. Allelic heterogeneity test and discriminant analysis indicated that the progeny plantation from the clonal seed orchard differed from other black spruce samples. It is proposed that non-random mating conditions in the clonal seed orchard altered allele frequencies of the resultant progeny plantation.

FOREST GENETICS AND TREE BREEDING
AT THE FACULTY OF FORESTRY
UNIVERSITY OF TORONTO
1984-1985

Louis Zsuffa and Robert Gambles

*Faculty of Forestry
University of Toronto
203 College St.,
Toronto, Ont., M5S 1A1*

A full time staff position was established in 1984 for teaching and research in forest genetics and tree breeding. A laboratory was equipped with capabilities in isozyme research, tissue and cell culture work, cytogenetics and computing. The research interests of the lab focus on genetics and breeding of Populus, Salix and Pinus subgen., Haploxydon; biotechnology in breeding; special problems in breeding (early testing criteria, studies into vegetative propagation and cloning, breeding for disease resistance, flower induction and seed crop improvement); and breeding for short rotation plantations in relation to production technology and biomass studies. Proposals for research funding were prepared in the areas of Populus and Salix genetics and species compatibilities, Salix hybridization, introduction and evaluation of hybrids in Populus, and white pine breeding for blister rust resistance. Funding support is being received from Ontario Renewable Resources Research Grant, Canada Department of Energy, Mines and Resources, Canadian Solifuels Inc. and from countries cooperating within the frame of the Forestry Energy Agreement of the International Energy Agency. Several of the submitted proposals are still in the course of consideration. Consulting contracts were received from Ontario Ministry of Natural Resources' Northern and Eastern Forest Regions for tree improvement problems related to intensive plantation management.

In 1984-85, undergraduate teaching was limited to a fourth year elective, one semester course. A second year, one semester core course was accepted as part of the new curriculum. This will be offered starting in 1986, in addition to the fourth year course.

Three Ph.D. students were enrolled in Forest Genetics in 1984-85 working on the following topics: (i) Genetic Variation in Populus balsamifera L. (Ms. K. Falusi), (ii) Genetic Relationships and Species Preferences in Populus (Mr. O.P. Rajora), and (iii) Species Compatibilities in Interspecific Hybridization of Salix (Mr. A. Mosseler). In 1985, a new Ph.D. student has started work on Introduction and Evaluation of Haploid and Di-haploid Lines in Populus, (Mr. M. Stoehr). A visiting scientist from Hungary (Dr. C. Matyas) holding a University Service of Canada fellowship, works as a research associate in forest genetics on the genecology of jack pine.

GRADUATE STUDENTS PROJECTS

(i) Genetic Variation in *Populus balsamifera* (Ms. K. Falusi)

The genetic structure of *P. balsamifera* along the Hudson Bay - Lake Erie corridor in Ontario was studied. The results to date indicate that balsam poplar exhibits strong growth responses to differences in photoperiod length. Isozyme data indicates that 94% of the genetic variability lies within populations, and only 6% is due to differences between populations. Taxonomic data analysis indicates that clones may be grouped, however, there are no north-south trends evident based on leaf characteristics.

(ii) Studies into Genetics and Hybridization of some *Populus* Species (Mr. O.P. Rajora)

The objective is to study the genetics and hybridization of *P. deltoides* Marsh., *P. nigra* L. and *P. maximowiczii* Henry.

Inheritance and linkage of isozymes was studied from the segregation patterns of isozyme variants in F-1 progenies of intraspecific and interspecific controlled crosses. Genetic similarities and divergence among species was estimated from allelic data and compared with morphological divergence of leaf characters. Interspecific pollen competition was studied by a pollen mixture technique.

Species, hybrids and clones could be identified based on their multi-locus genotypic organization. Linkage studies showed that the tested genes were located on different chromosomes. Species relationships were observed from allelic, morphological and pollen competition data.

(iii) Interspecies Crossability Relationships among Eastern North American *Salix* Species (Mr. A. Mosseler)

The objective of this study is to determine crossability relationships between willow species suitable for forest biomass production systems and to investigate interspecific pollen-pistil incongruity as a reproductive barrier to hybridization.

The pollen-pistil relationships were studied using fluorescence microscopy to monitor pollen tube development in order to determine the nature of the incompatibility relationships between species. To date the crossability relationships between species and the viabilities of their interspecific F1 hybrids have been determined. Field trials of 80 hybrid families have been monitored for phenological traits, and the fertility of many of the F1 hybrids has been assessed for the purpose of advanced generation breeding.

OTHER RESEARCH PROJECTS

(i) Selection and Evaluation of Salix Species for Biomass Production in Short Rotation Plantations

This study, lead by Canada and the Faculty, is financially supported by the Forestry Energy Agreement, International Energy Agency, in cooperation with Belgium, Finland, Ireland, Sweden and U.S.A.

The objectives are to collect worldwide, propagate, evaluate and distribute clones of species and hybrids of genus Salix which are of importance for biomass production in energy plantations according to the needs of the project participants. A special focus of the project is on selection and evaluation of North American Salix species, little studied up to now.

Collections have been made across North America and propagated at the Ontario Tree Improvement and Forest Biomass institute at Maple, Ontario for subsequent evaluation. Several hundred clones from across the North Central U.S.A., the Southeast U.S.A., Northwestern Canada and Ontario were shipped to Belgium, Ireland and Sweden during 1984 and 1985.

(ii) Refinement of Breeding Zones in the North Forest Region of Ontario (Dr. C. Matyas)

The objective of this study is to define genecological guidelines for the geographic transfer of seed and plant material of jack pine (Pinus banksiana Lamb.) and black spruce [Picea mariana (Mill.) B.S.P.]. The purpose is to optimize gains and identify risks incurred in the geographic transfer of planting stock in forest regeneration programs.

The analyses are based on information provided by Dr. C. W. Yeatman, Canadian Forestry Service, Petawawa National Forestry Institute on the genetic variation of seed sources at eight testing sites in Ontario. The modeling of this adaptive growth response over a series of environmental conditions is attempted. Seed transfer rules are formulated and prepared to replace the seed zones, based on ecological boundaries. This offers more flexibility in utilizing the adaptive potential of seed sources. The project is funded by the Ontario Ministry of Natural Resources.

COORDINATION OF INTERNATIONAL RESEARCH AND DEVELOPMENT PROJECTS

Forest genetics and tree breeding at the Faculty, with the assistance of Dr. R. Gambles, acts as the coordinator and secretariat of a programme group of the Forestry Energy Agreement, International Energy Agency. The programme group's task is the improvement of biomass growth and production technology in short rotation forestry. The

participants in this task are Austria, Belgium, Canada, Denmark, Finland, Ireland, New Zealand, Norway, Sweden, and U.S.A. The means are cooperative and coordinated R & D, transfer of technology and material, and exchange of information in the areas of genetic improvement, factors of growth, production technology and evaluation. The participating countries cooperate in planning and executing the task. The work is structured in activities, and activity leaders are from countries with the most expertise, strong support and funding. Results are in the form of reports and recommendations, handbooks and manuals, standardized procedures and evaluations, superior stocks, disease-free plant banks, evaluated root symbionts, and machine designs. The participants contribute to the work in-cash and in-kind.

PUBLICATIONS AND REPORTS

- Anderson, H.W., C.S. Papadopol and L. Zsuffa. 1983. Wood energy plantations in temperate climates. *Forest Ecology and Management*, 6: 281-306.
- Anderson, H.W. and L. Zsuffa. 1984. Genetically improved hardwoods as a potential energy source in Ontario. *Proc. ENERGEX, The Global Energy Forum, Regina, Saskatchewan, May 14-19, 1984*. 4 pp.
- Drysdale, D., D. Morgan and L. Zsuffa. 1982. Energy plantations - The present situation and plans for 1983-1988. In: *Proc., Joint PG"B" - PG"C" Meeting, Oslo, Norway, Oct. 11, 1982*. pp. 3-11.
- Gambles, R.L. and L. Zsuffa. 1984. Conversion and use of poplar and willow biomass for food, fodder and energy in North America. *International Poplar Commission, FAO, Rome. FO: MISC/84/15*. 154 pp. (mimeo).
- Ho, Rong H., A. Yesoda Raj and Louis Zsuffa. 1982. Poplar plants through anther culture. In: *Proc. 28th Northeastern Forest Tree Improvement Conference, Durham, New Hampshire, June 6-7, 1982*. pp. 294-300.
- Ho, R.H. and L. Zsuffa. 1984. Biotechnology in breeding for biomass production. In: *Proc. First Bioenergy Specialists' Meeting on Biotechnology, Waterloo University, Oct. 14-17, 1984*. pp. 70-82.
- Hubbes, M., R.S. Jeng and L. Zsuffa. 1983. *Melampsora* rust in poplar plantations across southern Ontario. *Plant. Dis.* 67: 217-218.
- Morgan, D., M. Neenan and L. Zsuffa. 1983. Forest biomass energy and its potential - Report No. 7/83, PG "B", IEA/FE. 16 pp.
- Mosseler, A. and L. Zsuffa. 1984a. Artificial interspecific hybridization in willows (*Salix* spp.) for forest biomass production. *IUFRO Pl.09.00 Symposium, Uppsala, Sweden, June 8-9, 1984*. 2 pp. (mimeo).

- Mosseler, A. and L. Zsuffa. 1984b. The genetic improvement of willows (Salix spp.) through artificial interspecific hybridization. International Poplar Commission, 17th Session, Oct. 1-4, 1984, Ottawa. 14 pp. (mimeo).
- Nilsson, P.O. and L. Zsuffa. Eds. 1983. Short rotation forest biomass - production technology and mechanization. Proc. IEA/FE Workshop, Oct. 11, 1982, Vettre, Norway. Swedish University Agricultural Sciences Publ. No 229. 69 pp.
- Raj, A. Yesoda, Rong H. Ho and L. Zsuffa 1982. In vitro propagation of forest trees by tissue culture. In Proc. 28th Northeastern Forest Tree Improvement Conference, Durham, New Hampshire, June 6-7, 1982. pp. 281-293.
- Rajora, O.P. and L. Zsuffa. 1984a. On genetic improvement of trees for social forestry in India. IUFRO Pl.09.00 Symposium, June 8-9, 1984, Uppsala, Sweden, 6 p. (mimeo).
- Rajora, O.P. and L. Zsuffa. 1984b. Interspecific crossability and its relation to the taxonomy of the genus Populus L. International Poplar Commission, 17th Session, 1-4 October, 1984, Ottawa. 11 pp. (mimeo).
- Saul, G.H. and L. Zsuffa. 1983. The use of small scions and bare-root stock in grafting white pine. Ontario Ministry of Natural Resources - Forest Research Note 34. 3 pp.
- Zsuffa, L. 1981a. The production of wood for energy. In: XVII IUFRO World Congress Proc., Division 3. Japan, 1981: 403-413.
- Zsuffa, L. 1981b. Poplars and willows in wood production and land use. Book review. The Forestry Chronicle, 57(5): 252.
- Zsuffa, L. 1982a. Biomass production for energy in Canada. In: Proc. 31st Session Executive Committee, International Poplar Commission, Casale Monferrato, Italy, 6-8 Sept. 1982. FO:CIP:BS/82/1: 1-4.
- Zsuffa, L. 1982b. The production of wood for energy. In: W.R. Smith, Ed., Energy From Forest Biomass, Academic Press. pp. 5-17.
- Zsuffa, L. 1983a. Forest tree improvement. Book review. The Forestry Chronicle, 59 (1): 41.
- Zsuffa, L. 1983b. Conifers: Morphology and variability. Book review. The Forestry Chronicle, 59 (5): 279.
- Zsuffa, L. 1983c. Forest biomass energy production for the north. In: Proc. 34th Alaska Science Conference, Arctic Division - AAAS, Whitehorse, Yukon, September 28 - Oct 1., 1983. 12 pp.

- Zsuffa, L. 1983d. Poplar breeding - tree improvement overview. Abstract. Fast Growing Hardwood Plantation Workshop, SUNY, School of Forestry November 15, 1983. 1p. (mimeo).
- Zsuffa, L. 1983e. Aspects of short rotation farming in Canada. Workshop on Development and Utilization of Lignocellulosic Raw Materials, Nuclear Research Establishment, Julich, West Germany, Nov. 21-22, 1983. pp. 101-129.
- Zsuffa, L. 1984a. Spacing and thinning with particular reference to the production of biomass for energy. Position paper 4.1. Planning Workshop for Asia on Forest Research and Technology Transfer, IUFRO/FAO, Kandy, Sri Lanka, 16-28 July, 1984. 23 pp. (mimeo).
- Zsuffa, L. 1984b. Biomass production for energy in Canada. In: Proc. International Poplar Commission, Casale, Monferrato, Italy. Sept. 6-10, 1982. FO:MISC/23; FOCIP:BS/82/1: 1-4.
- Zsuffa, L., 1984c. Genetics in intensive silviculture. Weyerhaeuser Lecture, Faculty of Forestry, University of Toronto, Nov. 17, 1983. pp. 12-32.
- Zsuffa, L. 1985a. Concepts and experiences in clonal plantations of hardwoods. In: Proc. 19th Meeting CTIA, Toronto, August 22-26, 1983. Part 2. pp. 12-25.
- Zsuffa, L. 1985b. Breeding fast growing hardwoods and white pines at the Ontario Tree Improvement and Forest Biomass Institute, Maple, Ontario, during 1981 to 1983. In: Proc. 19th meeting, CTIA, Toronto, August 22-26, 1983. Vol. I: 115-118.
- Zsuffa, L. and B. Barkley. 1984. The commercial and practical aspects of short rotation forestry in temperate regions: A state-of-the-art review. Position paper at Bioenergy 84 World Conference, Gothenburg, Sweden, June 18-21, 1984. In: Bioenergy 84, H. Egneus and A. Ellegard Eds., Elsevier Applied Science Publ., London. Vol I: 39-57.
- Zsuffa, L., and D. Morgan. 1982. The use of Populus and Salix biomass for energy - a survey of International Poplar Commission countries. In: Proc. 31st Session Executive Committee, International Poplar Commission, Casale Monferrato, Italy, 6-8 Sept. 1982. FO:CIP:BS/82/2: 1-6.
- Zsuffa, L. and D. Morgan. 1983. Forest biomass energy production - a five year retrospect of the work of programme group "B", IEA/FE. Report No. 6/83, PG"B", IEA/FE. 16 pp.
- Zsuffa, L., A. Mosseler and Y. Raj. 1984. Prospects for interspecific hybridization in Salix for Biomass Production. In: Ecology and Management of Forest Biomass Production Systems. Swedish Univ. of Agricultural Sciences Report 15. pp. 261-281.

- Zsuffa, L. and C.S. Papadopol. 1984. Salicaceae biomass systems: critical aspects of influencing production and economics. International Poplar Commission, 17th Session, Oct. 1-4, 1984, Ottawa. Ad-hoc Committee on Biomass Production Systems in Saliaceae position paper. 12 pp. (mimeo).
- Zsuffa, L., R.M. Rauter and C.W. Yeatman. Eds. 1985. Clonal forestry: its impact on tree improvement and our future forests. Proc. 19th Meeting CTIA, Toronto, August 22-26, 1983. Part 2. 235 pp.

SHELTERBELT TREE IMPROVEMENT PFRA TREE NURSERY 1983-85

W.R. Schroeder

Tree Nursery Division, PFRA
Agriculture Canada
Indian Head, Saskatchewan
S0G 2K0

Keywords: Provenance test, seed orchard, progeny test, shelterbelt, Populus, Pinus sylvestris, Pinus ponderosa, Larix sibirica, Fraxinus pennsylvanica.

Tree improvement has been carried out at the PFRA Tree Nursery for many years. Recently several new programs have been initiated. Current emphasis is on genetic improvement of shelterbelt species through plus tree selection, provenance testing, establishment of seed orchards and progeny tests. This work has focused on poplar (Populus species), Scots pine (Pinus sylvestris L.), Ponderosa pine (Pinus ponderosa var. scopulorum Laws.), Siberian larch (Larix sibirica Ledeb.) and green ash (Fraxinus pennsylvanica Marsh, var. subintergerrima (Vahl) Fern.).

POPLAR

The poplar improvement program has been underway at the Tree Nursery for the past 20 years. Poplars, because of their exceptionally fast growth, have been utilized extensively in farmstead shelterbelts in the Canadian prairies. However, most poplar plantings have tended to be short lived, often dying out or losing their effectiveness within 20 years after planting, due to drought, insect and/or canker damage. The major emphasis of the poplar improvement program, initially, was to screen large numbers of clones and assess their suitability for planting under prairie conditions. Over 50 different poplar clones and species have been evaluated with respect to survival, growth and resistance to disease. More recently, breeding work has been carried out between various promising clones and species to provide new selections with superior characteristics.

Numerous selections, based on hardiness, vigor, form, ease of propagation, as well as resistance to insects and disease have been made from open-pollinated populations of P. deltoides 'Walker' as well as controlled breeding populations that include P. 'Walker', P. 'Northwest', P. 'Saskatchewan', P. 'tristis', and P. 'serotina de selys'. Preliminary testing of selections has been carried out at the Tree Nursery with further testing at several locations throughout the prairies scheduled for 1986.

A new poplar clonal library was established in 1983 with a total of 64 clones represented. In addition, a breeding arboretum containing 33

poplar clones and hybrids was established in 1985.

A test planting of ten poplar clones in northeast Saskatchewan was evaluated in 1984 after 20 growing seasons. Five clones, *P. 'sargentii'*, *P. petrowskyana*, *P. 'volunteer'*, *P. 'tristis #1'* and *P. 'gelrica'* were severely infected with canker. There was no evidence of insect or mite damage and winter injury was restricted to frost cracks. Of the clones tested, *P. 'Northwest'*, *P. 'Brooks #1'* and *P. 'Walker'* were best suited for farmstead shelterbelt planting in the northeast region of Saskatchewan.

SCOTS PINE

The Scots pine improvement program includes provenance trials, progeny tests, and controlled matings as well as importation of Scots pine seed from its natural range. The objectives of these activities are to develop Scots pine with a vigorous upright growth habit, superior crown density and dark green foliage colour with good needle retention for farmstead and field shelterbelts in the prairie provinces. Various ecotypes and seed sources of Scots pine have been evaluated over the years. Without exception, seed obtained from the natural range of Scots pine in the Soviet Union has performed best under prairie conditions.

In 1962, a provenance test that included 28 Soviet Union seed sources was established at the Tree Nursery. Twenty year data for this planting indicated that seed of the 'balcanica' ecotype from Voronezh, Province of Orel and Smolensk, as well as the 'eniseensis' ecotype from Krasnoyarsk region and the 'altaica' ecotype from the Altai Mountains in southern Siberian were best adapted for shelterbelt planting in southern Saskatchewan.

The progeny of twenty seed sources from the 1962 provenance test were field planted in south central Saskatchewan. After five years, trees from the Province of Orel, Krasnoyarsk and Altai Mountain regions had the highest survival, and were the most vigorous.

In 1983, each tree in the provenance plantation was rated for vigor, needle retention, crown density, form and winter foliage colour, all of which are desirable shelterbelt characteristics. Twenty-four superior phenotypes were selected as the breeding population for the development of an improved strain of Scots pine. A variable tester scheme in which each successive female parent has one new tester added and one of the previous testers dropped was adopted for the breeding program. Data obtained from full sib progeny tests will be used to design a clonal seed orchard. As well, progeny will provide material for recurrent selection at a later date.

PONDEROSA PINE

A Ponderosa pine provenance test established at Indian Head in 1967 indicated that several Nebraska and South Dakota seed sources were

adapted to prairie conditions. Based on the results of this study a mass selection progeny test of three seed sources from Valentine and Ainsworth, Nebraska and Rosebud, South Dakota was established near Indian Head in 1983. Subsequent to this an open-pollinated progeny test consisting of 84 families from 12 seed source locations in Nebraska, South Dakota and Montana will be established at Indian Head in co-operation with the Great Plains Agricultural Council Forestry Committee. Seed has been collected and is currently being propagated for field planting in 1986.

SIBERIAN LARCH

A Siberian larch improvement program was initiated at the Tree Nursery in 1983. The seed source currently used at the Tree Nursery originated from the Ural Mountains in the Soviet Union. The plantation was established in 1905 and is now a mature stand. Numerous Siberian larch shelterbelts originating from the 1905 plantation were established on the Nursery in the mid 1970's. In 1983, superior trees were selected from these shelterbelts and vegetatively propagated for inclusion in a clone bank for future breeding programs. In 1983 Siberian larch seed of Soviet origin was obtained from the Canadian Forestry Service National Seed Bank at Petawawa. The seed was propagated and seedlings planted in shelterbelts at various locations in Saskatchewan. Currently attempts are being made to obtain seed from the native range of Siberian larch in the Soviet Union so that a base population for future breeding programs with this specie can be established.

GREEN ASH

Green ash is a moderately fast growing, deciduous tree that is utilized extensively in the prairies for field and farm shelterbelts. In 1985 a green ash tree improvement program was initiated by the Investigation Section of the Tree Nursery. The program will involve:

- (1) Selection of superior phenotypes of green ash from its natural range in the prairie provinces and northern great plains of the United States,
- (2) Vegetative propagation of the superior phenotypes and establishment of a clone bank,
- (3) Progeny test the selected phenotypes at various locations in the prairie provinces,
- (4) Recurrent selection for increased genetic gains in second generation seed orchards.

In addition, seed will be collected from representative stands throughout the natural range of green ash in the prairies and provenance trials established at various locations in Saskatchewan and Manitoba. Seed collection and plus-tree selection was initiated in 1985, whereas provenance testing is scheduled for 1988.

PUBLICATIONS

- PFRA Tree Nursery. 1983. Propagation Projects. Annual Report, Tree Nursery Division, Agric. Canada. Indian Head, Sask. p. 10-23.
- PFRA Tree Nursery. 1984. Propagation Projects. Annual Report, Tree Nursery Division, PFRA, Agric. Canada. Indian Head, Sask. (In Press).
- Schroeder, W.R. 1984. Development of cold hardiness through tree improvement. In Proc. 36th Ann. Mtg. For. Comm., Great Plains Ag. Council. Watertown, South Dakota. Publ. No. 112 p. 116-120.

PRINCE ALBERT PULPWOOD
TREE IMPROVEMENT UPDATE

D.M. Roddy

*Prince Albert Pulpwood
P.O. Box 1720
Prince Albert, Saskatchewan
S6V 5T3*

Keywords: Jack pine, white spruce, clonal orchard, controlled crosses, progeny tests, wood density.

An update on the jack pine tree improvement program, started in 1978, and the more recent white spruce program, started in 1982, are given below. Each program has now yielded the first seeds to be planted operationally, giving us some very concrete results, and putting a new emphasis on cone and seed processing equipment and techniques.

THE JACK PINE PROGRAM

Seed Orchard

The establishment of this clonal orchard was completed with the "fill-in" grafting of 1985. There are now 7.2 hectares of orchard, two hectares of which have been in limited cone production for two years, while cone production in the younger 5.2 hectares is just beginning.

A drip irrigation system was installed in the orchard in 1984, enabling us to water when necessary, add fertilizers through the system, and help control soil PH levels by irrigating with acidified water.

Cone Crops

The first cone crop was harvested from the oldest section of orchard in 1983. As there were really only three orchard clones producing pollen at the time, the pollen parent of those seeds is probably pretty much limited to those three clones. In all, 20,000 viable seeds were collected.

The second cone crop, harvested in 1984, will yield approximately 25,000 viable seeds. At the time these seeds were being formed, pollen from two selected trees in natural stands were brought in to supplement the small quantity of orchard pollen. This was also done for the third cone crop, to be harvested in the fall of 1985.

These three crops will be raised in the Saskatchewan government greenhouses in 1986 for use in our operational plantings.

Controlled Crosses

The first controlled matings were done in the spring of 1985, to get information on the general and specific combining ability of the orchard clones. A six tree, half diallele pattern was used, with the timing and amount of flowering determining which clones were used in this first diallele.

Progeny Tests

The first phase of selecting plus trees and establishing progeny trials to test the growth of seeds from them, is now complete. Five year measurements on the oldest of these trials will be made in the fall of 1985.

Seed Trials

Trials to test the growth of selected tree seed versus that of average nursery seed were outplanted in 1984 to get some early, rough estimates of gain from the tree improvement program.

THE WHITE SPRUCE PROGRAM

Seed Orchard

Over half of the clonal orchard is now established, with just a few more super trees to be added and some fill-in grafting to be done in 1986. Many of the grafts were already producing large numbers of cones in 1985 (one small graft had 44 cones on it) which were picked off to promote vegetative growth.

The drip irrigation system in the jack pine orchard was expanded to include the white spruce orchard in 1985.

Selection and Progeny Testing

The selection of plus trees was started in 1984, and, as it was a light seed year, cones and wood samples were collected from these trees in the fall. This enabled us to seed progeny tests of this first group of selections in 1985, for outplanting in 1986.

Cone Collection for Operational Planting

Surplus seeds, not needed for the progeny testing of the plus trees, were seeded in the Saskatchewan government greenhouses in 1985 for use in operational planting in 1986.

Seed production areas will be thinned in 1985 so that an interim supply of seeds can be harvested from them in good seed years, until the orchard itself is producing all the required seed.

Wood Density Studies

The testing of wood density, or specific gravity, is again being done for all selected trees.

Tests done to date show that juvenile wood of white spruce, (defined as the first 10 rings from the pith), has a higher specific gravity than the mature wood. Faster growing trees, harvested at a younger age when there is a higher proportion of juvenile wood in the bole, will therefore bring about an increased specific gravity.

A very strong relationship has also been found between the specific gravity of an 11 mm core of wood taken at breast height, and the specific gravity of the whole tree. In the future, the specific gravity of selected trees can be estimated from a core of wood only, eliminating the need to take wood discs, and enabling non-destructive sampling of trees we wish to preserve.

GENETICS AND TREE IMPROVEMENT PROGRAM
ALBERTA FOREST SERVICE, 1983-1985

N.K. Dhir, J.M. Schilf, and A. Yanchuk

*Reforestation and Reclamation Branch
Alberta Forest Service
Edmonton, Alberta
T5K 2M4*

Keywords: forest genetics, tree breeding, genetic improvement, provenance studies, species testing, seed orchards, white spruce, lodgepole pine.

This report summarizes the progress of the Alberta Forest Service (A.F.S.) genetics and tree improvement program for the period 1983-1985.

PROGRAM DEVELOPMENT

The genetics and tree improvement facilities at Pine Ridge were expanded for planned enhancements in A.F.S. and joint A.F.S./industry program. The expansion provides much needed additional greenhouse space and a new laboratory for pollen and wood quality assessment work.

As part of the cooperative tree improvement program with the forest industry, a general seed orchards agreement was finalized. It commits the industry to develop and operate its own seed orchards, whereas A.F.S. is committed to provide developed land for industry seed orchards.

A comprehensive review of Alberta's genetics program was completed by an outside consultant (Dr. B. Zobel). It provided an excellent opportunity to examine the overall approach, progress to date, and to reassess future direction. The opportunities for increased participation in the provincial program by the forest genetics staff of the University of Alberta was thoroughly reviewed by the consultant. As a result, A.F.S. and Industry (Alberta Forest Products Association) agreed to support and partly fund new initiatives by the University to expand its forest genetics staff and program in support of the provincial program.

GENETIC IMPROVEMENT

Assembly of Breeding Stock

Selection of superiors trees to provide base material for selection and breeding continued with the efforts primarily directed at

white spruce for A.F.S. responsibility projects. During the report period a total of 80 white spruce trees were selected. In addition, nine lodgepole pine trees were selected jointly by A.F.S. and Blue Ridge Lumber Ltd.

Starting in 1984, all selected superior trees are assessed for wood quality parameters. Large (11 mm) cores are collected from each tree and these are analyzed for wood density and fibre length. This information will be used for relating parent-progeny performance and for roguing seed orchards.

Progeny Testing

Eight lodgepole pine open pollinated half-sib family field trials have been established so far under the cooperative tree improvement program involving A.F.S. and Industry (B.C. Forest Products, Blue Ridge Lumber, Canadian Forest Products, Procter and Gamble Cellulose). Yearly maintenance of these trials continued as required. The four field trials established as part of breeding region B1 genetic improvement project were assessed for survival and sixth year height. Total number of families in these trials vary from 272 to 400. Mean height for the four test sites varied from 40 to 70 cm and family means on individual sites showed a variation of approximately 60 to 140 percent from the plantation mean.

Development of test sites for genetic improvement of white spruce in breeding region D was completed. Four open pollinated half-sib family field trials will be established on these sites in the spring of 1986 using 3-year old transplant stock from 150 families.

Nursery seeding of white spruce for planting stock production for open pollinated progeny tests in breeding region G was completed. These tests will be cooperatively established by A.F.S., Procter and Gamble Cellulose and Canadian Forest Products.

Seed Orchards

Considerable time was spent on planning seed orchards network for genetic improvement projects of A.F.S. and Industry. Many locations and parcels of land were considered and investigated for various seed orchards development. Several locations were finalized and land banking started with an objective to provide sufficient land for proposed orchard developments and future expansions.

A.F.S. purchased 130 hectares of agricultural land near Grande Prairie to be used for development of three separate seed orchards by Industry in that region. Land search and acquisition was completed for a lodgepole pine seed orchard site near Whitecourt and site development started. Plans were finalized to consolidate A.F.S. responsibility for white spruce seed orchards at the Pine Ridge Forest Nursery complex. Three orchards are presently being considered. These will be spaced approximately 1 km apart to provide isolation from pollen contamination.

Outplanting of white spruce seedling seed orchard for breeding region D was completed at Pine Ridge in 1983. It is 2.5 hectares in size. The planting stock consisted of one-year old seedlings grown in large containers (4.5 litre size) in the greenhouse under accelerated growth growing regime.

A small Siberian larch seed orchard was established at Pine Ridge in 1985. This is also a seedling seed orchard and was started with large container stock produced from seed obtained from a seed orchard in Finland.

The technical plan and design of field layout for the lodgepole pine seed orchard, breeding region B1, was developed and provided to the participants. This will be a 14.7 hectare seedling seed orchard and is scheduled to be planted in 1986. It is being jointly established by Canadian Forest Products and Procter and Gamble Cellulose on AFS-owned land near Grande Prairie.

Stock production for three white spruce clonal seed orchards (breeding regions E, G and H) is in progress. Sites for these orchards have already been identified and planting is scheduled for 1987-89.

GENETICS & TREE IMPROVEMENT RESEARCH

Species Testing

The first assessment of Siberian larch outplantings established in 1977 and 1980 was completed. The results provided preliminary confirmation of good reforestation potential with this species. Mean tree heights in two 8-year old plantings in northern Alberta was 3.0 m and 1.7 m. Two other 6-year old plantings showed mean tree heights of 2.3 m and 1.4 m.

A Ponderosa pine seed source trial established in 1979 at Pine Ridge with northern high elevation seed sources was completely winter killed in 1984. Several sources had shown good growth and winter hardiness. The winter of 1984 was considerably colder than the past several winters. In another pine species comparison trial, also located at Pine Ridge, red pine survived the 1984 winter well with only 14 percent of the trees showing winter damage.

A field trial of red maple and sugar maple of more northern seed origins from Ontario was outplanted. Container stock of a collection of northern European species (Picea abies, Larix decidua, Larix siberica, Pinus sylvestris and Betula pendula) was also outplanted in nursery transplant beds prior to field outplanting.

Provenance Studies

Three additional field trials were added in 1984 to the Alberta-wide white spruce provenance trials started in 1980. This brought the total number of trials established to 15 and completed the series. Two

plantings established in 1980 were measured in the fall of 1985 for 10-year results (after 6 growing seasons in the field). In both cases 'local' and 'non-local' groups of seed sources showed similar performance. The trees in these plantings are still less than 1 metre tall. It was concluded that the first assessment of similar trials in the future should be done at 12 years of age.

Two Scots pine seed source trials containing 25 seedlots of U.S.S.R. origin were assessed for 5-year survival and height. Survival of all seed sources at both locations was above 90 percent and no winter damage occurred in any of the sources. Large seed source differences were found for height growth. At one location (Footner Lake) the best source showed height growth similar to local lodgepole pine. At the second location (Pine Ridge) the best Scots pine seed sources showed 40 percent better height growth than lodgepole pine.

Field testing of a U.S.S.R. collection of Siberian larch seed sources provided by the Petawawa National Forestry Institute was started. Four field trials were established in 1985. These trials contain U.S.S.R. seed sources of Siberian larch as well as 'local' Siberian larch seedlots collected from amenity plantings at several locations in the Prairie provinces and a Raivola Siberian larch seedlot.

A study was started to evaluate the variability and comparative performance of jack pine-lodgepole pine population complex in Alberta. A collection of 37 seedlots was outplanted in 1985 at four locations in central and northern Alberta. The seedlots used represent geographic sampling of pure jack pine and lodgepole populations, introgressed populations of both species, and 'outlier' lodgepole pine populations.

Provenance testing of black spruce and tamarack was started. Province wide seed source collections of both species were sown in nursery experiments. Field outplanting of this material will be done in 1987 to establish three tamarack and one black spruce test plantings. Further seeding will be done in 1986 and 1987 to provide planting stock for additional plantings of both species.

Genetic Studies

Nursery evaluation of an experiment consisting of 150 open pollinated families of white spruce from central Alberta was concluded. Genetic variability and relationships for 1, 2 and 3 year seedling heights were studied. Heritability values for the three height measurements were very similar (0.46-0.49). Genetic correlations among 1 and 3 year height and 2 and 3 year height measurements were 0.57 and 0.94 respectively.

A collection of Siberian larch materials developed in 1978-79 as part of a controlled crossing program using trees growing in amenity plantings in Alberta was outplanted in five areas in central and northern Alberta. The material consists of biparental crosses, selfs and one pollinated half-sib seedlots. Very little is known about genetics of

Siberian larch. This study is expected to develop information necessary for genetic improvement of this species in Alberta as well as identify some promising genetic stock for practical breeding.

Alberta is currently divided into nine breeding regions for the purpose of practical tree breeding. There are five breeding regions for white spruce and four for lodgepole pine. These are presumed to be conservatively delineated. A series of research studies are planned to develop the necessary genetic information to objectively examine breeding regions and make appropriate changes. The first study for this purpose was already started. It covers the three white spruce breeding regions located in northwest Alberta. Greenhouse seeding was completed to produce planting stock for reciprocal testing of materials to be established in field trials in the three regions in 1988. A total of 127 seedlots were used for nursery seeding. These systematically sample the area involved in a nested treatment design consisting of regions, subregions, stands and individual trees.

Seed Production and Related Studies

An extensive flowering and seed production monitoring program was started in 1979 to develop information on these variables for seed orchard planning. Also, several experiments were started to study the effectiveness of selected treatments on enhancing flowering and seed production and to develop experience in establishing and managing seed orchards. Considerable valuable information has been accumulated to date, particularly during the past two years. Of particular interest were the following findings:

1. The Pine Ridge Forest Nursery site located 140 km east of Edmonton has proven to be a good location for seed orchards of all species of current interest to the tree improvement program. Both male and female flowering has occurred on white spruce, black spruce, tamarack, jack pine, lodgepole pine, Siberian larch and Scots pine seedling material starting as early as 2-6 years of age.
2. Accelerated growth treatment has proved to be very effective in inducing early and enhanced flowering in white spruce and lodgepole pine. The treatment involves growing of seedlings under 24 hour photoperiod and a heavier application of nutrients for eight months in the greenhouse prior to outplanting.

Flowering and seed production of white spruce grafts were studied in an experiment established at four climatically diverse locations (Vernon in British Columbia, Brooks in southern Alberta, Pine Ridge in central Alberta, and Grande Prairie in northern Alberta). Grafts were made in 1979 and outplanted during 1980-1982. Data from 1983, 1984 and 1985 showed Brooks to be the best location for flowering and cone production. The mean number of female flowers per ramet averaged over the three years gave the following values: Brooks = 4.5; Vernon = 3.2; Pine Ridge = 2.6; Grande Prairie = 0.3.

Two additional studies were started. The first study consists of a small clonal white spruce research seed orchard which includes grafts made on potted rootstock in the greenhouse as well as grafts made on rootstock trees already established in nursery transplant beds. The second consists of a strip-plot design spacing trial designed to determine the best within-row and between-row spacing combinations for white spruce seed orchards.

JACK PINE SEED ORCHARDS FOR MANITOBA 1983-1985

J.I. Klein

*Northern Forest Research Centre
Canadian Forestry Service
5320 - 122 Street
Edmonton, Alberta
T6H 3S5*

The genetic improvement program for jack pine (*Pinus banksiana* Lamb.) for Manitoba and Saskatchewan, initiated in 1976, seeks to provide genetically superior planting stock to cooperators. Superior genotypes are identified by assessment of open-pollinated tests, while a clone bank is under development to provide propagation materials of selected families (Klein 1982).

Major activities during the past two years included selection of superior progeny trees within selected eastern breeding district families (Klein 1983), establishing a computer-based records management system for the clone bank, 10-year measurement and preliminary analysis of the western breeding district family test, staffing actions, clone bank development, and planning of a program to develop jack pine seed orchards for Manitoba under the Canada-Manitoba Forest Renewal Agreement. A few highlights of the seed orchard development program will be reported here. New resources for this program include two person-years of additional staffing for each year of the agreement, a new tree improvement greenhouse complex, and funding for operations.

STAFFING

Implementation of the seed orchard program will be the responsibility of Mr. Albert Nanka, who has 15 years experience in the jack pine genetics program of the Northern Forest Research Centre. Mr. Paul Chapman, formerly of Sault Ste. Marie, Ontario has replaced Mr. Nanka as forest genetics research technician in Edmonton. Mr. Chapman's extensive experience related to forest nurseries and forest planting will be valuable in the research program. Another person-year or more allocated to the seed orchards program is being used to hire seasonal workers.

GREENHOUSE COMPLEX

Construction is expected to begin shortly on a tree improvement greenhouse complex at Pineland Forest Nursery near Hadashville, Manitoba. The complex will consist of one 300 m² greenhouse for Canadian Forestry

Service (C.F.S.) use, another for the Manitoba Forestry Branch (M.F.B.), shared headerhouse with propagation, laboratory, and office facilities, attached to the greenhouses, and a shade house. The C.F.S. greenhouse will be used primarily to rear jack pine trees for seed orchards, and secondarily for research on vegetative propagation of jack pine. The design team for the complex consisted of Public Works Canada engineers, Mr. Nanka, and Ms. Donna Gillis of M.F.B.

EASTERN BREEDING DISTRICT SEED ORCHARD

Based on measurement of height and diameter, and scoring of stem quality at 10 years from planting, the five best progeny trees were selected in each of 40 selected families (out of 209 tested) to serve as parents of seed orchard trees. Mating was done in a single-pair design. Pollen was bulked and seeds will be bulked among trees within families to produce double first-cousin families for the seed orchard. Mating was attempted in 1984 but flowering was poor that year. In 1985, with good flowering and one practice run, results appear to be entirely satisfactory. Site development will be done in 1986 at the C.F.S. property near Winnipeg. Planting is scheduled for 1987 and 1988. With accelerated greenhouse rearing, the first cone harvest is expected no later than 1995.

PUBLICATIONS AND REFERENCES

- Klein, J.I. 1982. Establishment and first results of a jack pine breeding program for Manitoba and Saskatchewan. Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta. Inf. Rep. NOR-X-247.
- Klein, J.I. 1983. Selection for eastern Manitoba jack pine seed orchards based on 10-year family test results. Environ. Can., Can. For. Serv., North. For. Res. Cent. Edmonton, Alberta. For. Manage. Note 24.
- Klein, J.I. 1984. Genetic improvement of jack pine for the prairie provinces, 1981-1983. Pages 150-153 in Proc. 19th Meet. Can. Tree Improv. Assn., Part 1.

FOREST GENETICS ACTIVITIES AT THE UNIVERSITY OF ALBERTA 1983-1985

Bruce P. Dancik

*Department of Forest Science
The University of Alberta
Edmonton, Alberta
T6G 2H1*

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 early evaluation of progeny performance, quantitative inheritance and molecular genetics.

MATING SYSTEMS OF CONIFERS

Daniel J. Perry completed his M.Sc. study of the mating system of three widely separated lodgepole pine (Pinus contorta var. latifolia Engelm.) populations in the foothills. Population multilocus outcrossing rate estimates ranged from 0.926 to 0.983. There were no significant differences in outcrossing rates among stands, among pollination years within stands, or among crown positions within trees. However, a tentative temporal trend was suggested in which selection against inbred seed is occurring over time in the seed pool retained on the tree. Significant heterogeneity was found among single-tree multilocus outcrossing estimates in one stand. A paper from this study has been submitted for publication.

Mr. Albert Sproule is continuing his Ph.D. study of the mating system of black spruce (Picea mariana (Mill.) B.S.P.). Preliminary estimates suggest a mixed mating system with a significant proportion of inbreeding ($t \approx 0.7$). Mr. Willi Fast is writing his M.Sc. thesis on a study of the mating system and possible pollen contamination in a Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) seed orchard near Nanaimo, B.C. (in cooperation with Dr. Ralph Bower, Macmillan Bloedel). Ms. Nola Daintith has begun a study of polyembryony in Douglas-fir. Dr. John Owens, University of Victoria, is

helping guide the project, and Dr. Joe Webber, B.C. Ministry of Forests, and MacMillan Bloedel have provided important aid.

Completed studies by Cheliak (Cheliak et al. 1984, 1985) and King (King et al., 1984) have been published. The mating system studies have been funded by NSERC operating and forestry development grants, the CFS, MacMillan Bloedel Ltd. and the Alberta Forest Service.

POPULATION STRUCTURE STUDIES

Gregory Lee completed his M.Sc. thesis on genetic variability and population structure of three lodgepole pine populations along each of three elevational transects in Alberta. Seventy-six alleles were scored at 29 enzyme loci. Mean expected heterozygosity ranged from 0.130 to 0.193 over the nine populations. The percentage of polymorphic loci ranged from 58.6 to 86.2. The mean number of polymorphic loci decreased from north to south, while the high elevation populations were the least polymorphic. A heterogeneity chi-square analysis indicated that there was significant heterogeneity among all nine populations, among the three transects, and among the elevations sampled. Most (95.3%) of the detected genetic variability resided within populations. Little among-population differentiation has occurred, but there is evidence of family structure within populations, as illustrated by high levels of inbreeding.

Dr. Glenn Furnier, Dancik, and Dr. Peggy Knowles continued a study of population structure of the high elevation conifers Pinus flexilis James and P. albicaulis Engelm. Ph.D. student Agnes Vanende has begun a study of the chemotaxonomy of the Populus balsamifera L. - P. trichocarpa Torr. & Gray complex, under the joint direction of Dancik and Keith Denford (Botany). Ph.D. student Chang Yi Xie began a study of the population structure of Thuja orientalis L. Knowles, Furnier, and Dancik also cooperated on a study of population structure of eastern larch (Larix laricina (Du Roi) K. Koch).

These projects were supported by the NSERC Forestry Development Grant and the CFS.

MOLECULAR GENETICS OF CONIFERS

Joyce Kenny is nearing completion of her M.Sc. work. A 1.65 Kb HindIII restriction fragment containing the carboxyl portion of a lodgepole pine actin gene has successfully been cloned into the vector puc 19. This recombinant clone was obtained by screening a partial plasmid library consisting of HindIII endonuclease restriction fragments sized

from 0.5 - 7.0 Kb cloned into puc19 using pSA3, a soybean actin gene as a probe. Sequencing data using Sanger's method suggest that the portion of pine actin obtained shares a high degree of homology with other actins, such as *Drosophila*, soybean, and maize. The extent of the cloned actin fragment PAct1 is roughly 650 - 700 nucleotides. A manuscript on the isolating of DNA from conifers, prepared by Kenny, Zack Florence, and Dancik, has been submitted for publication.

Dr. Glenn Furnier also has initiated some work with lodgepole and jack pine (*P. banksiana* Lamb.) DNA in cooperation with Mr. David Wagner, University of California Davis. Furnier also has begun a study of chloroplast DNA of the *Cembrae* section of *Pinus*.

EARLY EVALUATION OF PROGENY PERFORMANCE

Ms. Dianne Williams completed her M.Sc. study of early juvenile performance of black spruce families grown under optimum conditions. The study was conducted in cooperation with Dr. R.P. Pharis of the University of Calgary, and funded by the CFS. Seed from sixteen controlled crosses of black spruce (*Picea mariana* (Mill.) B.S.P.), outplanted in 1973 and 1976, was utilized in a greenhouse experiment from which juvenile:mature correlations were prepared. Results of the field test alone indicated highly significant family effect for height, diameter, and volume from four through ten years from outplanting. Moreover, 'slow' families ranked consistently at the bottom, and were statistically distinct from the 'fast' families. This enables family selection (for ten-year height) to be made as early as four years from outplanting. Weekly application of GA_{4/7} beginning at 4.5 months influenced five- and six-month volume, six-month branch length, all dry weight measurements, but not height growth. Simple correlations between field and greenhouse results indicated that height and dry weight measurements in the greenhouse were highly correlated with height at four to ten years in the field, as well as ten-year volume. Differences in levels of endogenous GAs can be identified at the family level; this variation may be useful as a selection tool. Trends of higher endogenous GAs in 'fast' growing families were suggested by the data. A manuscript is being submitted. Williams, Pharis, and Dancik are continuing this work with other species.

QUANTITATIVE INHERITANCE

Two studies of quantitative inheritance of growth and wood characters are nearing completion. Mr. John King is investigating several traits of full-sib families of Douglas-fir at Cowichan Lake, B.C., for his Ph.D. thesis. Mr. Alvin Yanchuk is investigating several properties of families of

lodgepole pine 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 Adjunct Professor 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.

PUBLICATIONS AND REFERENCES

- Barnes, B.V., and B.P. Dancik. 1985. Characteristics and origin of a new birch species, Betula murrayana, from southeastern Michigan. *Can. J. Botany* 63:223-226.
- Cheliak, W.M., K. Morgan, B.P. Dancik, C. Strobeck and F.C.H. Yeh. 1984. Segregation of allozymes in megagametophytes of viable seed from a natural stand of Pinus banksiana. *Theor. Appl. Genet.* 69:145-151.
- Cheliak, W.M., B.P. Dancik, K. Morgan, F.C.H. Yeh and C. Strobeck. 1985. Temporal variation of the mating system in a natural population of jack pine. *Genetics* 109:569-584.
- Florence, L.Z., and F.D. Cook. 1984. Asymbiotic N₂-fixing bacteria associated with three boreal conifers. *Can. J. For. Res.* 14:595-597.
- Govindaraju, D.R. 1984. Mode of colonization and patterns of life history in some North American conifers. *Oikos* 43:271-276.
- Govindaraju, D.R. 1984. Path analysis of changes in quantitative characters in jack pine during self-thinning. *New Phytologist* 97:691-696.
- King, J.N., B.P. Dancik, and N.K. Dhir. 1984. Genetic structure and mating system of white spruce (Picea glauca) in a seed production area. *Can. J. For. Res.* 14:639-643.
- Pollack, J.C., and B.P. Dancik. 1985. Monoterpene and morphological variation and hybridization of Pinus contorta and P. banksiana in Alberta. *Can. J. Botany* 63:201-210.
- Yeh, F.C., W.M. Cheliak, B.P. Dancik, K. Illingworth, D.C. Trust, and B.A. Pryhitka. 1985. Population differentiation in lodgepole pine, Pinus contorta ssp. latifolia: a discriminant analysis of allozyme variation. *Can. J. Genet. Cytol.* 27:210-218.

TREE IMPROVEMENT AND ASSOCIATED RESEARCH
BRITISH COLUMBIA MINISTRY OF FORESTS, 1983-1985

Director
K. Illingworth

*B.C. Ministry of Forests
Research Branch
1450 Government Street
Victoria, B.C.
V8W 3E7*

Tree improvement in the British Columbia Ministry of Forests is divided administratively between the Research and Silviculture Branches. Research Branch is responsible for identifying genetically improved breeds through selection, testing, and propagation, and for physiology research supporting tree improvement. The Silviculture Branch is responsible for determining operational requirements for improved seed and for the establishment and operation of seed orchards to match operational demands.

Coordination of in-house programs is achieved through daily working communications, committees, and technical reviews. The provincial priorities established by the Ministry are integrated in cooperation with the forest industry through the Coast Tree Improvement Council (CTIC), and the Interior Tree Improvement Council (ITIC). At the operational level, part of the work is achieved through company participation financed through Section 88(1) - Credit to stumpage - of the Forest Act. More detailed information on organization and program highlights were published in previous proceedings (Illingworth 1982 and 1984).

The following reports provide updates on individual components of the Ministry program.

REFERENCES

- Illingworth, K. 1982. Tree breeding and Associated Research, British Columbia Ministry of Forests. 1979-1981, In Proc. 18th Mtg. Can. Tree Impr. Assoc. Part 1:38-41.
- Illingworth K. 1984. Tree Breeding and Associated Research, British Columbia Ministry of Forests 1981-1983, In Proc. 19th Mtg. Can. Tree Imp. Assoc. Part 1:173-176.

LODGEPOLE PINE BREEDING IN THE BRITISH COLUMBIA INTERIOR 1983-1985

Michael R. Carlson

*B.C. Ministry of Forests
Research Branch
Kalamalka Research Station & Seed Orchard
3401 Reservoir Road
Vernon, B.C.
V1B 2C7*

Keywords: Lodgepole pine, provenance testing, progeny testing, progeny testing efficiencies, inter-population crossing, rooted cutting.

Interpretation of 10-year provenance trial results, drafting of a breeding strategy, establishment of progeny tests for three of seven high productivity breeding zones, and associated research to improve progeny testing efficiencies were the top-priority activities for this period. Also initiated were studies involving long-term inbreeding effects, intra- and inter-provenance cross combining abilities, rooted cutting/seedling growth comparisons, and hedge orchard management techniques.

HISTORY

The breeding of lodgepole pine in the British Columbia Interior had its unofficial beginning in the late 1960's, as plans were laid for a range-wide sampling of the species for an extensive series of provenance tests in both British Columbia and various parts of northern Europe. As will be described here, our interpretation of 10-year growth and form data for 154 sources (54 from the British Columbia Interior), planted on as many as 40 wide-ranging sites each, has had a significant impact on the overall breeding strategy adopted for lodgepole pine.

Officially, the breeding of lodgepole began in 1975 with the hiring of Nick Wheeler as the breeder. Between 1975 and 1978, four large breeding zones were recognized and nearly 600 parent-tree selections, approximately evenly distributed across zones, were made. Between 1978 and 1983, the program was under the supervision and care of various B.C. Forest Service staff. During this time, more selections were made (approx. 500), and clone banks and parent-tree seed inventories expanded. In 1983, the author was lured to assume lodgepole pine breeding responsibilities.

Throughout 1983, 10-year measurements were made for the 154 provenances under test. Analysis and interpretation of these data were summarized by Ying *et al.* (1985). Lodgepole pine from the British Columbia Interior appears to be a "generalist" with little genotype x environment interaction at the provenance level. Several low- to mid-elevation sources were identified that exhibited high productivity over a wide range of growing conditions. A breeding strategy for the species evolved and was implemented in early 1984. This strategy recognizes 16 interior breeding zones for lodgepole pine based upon interpretations of biogeoclimatic data and insights gained from provenance trial analyses.

BREEDING STRATEGY

Recurrent selection programs are under way in seven of the 16 zones. Zones of highest priority are those of demonstrated high productivity for pine and for large estimated future seedling demands. The basic strategy for these programs calls for the immediate wind-pollinated family testing of approximately 300 parent-trees per zone. Half the trees to be tested in a zone are within-zone selections (approx. 150). The other half come from: 1) selections made in or near provenances of demonstrated growth potential; and 2) zones adjacent to the zone of concern. These tests are designed to screen candidate trees for breeding and production populations and to estimate genotype x environment interaction at the wind-pollinated family level. As of June, 1985, 10 progeny sites have been established across three zones and a total of more than 500 wind-pollinated families have been grown and outplanted. Plans call for the establishment and planting of a total of 19 sites across seven zones, with a total of approximately 1200 trees under test by June, 1988.

In addition to these progeny testing activities, parent-tree selection continues with 250 trees being selected this year in the north-central Interior. With these additional parent trees, all first generation selections for the seven high priority zones will have been made.

APPLIED RESEARCH

Research activities initiated during this period have focused on: 1) improving progeny testing efficiencies; 2) effects of mild inbreeding and intra- and inter-populational crossing; and 3) rooted-cutting and hedge orchard technologies. Early progeny evaluation and increasing design precision are the goals of three studies established in 1984/85.

A long-term inbreeding effects study will help to quantify the tradeoffs involved in retaining related individuals in production populations. Intra- and inter-population cross performance comparisons will aid in "fine-tuning" a long-term breeding strategy. Rooting techniques, hedge management, and cutting/seedling performance trials will provide information necessary to making decisions about the utility of rooted pine cuttings in reforestation. In addition, a tissue culture project using full-sib family materials is under way at the University of British Columbia, Botany Department, under the supervision of Dr. Iain Taylor.

PRODUCTION

The first lodgepole pine clonal seed orchard made up of the best individuals of the best families from top ranking provenances (selected in a provenance/family plantation) was field grafted this spring. Other small orchards of this type are planned for grafting in 1986/87 to augment the larger but later 1.5-generation orchards whose establishment must await wind-pollinated progeny test information.

REFERENCES AND PUBLICATIONS

- Ying, C.C., K. Illingworth, and M. Carlson. 1985. Geographic variation in lodgepole pine and its implications for tree improvement in British Columbia. In Proc. of the symp. Lodgepole pine: the species and its management. D.M. Baumgartner, R.G. Krebill, J.T. Arnott, G.F. Weetman, (editors). Spokane, Wn. May 8-10, 1984, Vancouver, British Columbia May 14-16 1984, Cooperative extension, Washington State University, Pullman, Wn. pp. 45-53.

A BREEDING PROGRAM IN COASTAL DOUGLAS-FIR
(PSEUDOTSUGA MENZIESII MIRB. [FRANCO])
1983-1985

J.C. Heaman

*B.C. Ministry of Forests
Research Branch
1450 Government St.
Victoria, B.C.
V8W 3E7*

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

Tree improvement work in coastal Douglas-fir began in 1957, with early emphasis on phenotypic selection and seed orchard establishment. The breeding program is now directed at establishing full-sib progenies from the original, wild-stand selections 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.

BACKGROUND

A detailed outline of the extensive progeny testing and second-generation selection program in coastal Douglas-fir was given previously (Heaman, 1982). Progenies produced through a disconnected, modified diallel mating design, with six-parent groupings among the selected plus trees, are being established at lower and middle elevations in the south coastal region. These plantations are generating information on genetic parameters and parental breeding values for selection of second generation seed production and breeding populations.

DEVELOPMENT

The breeding program started in 1973, and since 1975, seven series of crosses have been planted on a total of 77 sites. This amounts to over 200 ha of plantation and involves over 200 000 pedigreed seedlings. Currently 312 parents are represented on the sites, and a further 60 parents were included in pollinations in 1982 and 1983. Seeds from these matings were sown in 1985 at the Cowichan Lake Research Station for planting on a further 11 sites. There are 372 selected parents involved in the program, representing an adequate, although far from complete sample in the main portion of the species range in British Columbia and northwest Washington.

Performance assessments have been completed on the first 44 test sites, involving crosses from 198 parents and about 80 000 trees. Total height and height increment were measured. These data have guided selections for the first 2nd-generation Coastal Douglas-fir seed orchard, and for the advanced breeding collection. Selection was based primarily on the general combining ability of the parents, and the stability of parents and crosses over sites. Within-family selection was based on numerical superiority, and form assessment was included in subjective field examination. True index selection involving qualitative as well as quantitative traits should be possible when the next set of measurements are taken at age 12. The selection of material from field sites at this early stage is justified, but incorporates a degree of risk balanced against savings in time.

Analysis of data is continuing, and it is evident that additive genetic effects far outweigh non-additive effects in general, and that genotype x environment interactions are relatively small within the conditions sampled by the program at this stage. This information supports the selection approach, using a widely based population.

Collection of United States material for trials in the milder parts of the British Columbia coast represents another allied project which is going ahead with cooperation from U.S. industrial foresters and the Industrial Forestry Association.

INTER-RACIAL CROSSES

Remeasurement of some of the plantations of wide inter-racial crosses established between 1966 and 1969 took place in 1984. This project has had lower priority in recent years and the planned remeasurement schedule has therefore been delayed. Nineteen test sites were measured which represents about half of the total number of trees in the project's 28 test sites. The trees on these test sites are now reaching over 20 m in height and up to 35 cm in diameter. Preliminary results indicate that the crosses made between trees from coastal Washington and Oregon and British Columbia parents are still maintaining their early growth superiority over crosses between parents from coastal British Columbia.

SUPPORT STUDIES

Pursuit of this single breeding objective has meant that alternative research on the species has been given less priority. However, during the consolidation phase of the selection project, the opportunity for support studies has arisen. One of the advantages of having a large collection of pedigreed material established in field tests is availability of research material for cooperative projects.

The following co-operative support studies are currently underway:

1. Importance and assessment methods for quality traits - John King, PhD candidate University of Alberta.
2. Response surfaces and genotype x environment interactions in a nursery study, linked to field performances - Sally John, PhD candidate, North Carolina State University.
3. Tree form and site factor interactions - John King and Reid Carter (Univ. of B.C.)
4. Low level inbreeding effects - Jack Woods (Ministry of Forests)
5. Farm-field testing - Jack Woods

REFERENCE

- Heaman, J.C. 1982. A breeding program in Coastal Douglas-fir (P. menziesii Mirb. [Franco]) 1979-1981, In Proc. 18th Mtg. Can. Tree Imp. Assoc. Part I:34-37.

GENETIC IMPROVEMENT OF DOUGLAS-FIR IN THE BRITISH COLUMBIA INTERIOR 1984-85

Barry C. Jaquish

*B.C. Ministry of Forests
Research Branch
Kalamalka Research Station & Seed Orchard
3401 Reservoir Road
Vernon, British Columbia
V1B 2C7*

Keywords: Interior Douglas-fir, parent tree selection, progeny testing, gene archives.

The tree improvement program for Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) in the British Columbia interior was initiated in 1982. Emphasis of the program is on the highly productive areas of the Interior Wet Belt and the surrounding transition zone where silvicultural regimes are suitable for planting genetically improved seedlings. Within this region, seven interior breeding zones have been delineated on the basis of biogeoclimatic information.

The breeding strategy for each breeding zone calls for the selection of between 150-300 parent trees with accompanying wind-pollinated progeny testing. Each selected parent will be maintained in the Barnes Creek gene archive and breeding orchards at Vernon. First-phase seed orchards will be established on the basis of early progeny test results.

PARENT TREE SELECTIONS

To date, Ministry of Forest personnel and member agencies of the Interior Tree Improvement Cooperative have selected some 1320 parent trees from six breeding zones. Criteria for selection emphasized height and diameter growth, stem form, and branching habit. Wood specific gravity of each selected parent has been determined by Forintek Canada Corporation.

The 1985 parent tree selection program concentrates largely on the high elevation subunit of the West Kootenay breeding zone. The target number of selections for this zone is 200.

BREEDING ORCHARDS

Breeding orchards containing three ramets of some 800 clones from three breeding zones were established at Vernon. Breeding orchards for the Mica and West Kootenay low elevation breeding zones, are scheduled for planting in spring, 1986.

GENE ARCHIVES

Development of the Barnes Creek gene archives has proceeded rapidly. In spring, 1985, five ramets of some 800 clones were planted. Initially, these ramets will be managed to produce sufficient quantities of high quality scion material for seed orchard establishment.

PROGENY TESTING

The plan for progeny testing is to evaluate all selections from within the breeding zone plus a number of randomly selected families from adjacent breeding zones on a minimum of four test sites per breeding zone. Thirty-two seedlings per family are planted on each site.

In 1984, seedlings from 400 families were planted on six sites in the Cariboo Transition breeding zone. The 1985 program saw 160 families planted on six sites in the Central Plateau breeding zone. Seedlings from 275 families are currently being grown at the Cowichan Lake Research Station for testing in the Shuswap/Adams breeding zone. Planting will commence in spring, 1986.

GENETIC IMPROVEMENT OF WHITE AND ENGELMANN SPRUCE
IN BRITISH COLUMBIA
1983-1985

Gyula K. Kiss

*B.C. Ministry of Forests
Research Branch
Kalamalka Research Station & Seed Orchard
3401 Reservoir Road
Vernon, British Columbia
V1B 2C7*

Keywords: White spruce, Engelmann spruce, tree breeding, progeny trial, 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).

Considerable progress has been made since the last reporting period (Kiss 1984).

PROGENY TRIALS

Analyses of the 10-year height measurements for the Prince George selection unit have been completed. A summary of the major conclusions follows:

1. Differences in height and survival among families were highly significant. Mean height of the best 25% (44) of the families was 10.7% greater than the mean for all the progenies. This can be characterized as realized gain. Survival differences between the best and poorest 25% of the families was 5.8%. The difference is substantial considering the high overall survival (93%).
2. For height growth family heritability was 0.68 ± 0.40 , while individual heritability was 0.26 ± 0.19 .
3. The best and the poorest performing families can be identified at an early age. Over 80% of the families identified as being in the top 25% at age 3 were still in the same group at age 10. Correlation between 3- and 10-year family heights was $r_{3,10} = 0.8466$.
4. Genotype-environment interactions were non-significant. It was noticed however, that good site preparation and plantation maintenance improved survival and growth, and increased precision of the trials.

Open-pollinated progeny trials for 550 new interior spruce selections were established in the spring of 1984 on seven test sites (Kiss 1984).

Working plans for progeny testing an additional 850 interior spruce selections have been completed, and these plans incorporate knowledge gained from earlier trials. Basically, open-pollinated seed from all the selected trees will be tested in a "farm-field test". This site is prepared to agricultural standards at the Red Rock Seed Orchard Reserve, Prince George. Planting will be done in spring, 1986, at 1x1 m spacing, with eight replications of four-seedling rows from each family.

In order to evaluate the reliability of results from the farm-field test, additional test sites will be established in each of the four seed orchard planning zones from which the selected trees originated. In addition, there will be one test site at Fort Nelson to evaluate movement of material from more southerly origins to the far north. These sites will be well prepared (but not to farm-field standards). On each site, all local selections will be planted, as well as representative samples from all the other seed orchard planning zones. This design makes it possible to evaluate the extent to which the progenies can be transferred between zones.

Seedlings for these trials are presently being raised in containers at the Red Rock Nursery and will be field planted in the spring of 1986.

Ten-year height measurements for the Smithers and East Kootenay progeny trials were completed in the fall of 1983 and 1984, respectively, and the data are being evaluated.

CONTROLLED CROSSING PROGRAM

Matings for the comprehensive controlled-crossing program (Kiss 1984) are now over 90% complete. There was heavy flowering at the Vernon Breeding Arboretum in 1985 with over 85% of the grafts producing. Many of the older ramets (12 years from grafting) are producing bumper crops. It is of interest to notice that the same clones at Prince George, which were the donors of the Vernon grafts, have no cones at all this year.

A pilot project comparing seedlings from controlled crosses with open-pollinated progenies, at different geographic regions in British Columbia (Kiss 1984) was measured in 1984 at 3 years of age (4 years from seed). The data are being analyzed.

NOTES OF INTEREST

Albinism

Seeds resulting from the complete diallel crossing of three trees identified as albino carriers (Kiss 1984) have been germinated. All the selfed seed produced albino seedlings, but none of the crosses did, indicating that mutant alleles of different loci are responsible for the lack of chlorophyll in the homozygous mutant seedlings. A collection of albino mutant carriers could supply valuable material for unravelling the genetic code responsible for chlorophyll production, and as well supply marker genes for genetic studies. An example is the "golden" mutant that can be detected in heterozygous condition.

Inbreeding Depression

It is generally acknowledged that inbreeding is deleterious in spruce. However, observations indicate the amount of inbreeding depression varies between families. Several selfed parents produced offspring as tall at 2 years of age as their outcrossed progeny. Other parents produced extremely retarded selfed progenies. One parent appears to possess a dwarfing mutant. A publication evaluating these results is planned in the near future.

REFERENCE

- Kiss, G.K. 1984. Genetic improvement of white and Engelmann spruce in British Columbia 1981-83. In Proc. 19th Mtg. Can. Tree Improve. Assoc., Part 1:181-183.

THE ACCOMPLISHMENTS OF THE SILVICULTURE
BRANCH, B.C. MINISTRY OF FORESTS IN COOPERATIVE
TREE IMPROVEMENT, 1983-1985

J. Konishi, C. Bartram, D. Summers, M. Crown, A. Wolfe,
M. Albricht, P. Birzins, C. Hewson

*Silviculture Branch
B.C. Ministry of Forests
1450 Government Street
Victoria, B.C.
V8W 3E7*

Key Words: tree improvement cooperatives, advanced generation orchards,
information systems.

This report highlights achievements of the Silviculture Branch in cooperative tree improvement. "Planning and Administration" describes joint staff efforts at a provincial level, and "Coast Activities" and "Interior Activities", reviews specific management accomplishments, orchard trials, and contributions of staff to cooperative tree improvement.

PLANNING AND ADMINISTRATION

Wang micro computers were purchased for each of the three administration centres. Comprehensive Parent Tree and Propagation Information Systems have since been implemented through contract, using 'PC/FOCUS' software, and are presently being installed. These systems were developed after meeting with and discussing information needs at all levels of management.

Predicted annual planting needs for the year 2000 were recalculated in 1983. Orchard allocations and needs were reviewed, and the revised planting production targets were subsequently recommended for approval by the Tree Improvement Councils and accepted by the Chief Forester in 1984.

A publication entitled "Seed Orchards of British Columbia" was printed in May 1985. It includes general location maps, site maps, and orchard information on all developing, established and producing orchards that are managed by the Ministry of Forests, cooperators and private agencies. This publication may be obtained from the Ministry of Forests, Silviculture Branch, Victoria, B.C.

The two cooperative tree improvement councils (Coast - CTIC and Interior - ITIC) continued to develop and monitor seed orchard expansion and progress to meet objectives of future planting requirements recently revised in B.C.

The first ITIC progress report has been prepared to the first draft stage, and the CTIC has reached the second draft stage of its second progress report (1982-84).

The recent signing of the "federal/provincial agreement (Forest Resource Development Agreement)" confirmed that direct delivery funding by the Province will be made available for a new provincial seed centre, to be located in Surrey. This facility will incorporate state-of-the-art processing equipment which will enhance seed quality and yield from both orchard and natural stand collections.

These above achievements have been accomplished, despite the financial and capital constraints and budget limitations of the seed orchard program, in the past couple of years.

COASTAL ACTIVITIES

As the propagation phase of many coastal orchards approached completion, priority shifted to orchard site preparation and establishment, growing stock maintenance and crop management activities. The Ministry continued to intensively manage four producing Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco var. menziesii) orchards, totalling 21.81 ha, and was actively involved in administration of three producing coop orchards: two Douglas-fir and one Sitka spruce (Picea sitchensis (Bong.) Carr)¹.

The coastal cooperative was also responsible for the management of 14 established and 10 developing seed orchards.

The best crop year on record was 1983, which yielded a total of 391.88 kg of seed from all six producing Douglas-fir orchards, and 2.045 kg of Sitka spruce seed. While there is no scientific proof that the seed yields achieved are a direct result of pollination techniques used, for there are several contributing factors, it is encouraging to note that the best seed yields were achieved in orchards where low cost "extensive" pollen management techniques were used. The coastal

¹Excluded are private seed orchards, as they are not part of the cooperative program.

staff assisted the Research Branch by making approximately 3,000 individual tree collections from our four producing orchards to provide seed for isozyme analysis.

In contrast, 1984 was a non-crop year, and efforts were concentrated on growing stock maintenance (including top pruning, fertilization, weeding), thinning, and general site management activities. This small crop experienced considerable flower abortion, as well as significant insect damage, which contributed to the very low seed production (2.94 kg Douglas-fir seed, 0.285 kg Sitka spruce seed). Management practises undertaken were: fertilization and root pruning for cone induction; insect and disease monitoring and control; and bud surveys and pollen flight monitoring. A sampling procedure to evaluate seed production efficiencies was adopted operationally in 1984 in all producing MOF coastal Douglas-fir orchards.

The numbers of parent and/or plus trees selected in 1984 and now registered in the Coastal Tree Improvement Program by species, are listed in Table 1. Tree selection activities are currently being conducted for western white pine (Pinus monticola Dougl.)

Table 1: Summary of Parent Trees Selected in the Coastal Cooperative (1984 - Total)

	<u>Species^a</u>												
<u>Year</u>	<u>Fdc</u>	<u>Se</u>	<u>Plc</u>	<u>Hw</u>	<u>Hm</u>	<u>Pw</u>	<u>Ss</u>	<u>Ba</u>	<u>Cw</u>	<u>Cy</u>	<u>Act</u>	<u>Bg</u>	<u>Total</u>
1984	0	0	100	0	0	0	103	0	0	0	0	0	203
to date	968	171	134	1404	5	40	706	422	453	269	13	53	4638

^aSpecies abbreviations are defined as follows:

- Fdc - Douglas-fir (coastal) (Pseudotsuga menziesii (Mirb.) Franco var. menziesii)
- Se - Englemann spruce (Picea engelmannii Parry)
- Plc - Lodgepole pine (coastal) (Pinus contorta var. contorta Dougl.)
- Hw - Western hemlock (Tsuga heterophylla (Raf.) Sarg.)
- Hm - Mountain hemlock (Tsuga mertensiana (Bong.) Carr.)
- Pw - Western white pine (Pinus monticola Dougl.)
- Ss - Sitka spruce (Picea sitchensis (Bong.) Carr.)
- Ba - Amabilis fir (Abies amabilis (Dougl.) Forbes)
- Cw - Western red cedar (Thuja plicata Donn.)
- Cy - Yellow cedar (Chamaecyparis nootkatensis (D.Don) Spach.)
- Act - Black cottonwood (Populus trichocarpa Torr. and Gray)
- Bg - Grand fir (Abies grandis (Dougl.) Lindl.)

The main orchard management trials conducted in recent years include: efficacy trials for various fungicides and insecticides against pests of Douglas-fir and interior spruce; collecting cone production data for western hemlock; documenting procedures for operational cone-induction of Douglas-fir using gibberellins; and assessing cone production response and the biological effect of rootpruning treatments, which varies with rootpruning distance from the tree and the number of sides of the tree rootpruned.

INTERIOR ACTIVITIES

The interior orchard program has expanded to include six seed orchard complexes: Balco Reforestation Centre, Eagle Rock, Grandview, Kalamalka, Red Rock and Skimikin. Sites were prepared for 1.5 and 1.0 generation interior spruce (Picea sp.) orchards, and have been partially established. Priorities have shifted in that 1.5 generation orchards are now favored over first generation orchards. Generally, results of parent tree ranking from 5 year old progeny tests will be obtained prior to new orchards being established.

Holding areas were prepared and will be established for grafted stock in excess of immediate orchard, clone bank and breeding arboretum needs, at three orchard sites as follows: interior spruce material from the Smithers selection unit at Heffley Creek, Thompson Okanagan lodgepole pine (Pinus contorta var. latifolia Dougl.) grafts at Eagle Rock, and Shuswap Adams Douglas-fir (Pseudotsuga menziesii var. glauca (Beissn.) Franco) grafts at Grandview.

The first interior spruce crop was produced in 1983 from three orchards at Skimikin, totalling 2.32 kg of seed. Red Rock produced 1.82 kg of lodgepole pine seed from one orchard. 1984 was a non-crop year for interior spruce, however a second lodgepole pine orchard came into production at Red Rock, with a total of 2.01 kg of seed produced from the two orchards.

Seed orchard establishment and management continued to be the major activities in the interior. Under the direction of Research Branch, other programs included site preparation and establishment of progeny tests and clonebanks, selection of parent trees, and collection of scion, seed, and wood specific gravity samples. Demonstration plantations and operational trials have also been established. In addition, pine rootstock was established on 4.1 ha at Kalamalka for the field grafting of screened material from a provenance plantation to establish a 1.75 generation lodgepole pine orchard.

Enthusiastic licensee involvement within the tree improvement program made it possible to select more parent trees and make cone, scion, and specific gravity wood core collections from these selections. Table 2 is a summary of parent trees selected in 1984 and currently registered in the interior tree improvement program, by species.

Table 2: Summary of Parent Trees Incorporated in the Interior Tree Improvement Program (1984 - Total)

Year	<u>Species^a</u>			Total
	Sx	Fdi	Pli	
1984	0	0	235	235
to date	3209	1329	1352	5890

^aSpecies abbreviations are defined as follows:

- Sx - Interior spruce (commonly white x engelmann hybrids) Picea sp.
- Fdi - Douglas-fir (interior) - Pseudotsuga menziesii var. glauca (Beissn.) Franco
- Pli - Lodgepole pine (interior) - Pinus contorta var. latifolia Dougl.

Propagation activities in 1984 involved interior spruce only with 6015 grafts being made at Skimikin.

Silviculture Branch trials that are currently being conducted include: flower induction of interior spruce ramets in two orchards, by treatments of either gibberellins, heat, drought, fertilizer, girdling or root pruning to provide seed for progeny testing; an ongoing study monitoring interior spruce production to update seed yield estimates; determination of interior spruce cone efficiency; and monitoring methods and control options for gall aphids and cone and seed insects on interior spruce. A study determining the size of pine seed orchards to meet the new future planting requirements, has been completed.

Other notable activities included a pollen workshop, with participation by licensees, and collection of interior spruce pollen from wild stands for preparing a polycross test mix. Tree selection activities are currently being conducted for western larch (Larix occidentalis Nutt.), interior Douglas-fir and western white pine.

Acknowledgement

The authors wish to gratefully acknowledge the assistance of Pauline Hanson, Forest Technician, Silviculture Branch, in the compilation of this report.

SEED ORCHARD MANAGEMENT RESEARCH

S.D. Ross and A.M. Eastham

*B.C. Ministry of Forests
Research Laboratory
Victoria, British Columbia
V8Z 5J3*

Keywords: cone induction, container seed orchards, crown management, gibberellin application methods

Research is presently underway in three areas aimed at improving the efficiency of tree breeding and seed production programs for commercially important B. C. conifers. One is the development of containerized orchards, both for accelerating breeding programs and the volume production of improved seeds for reforestation. Portions of this work are being done in collaboration with Dr. R.P. Pharis (University of Calgary) and Dr. R.C. Bower (MacMillan Bloedel Ltd.). A second area of research concerns the development of more efficient methods for seed orchard application of gibberellins (GAs) for cone induction, also in collaboration with Drs. Bower and Pharis. The third involves crown management as a means both to control height for improved efficiency of orchard operations, and to increase flowering by favoring the development of those types of shoots having a high potential for differentiating seed- and(or) pollen-cone buds.

CONTAINER SEED ORCHARD RESEARCH

A full discussion of the potential for container seed orchards, and of progress to date in achieving this potential for western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) and the interior spruces, Engelmann (*Picea engelmannii* Perry) and white (*Picea glauca* (Moench) Voss), is provided elsewhere by Ross *et al.* (1985b). The recent papers by Pharis and Ross (1985), Pharis *et al.* (1985), Ross (1985a) and Ross and Pharis (Pt. 2, Proc. 20th Mtg. CTIA) also are relevant to this subject and the control of flowering in conifers in general.

Western Hemlock

Studies over the past five years have demonstrated the potential that indoor-potted orchards of western hemlock offer for accelerating

seed production and realizing higher genetic gains. Production costs also promise to be lower due to improved efficiency of management compared with soil-based orchards presently being established. The basic treatment and cultural regimens for sustained abundant seed production have now been largely worked out, with current research aimed at further improving the efficiency of operations.

The potted orchard approach has already been utilized to accelerate the western hemlock breeding program, and pilot testing for volume production of genetically improved seeds for reforestation could begin shortly.

Interior Spruce

The key to successful promotion of flowering in interior spruce is properly timed high temperatures, coupled with water stress and GA_{4/7} applications. The critical times for each of these treatments have now been defined (Ross 1985a). A series of 1984 experiments (see Ross *et al.* 1985b) have confirmed that whereas such treatments will promote flowering in field-grown trees, they are far more effectively and efficiently used with potted trees subject to strict environmental control within a plastic-covered house.

Current research aims to further refine and improve the floral-induction regime, including determination of optimal conditions of shoot and root temperatures; to delineate the optimal environmental conditions for subsequent cone and seed development; to evaluate alternative pollen management strategies; and to better understand the physiology of flowering, its mechanism and control.

A working plan is presently being prepared to establish, by 1986, a pilot-scale test of the container seed orchard concept for interior spruce. As proposed, this will be a five-year project undertaken jointly between Research and Silviculture Branches. Its specific objectives are to: (a) demonstrate operational feasibility and cost effectiveness; (b) refine treatment strategy and container handling systems; (c) train operations personnel; and (d) gain a head start in the production of genetically 'elite' seed for reforestation.

HORMONE APPLICATION RESEARCH

Use of GAs to enhance cone production in conifer seed orchards (see Pharis and Ross 1985) is hampered by the practical difficulties of applying this relatively expensive hormone (\$13 to \$20 per gram, Can.) to large, field-grown trees. Bower and Ross describe elsewhere in these Proceedings the pros and cons of ultra low volume spraying based on two recent trials with Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) and western hemlock.

CROWN MANAGEMENT RESEARCH

Western Hemlock

Long-term crown pruning trials with western hemlock were initiated in 1982, in Western Forest Products' 1979-established clonal orchard #26 at Lost Lake and in the Canadian Forestry Service's 13-year-old clone bank at Cobble Hill (Ross 1984). Removal of the upper 50-60% of initial stem length has not adversely affected cone production in the older clone bank in the two years following top pruning, and it has resulted in a fuller crown that should in future years be capable of producing more abundant cones.

The younger trees have responded even more favorably in terms of vegetative development. However, flowering to date in this well-watered seed orchard has been sparse, even following a significant response to GA_{4/7} sprays in 1983. Both trials are continuing, with GA_{4/7} induction treatments being applied on a biennial basis (most recently in 1985).

Douglas-fir

Seedling trees in two blocks of the 1975-established Saanich seed orchard #20 received three levels of top pruning factored with three levels of branch thinning, each with and without stem injections of GA_{4/7} (Ross 1985b). A moderate top pruning from 6 back to 5 whorls of branches significantly depressed the production both of seed and pollen cones. So too did all levels of branch thinning designed to increase light penetration within the tree crown. More severe top pruning, back to 3 whorls of branches, caused a further significant reduction in flowering in one of the orchard blocks. However, this same treatment increased flowering relative to untopped controls in the other block wherein trees were slightly smaller and less vigorously growing. While the long-term response remains to be assessed, crown training beginning at a young age appears to have potential for increasing Douglas-fir seed yields, and for controlling tree size for improved efficiency of orchard management.

Trees in all treatments responded positively to stem injections of GA_{4/7} following procedures described by Ross et al. (1985a). Increases in seed- and pollen-cone bud production averaged 161 and 91%, respectively, although cone abortion also was 35% higher for the GA_{4/7}-treated trees.

PUBLICATIONS AND REFERENCES

- Pharis, R.P., and S.D. Ross. 1985. The flowering of Pinaceae family conifers with gibberellin A_{4/7} mixture: How to accomplish it, the possible mechanisms, and its integration with early progeny testing. In Symposium on Conifer Tree Seed in the Inland Mountain West. Univ. of Montana, 5-6 August 1985. In press.

- Pharis, R.P., S.D. Ross, and J.E. Webber. 1985. A morphogenic role for gibberellins in the flowering of conifers. In Symposium on Flowering and Seed Bearing in Forest Seed Orchards. Inst. of Dendrology, 1-8 September 1985, Kornik, Poland. In press.
- Ross, S.D. 1984. Western hemlock crown management study at Cobble Hill: First- and second-season growth and flowering responses. B.C. Ministry of Forests, Research Branch, Progress Report EP 944.02. 11 p.
- Ross, S.D. 1985a. Promotion of flowering in potted Picea engelmannii (Perry) grafts: effects of heat, drought, gibberellin A₄/7, and their timing. Can. J. For. Res. 15:618-624.
- Ross, S.D. 1985b. Initial flowering and height-growth responses by a young Douglas-fir seed orchard to different crown pruning regimes, with and without gibberellin A₄/7. B.C. Ministry of Forests, Research Branch, Progress Report EP 944.03. 25 p.
- Ross, S.D., J.E. Webber, R.P. Pharis, and J.N. Owens. 1985a. Interaction between gibberellin A₄/7 and root-pruning on the reproductive and vegetative process in Douglas-fir. I. Effects on flowering. Can. J. For. Res. 13:341-347.
- Ross, S.D., A.M. Eastham, and R.C. Bower. 1985b. Potential for indoor-potted seed orchards. In Symposium on Conifer Tree Seed in the Inland Mountain West. Univ. of Montana, 5-6 August, 1985. In press.

CLONAL PROPAGATION OF GENETICALLY IMPROVED STOCK FOR PRODUCTION PLANTING

J. Russell

*B.C. Ministry of Forests
Cowichan Lake Research Station
Box 335
Mesachie Lake, B.C.
V0R 2N0*

Keywords: clonal propagation, rooted cuttings, juvenile,
production planting, steckling.

The objective of the clonal propagation program is to replicate genetically superior families by rooted cuttings, for production plantings. The main emphasis is on interior spruce (Picea glauca (Moench) Voss and P. Engelmannii Parry).

RESEARCH

Three techniques of clonal mass propagation of juvenile material from identified good families are currently under investigation at the Cowichan Lake Research Station: accelerated growth, serial propagation, and hedge orchards. Work is carried out both in the field and on containerized stock in greenhouses. As confidence is gained in the technique of mass production and in the performance of stecklings in the field, production plantings will be undertaken.

IMPROVING SEED YIELD AND GENETIC QUALITY OF SEED ORCHARD SEED

J.E. Webber

*British Columbia Ministry of Forests
Research Branch
Victoria, B.C.
V8Z 5J3*

Keywords: pollen, storage, viability, pollination

In previous CTIA biennial reports, pollen management research for the important tree improvement species in B.C. was summarized. In the early development of orchards, emphasis was directed towards increasing production of seed. Techniques to increase both seed-cone buds and pollen supply were tested. Now in our most advanced tree improvement species, Douglas-fir [*Pseudotsuga menziesii* (Mirb.) Franco], over production of orchard seed is being realized. Since it is apparent that abundant seed can be available emphasis is now being focused on genetic quality of orchard production.

Many of the problems associated with genetically improving Douglas-fir orchard seed have been summarized (Webber 1985). Not only is it important to know how to handle pollen (i.e., collect, store, test) but also when to reapply it. Considerable field experience with Douglas-fir pollinations have indicated that pollen applied early to receptive seed-cone buds produce best yields. To a large extent the pollination mechanism of each species will determine when applied pollen will be most effective. For Douglas-fir, this has been determined (Owens *et al.* 1981; Owens and Simpson 1982) and the importance of applying supplemental pollen as early as possible to receptive seed-cone buds stressed (Webber and Yeh 1985). It should also be stressed that pollination mechanisms for other species are different and the results for Douglas-fir will not necessarily apply. This report summarizes recent data for pollen storage and viability tests and gives an example of how the pollination mechanism of Douglas-fir can affect the results of supplementally applied pollen.

POLLEN STORAGE

Early attempts to preserve pollen for breeding requirements often failed because storage conditions were poorly defined. Our initial trials for storing Douglas-fir pollen considered the freeze-drying procedures of Livingston *et al.* (1967) and Ching and Ching (1964). Pollen moisture content, storage temperature and storage atmosphere were all significant factors. We have recently determined that storage of

pollen under nitrogen can replace vacuum and foil-laminated, heat-sealed pouches that serve as effective containers. Douglas-fir pollen is now being successfully stored by ensuring that moisture contents are maintained between 2 and 6%, that containers (preferably glass or heat-sealed laminated foil pouches) provide a reliable air-tight seal and that storage temperature is kept at -26°C . Storage of pollen above 12% moisture content is not recommended under any conditions.

TESTING POLLEN VIABILITY

Pollen germination is the most widely used assay, but for Douglas-fir we find it gives a poor estimate of potential fertility. Over the past few years two viability assays have shown promise. These are respiration (Binder and Ballantyne 1975) and electrical conductivity of leachates (Ching and Ching 1976). Correlation coefficients for the three viability assays and seed yield (expressed as filled seeds per cone) are 0.64, 0.77 and 0.78 respectively.

More recent work has attempted to improve the germination assay so it can be used as a reliable technique for operational programs. This has involved redefining the germination media and what constitutes a germinating pollen grain. Progress is being made but more field testing is required.

POLLINATION DYNAMICS

Optimal time of pollination for Douglas-fir and the effect of supplementally applied pollen on improving seed yield have been determined (Owens *et al.* 1981; Webber 1985). However, a question still largely unanswered is what effect does supplemental mass pollination (SMP) have on genetic quality if significant increases in seed yields over wind-pollinated controls are not observed.

Several authors have suggested that in general pollen arriving first to a receptive seed-cone bud will have an advantage over pollen arriving later for successfully completing fertilization (Owens and Simpson 1982, Webber and Yeh 1985). We tested this first-on first-in pollination hypothesis in Douglas-fir using a reciprocal/time of pollination experiment (Webber and Yeh 1985). The two questions asked were: 1) if a pollen grain arrives first, is there a time period in which it can be replaced with a second pollen (i.e., SMP treatment), and 2) does the fertility of the first arriving pollen affect its competitive advantage. In one experiment, a self pollen (low fertility) was applied to seed-cone buds at two days beyond bud burst (BB+2) within 8 isolation bags. Cones in 2 of the bags were left as controls and those in 2 each of the remaining 6 bags received a second pollination with foreign pollen at either 5 min., 6 h or 24 h later. In the reciprocal experiment, a foreign pollen (high fertility) was applied first, followed by self pollen at 5 min., 6 h and 24 h later.

When self pollen was applied first and was not followed by foreign pollen (controls), average seed yield was 2.9 filled seeds per cone (fspc). Applying foreign pollen 5 min., 6 h and 24 h later, increased the seed yields to 21.1, 12.8 and 7.6 fspc, respectively. Thus, the second arriving foreign pollen significantly improved seed yields if it arrived within 5 min. of the self pollen but did not if it arrived 24 h later.

When foreign pollen was applied first, the effect of the second arriving pollen (self) was less apparent. Average yield for foreign pollen only (controls) was 29.6 fspc. If self pollen arrived within 5 min., seed yield was reduced (21.8 fspc) but not significantly. At 6 h and 24 h the effect of a self pollen arriving second diminished. Percent seed attributed to foreign pollen was slightly depressed (by 5%) at 5 min. At 6 h and 24 h less than 2% of the seed was derived from self pollen.

These data suggest that the longer a pollen grain occupies a receptivity site the less likely it will be replaced by pollen arriving later. To be considered first-in, it has to be engulfed for at least 24 h. The importance of pollen fertility is also apparent. If the first arriving pollen is of low fertility (self) then its major effect is to block receptivity sites to high fertility pollen arriving later (see Owens and Simpson 1982; Webber and Yeh 1985). Some displacement may occur if the high fertility pollen (foreign) arrives within 5 min. but not after 24 h. However, where the first arriving pollen is a high fertility foreign lot then there is little doubt that the first-on is also first-in.

The application of supplemental pollen to seed orchards can improve genetic quality if it arrives before competing pollen. However this is not always easily accomplished, especially if competing pollen cloud densities are high. Considerable work is required to determine when and how supplemental pollination should be applied to improve the overall genetic composition of orchard seed.

REFERENCES

- Binder, W.D. and Ballantyne, D.J. 1975. The respiration and fertility of Pseudotsuga menziesii (Douglas-fir) pollen. Can. J. Bot. 53:819-823.
- Ching, T.M. and Ching, K.K. 1976. Rapid viability tests and aging study of some coniferous pollen. Can. J. For. Res. 6:516-522.
- Ching, T.M. and Ching, K.K. 1964. Freeze-drying pine pollen. Plant Physiol. 39:705-709.
- Livingston, G.K. and Ching, K.K. 1967. The longevity and fertility of freeze-dried Douglas-fir pollen. Silvae Genet. 16:89-129.
- Owens, J.N., Simpson, S.J. and Molder, M. 1981. The pollination mechanism and the optimal time of pollination in Douglas-fir (Pseudotsuga menziesii). Can. J. For. Res. 11:36-50.

- Owens, J.N. and Simpson, S.J. 1982. Further observations on the pollination mechanism and seed production of Douglas-fir. Can. J. For. Res. 12:431-434.
- Webber, J.E. and Yeh, F.C. 1985. Test of the first-on, first-in pollination hypothesis in Douglas-fir. (m.s. in preparation)
- Webber, J.E. 1985b. Increasing seed yield and genetic efficiency in Douglas-fir seed orchards through pollen management. In: Proceedings, IUFRO Symposium on Flowering and Seed Bearing in Forest Seed Orchards. September 2-7, 1985. Kornik, Poland. In prep.

GENE ARCHIVES AND WESTERN
HEMLOCK GENETIC IMPROVEMENT
IN BRITISH COLUMBIA

J.H. Woods

*B.C. Ministry of Forests
Cowichan Lake Research Station
Box 335
Mesachie Lake, B.C.
V0R 2N0*

Keywords: Gene archives, clonebanks, gene conservation,
Tsuga heterophylla, breeding, progeny testing

WESTERN HEMLOCK GENETIC IMPROVEMENT

Economic constraints, and the resignation of Dr. Mike Meagher as Tree Breeder (Western Hemlock) to become the Western White Pine Geneticist with the Canadian Forestry Service, prompted initiation of a program review. The review was completed in December 1984, and recommendations concerning program direction were made. The B.C. Ministry of Forests will continue its commitment to the genetic improvement of western hemlock, and a revised breeding strategy will be prepared late in 1985, incorporating recommendations from the program review report and the Technical Planning Committee of the Coastal Tree Improvement Council.

Background

The western hemlock tree breeding program was started in 1977. Initial work involved selection of parent trees from throughout the important hemlock zones (primarily Vancouver Island and the south coast of British Columbia.) An open-pollinated testing strategy was adopted, and from 1979 to 1981, 23 test sites -- screening 146 parent trees -- were established. Difficulty in obtaining seed, changes in hemlock planting targets, and advances in cone induction techniques led to a revision of the improvement strategy, as outlined by Meagher (1983).

Progeny Testing

Fifth-year height measurements were obtained during 1983 and 1984 from the eight sites in each of series 1 and 2 of the open-pollinated progeny tests. Preliminary results from the first series (29 parents tested on eight sites) indicate significant family differences, with many of the better families consistently ranking near the top on all sites. Fifth-year heights will be obtained from the third series (76 parents, tested on seven sites) following the 1985 growing season.

Progenies from a six-tree complete diallel, forming part of a 10-tree half diallel, were sown in 1983 and out-planted on two southwestern Vancouver Island sites in 1984. Open-pollinated and poly-mix families were also included. This experiment will provide useful estimates of variance components, which can help guide future breeding strategies. A 3rd-year height measurement will be conducted in 1985.

BRITISH COLUMBIA GENE ARCHIVES

The primary objective of the gene archives in British Columbia is to conserve valuable genetic material from important coastal and interior forest tree species. Most of the gene archives consist of clonebanks of grafts or rooted cuttings from selected parent trees. Some plantations of seedling origin are also included. This material is available to breeders and other researchers, and is a source of scions for seed orchard development. This report briefly discusses the background, current status, and proposed development in the gene archives.

Background

Gene archives for the coastal region of British Columbia contain the products of tree selection and breeding by the Ministry of Forests, dating back to 1952. Located at the Cowichan Lake Research Station on southern Vancouver Island, the gene archives consist primarily of clonebanks which contain propagules from parent trees selected for tree improvement programs. There is also a large Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) provenance arboretum containing 148 population samples from throughout the species' range (Orr-Ewing 1973), and material from Douglas-fir inbreeding experiments, with several lines inbred to the S₃ generation (Orr-Ewing 1977). Other major plantations in the coastal gene archives include a yellow-cedar (Chamaecyparis nootkatensis [D. Don] Spach) hedging orchard for cutting production (Karlsson 1981), a Douglas-fir inter-racial cross progeny test, a lodgepole pine (Pinus contorta Dougl.) provenance collection, and species arboreta for the genera Pseudotsuga and Tsuga. Gene archives in the Interior of the province have been developed in conjunction with breeding programs for

interior spruce (*Picea engelmannii* Parry and *P. glauca* (Moench) Voss) and lodgepole pine (*Pinus contorta* Dougl.). Some clonebank development of spruce and lodgepole pine has taken place at the Red Rock Forest Reserve near Prince George, B.C., and a clonebank are also established at Barnes Creek, north of Vernon, B.C.

Development

Since the 1983 reporting (Woods 1983), coastal gene archive development has progressed rapidly. Clonebanks at the Cowichan Lake Research Station have been expanded to include eight species and 2850 clones (Table 1). Other plantations in the gene archives continue to be maintained, and constitute a valuable resource for tree improvement research, and research in other aspects of forestry in which some knowledge or control of genetic variability is an asset.

Interior gene archive development has also moved ahead quickly during the last 2 years. Clonebank development strategies are set for interior spruce, lodgepole pine, and interior Douglas-fir. Spruce clonebanks have been expanded at the Red Rock Forest Reserve near Prince George, and Douglas-fir clonebanks are being established at the Barnes Creek arboretum, north of Vernon. Breeding arboreta for each species continue to be developed by the respective breeders at the Kalamalka Research Station, Vernon.

TABLE 1. Number of clones of selected parent trees established in clonebanks in British Columbia

Species	Established clones	Location ^a
Douglas-fir (coast)	955	1
Douglas-fir (interior)	705	1, 2
Western hemlock	896	1
Interior spruce	1005	1, 2, 3
Lodgepole pine	792	3
Sitka spruce	138	1
Western redcedar	222	1
Yellow-cedar	335	1
Amabilis fir	186	1
Grand fir	49	1

^a1 = Cowichan Lake Research Station, Vancouver Island.

2 = Barnes Creek Arboretum, located 80 km north of Vernon, B.C.

3 = Red Rock Forest Reserve, Prince George, B.C.

REFERENCES AND PUBLICATIONS

- Karlsson, I. 1981. Propagation of Alaska yellow cedar (Chamaecyparis nootkatensis [D. Don] Spach.) by rooted cuttings for production planting. In Proc. of the International Plant Propagator's Soc. 31:112-116.
- Meagher, M. 1984. Western hemlock tree improvement for coastal British Columbia, 1981 - 1983. In Proc. 19th Mtg. Can. Tree Improve. Assoc., Part 1: 189 - 191.
- Orr-Ewing, A.L. 1973. The Douglas-fir arboretum at Cowichan Lake, Vancouver Island. B.C. For. Serv. Res. Note No. 57.
- _____. 1977. The collection of Douglas-fir inbreds at the Cowichan Lake Experiment Station, Vancouver Island. B.C. For. Serv. Res. Note No. 81.
- Woods, J. 1984. British Columbia coastal gene archives. In Proc. 19th Mtg. Can. Tree Improve. Assoc., Part 1:201-202.

ALLOZYME VARIATION IN CONIFERS

Francis C. Yeh

B.C. Ministry of Forests
Research Branch
1450 Government St.
Victoria, B.C.
V8W 3E7

Keywords: Allozymes, multi-locus analysis, population differentiation

Increasing use has been made of enzyme electrophoresis as an aid to conventional morphologically-based variation studies in conifers. The large body of allozyme data has shown that levels of variation are generally consistent with estimates of genetic variation from provenance/progeny tests. Those species considered quite variable in morphological and physiological traits, such as Picea sitchensis (Bong.) Carr. (Burley 1966) and Pinus contorta Dougl. (Critchfield 1957), also show moderate-to-high levels of allozyme polymorphisms (Yeh and El-Kassaby 1980; Wheeler and Guries 1982). More importantly, morphologically uniform species such as Pinus resinosa Ait (Wright *et al.* 1972) and Thuja plicata Don (Minore 1969) were also essentially monomorphic at all or most allozyme loci (Fowler and Morris 1977; Copes 1981).

From the perspective of conifer genetic resource management, differentiation among populations is one important objective in studies of allozyme variation (Brown 1978). The disclosure that population differences at allozyme loci were typically small was in apparent conflict with morphologically and physiologically based studies of variation in conifers (Guries and Ledig 1982; Wheeler and Guries 1982). This has led to the general notion that allozymes cannot be used as genetic markers for differentiating among populations, and much of the attention has focused on the biological significance of such variation.

In the past few years, major thrust of our research was to determine whether multi-locus analysis of allozyme data could detect non-random groupings of populations which were consistent with groupings based upon provenance/progeny testing data. Recently, we presented results on multi-locus analysis of allozyme differentiation in Pinus contorta spp. latifolia (Yeh *et al.* 1985). Contrary to earlier

reports on the lack of differentiation (Yeh and Layton 1979; Wheeler and Guries 1982; Dancik and Yeh 1983), we observed a rich structure of genetic variation associated with geography, concordant with the results of growth and morphological studies on this conifer (Critchfield 1957; Illingworth 1976). Both latitude and altitude appeared to be important, with northern populations exhibiting a greater extent of genetic differentiation. A similar conclusion on pattern of differentiation was reached for Picea mariana (Mill.) B.S.P. (Yeh et al. [1985]). On the basis of these findings, it appears that a large number of small differences at allozyme loci is equivalent to a small number of large differences. Therefore, traditional measures of population differentiation, such as genetic distance (Nei 1972) and F-statistics (Wright 1965), might obscure some underlying patterns because all loci are weighted equally. This has led us to support the thesis that there is a greater level of statistical significance from allozyme loci considered jointly, than that averaged from single loci (Mitton 1977: Smouse et al. 1982).

REFERENCES AND PUBLICATIONS

- Brown, A.H.D. 1978. Isozymes, plant population genetic structure and genetic conservation. *Theor. Appl. Genet.* 52: 145-157.
- Burley, J. 1966. Genetic variation in seedling development of Sitka spruce, Picea sitchensis (Bong.) Carr. *Forestry* 39:68-94.
- Copes, D.L. 1981. Isozyme uniformity in western red cedar seedlings from Oregon and Washington. *Can. J. For. Res.* 11:451-453.
- Critchfield, W.B. 1957. Geographic variation in Pinus contorta. Maria Moors Cabot Foundation Publication No. 3, Harvard University, Cambridge, Mass.
- Dancik, B.P. and F.C. Yeh. 1983. Allozyme variability and evolution of lodgepole pine (Pinus contorta var. latifolia and jack pine (P. banksiana) in Alberta. *Can. J. Genet. Cytol.* 25:57-64.
- Fowler, D.P. and R.W. Morris. 1977. Genetic diversity in red pine: evidence for low genic heterozygosity. *Can. J. For. Res.* 7:343-347.
- Guries, R.P. and F.T. Ledig. 1982. Genetic diversity and population structure in pitch pine (Pinus rigida Mill). *Evolution* 36:387-402.
- Illingworth, K. 1976. Inter- and intra-provenance variation in heights of three year old Pinus contorta Dougl. In Pinus contorta provenance studies. Edited by R. Lines (editor). *For Com. Res. Dev. Pap. No. 114*, pp. 98-106.

- Minore, D. 1969. Effects of high soil density on seedling root growth of seven northwestern tree species. USDA For. Serv. Res. Note PNW-112.
- Mitton, J.B. 1977. Genetic differentiation of races of man as judged by single-locus and multi-locus analyses. Am. Nat. 111:203-212.
- Nei, M. 1972. Genetic distance between populations. Am. Nat. 106:283-292.
- Smouse, P.E., R.S. Spielman, and M.H. Park. 1982. Multiple-locus allocation of individuals to groups as a function of the genetic variation within and differences among human populations. Am. Nat. 119:445-463.
- Wheeler, N.C. and R.P. Guries. 1982. Population structure, genic diversity, and morphological variation in Pinus contorta Dougl. Can. J. For. Res. 12:595-606.
- Wright, S. 1965. The interpretation of population structure by F-statistics with special regard to systems of mating. Evolution 19:358-420.
- Wright, J., R. Reed, D. Lester, C. Merritt, and C. Mohn. 1972. Geographic variation in red pine. Silvae Genet. 21:205-210.
- Yeh, F.C. and C. Layton. 1979. The organization of genetic variability in central and marginal populations of lodgepole pine Pinus contorta spp. latifolia. Can. J. Genet. Cytol. 21:487-503.
- Yeh, F.C. and Y.A. El-Kassaby. 1980. Enzyme variation in natural populations of Sitka spruce (Picea sitchensis). Genetic variation patterns among trees from 10 IUFRO provenances. Can. J. For. Res. 10:415-422.
- Yeh, F.C., M.A.M. Khalil, Y.A. El-Kassaby, and D.C. Trust. [1985]. Allozyme variation in Picea mariana: Genetic diversity, population structure and discriminant analysis of population differentiation. (Submitted to Can. J. For. Res.).
- Yeh, F.C., W.M. Cheliak, B.P. Dancik, K. Illingworth, D.C. Trust, and B.A. Pryhitka. 1985. Population differentiation in lodgepole pine, Pinus contorta spp. latifolia: A discriminant analysis of allozyme variation. Can. J. Genet. Cytol. 27:210-218.

PROVENANCE RESEARCH IN BRITISH COLUMBIA: 1983-85

Cheng C. Ying

*B.C. Ministry of Forests
Research Branch
1450 Government St.
Victoria, B.C.
V8W 3E7*

Keywords: Douglas-fir, lodgepole pine, Sitka spruce, provenance, Amabilis fir, grand fir, Noble fir, seed zone, seed transfer

Provenance research has been carried out by the Ministry of Forests since the early 1960's. It has been focussed on the major commercial species: Douglas-fir, lodgepole pine, interior and Sitka spruces, and more recently the minor species: grand fir, amabilis fir and Noble fir. There are currently 139 test plots established, covering 238 ha throughout the province. For many years the emphasis was on maintenance, but lately it has shifted to interpretation and the practical application of data from the assessments. This had led to the establishment of new seed transfer guidelines and seed zone boundaries for interior spruce and lodgepole pine.

Scheduled measurement and assessment of the provenance tests presented a heavy workload in 1983 and 1984. During that time 10-year measurements of 62 lodgepole pine, 15 Sitka spruce, and 5 Douglas-fir tests were made, as well as 15-year measurements of 13 Douglas-fir tests. Approximately 125 000 trees were measured. In addition to height and diameter, tree vigor and pest- and climate-related injuries were also assessed. Without the cooperation of regional research staff and forest companies, it would not have been possible to complete these assessments according to the schedule.

SITKA SPRUCE

Experience with the assessment of a large number of field tests indicates transferability, and suitability of provenances cannot confidently be determined until they have been subject to screening under the "whole environment" in long-term field tests.

Often differentiation among provenances in hardiness, resistance to pests, or environmental stresses is gradual and becomes clear only after testing for a number of years. This is obvious from two Sitka spruce provenance tests, but it has also been observed in both Douglas-fir and lodgepole pine tests. In the Sitka spruce test at Maroon Creek, (Table 1), a clinal pattern of geographic variation in winter hardiness has now become clear, and provenance No. 32 Kitwanga (suspected to be an introgressed population of white and Sitka spruce) is the most hardy. In the Nass Road test, which is heavily infested by white pine weevil, provenance No. 32 Kitwanga and No. 62 Big Qualicum, have emerged as the most resistant. The Nass Road test site also offers an opportunity to select trees with good growth potential which are resistant to weevils. These results also suggest that Sitka-white spruce hybrids, which combine the growth potential of Sitka spruce and the hardiness and weevil resistance of white spruce (Ying and Morgenstern 1982), may represent the best choice for planting in inner-coastal valleys.

TABLE 1. Sitka spruce provenance differences in white pine weevil resistance at the Nass Road test (assessed in 1984); and in winter hardiness at the Maroon Creek test (assessed in 1985)

#	Location	Provenance			% Weevil- ^a infested trees (Nass Rd.)	Winter ^b injury (Maroon Cr.)
		Lat.	Long	Elev(m)		
21	Yakutat, Alask.	59°31'	139°42'	12	78	0
32	Kitwanga, B.C.	55°10'	127°52'	660	32	0
44	Inverness, B.C.	54°12'	130°15'	15	75	0.3
49	Link Rd. (Q.C.I.) B.C.	53°30'	132°10'	90	97	0.2
56	Holberg, B.C.	50°37'	128°07'	30	88	0.4
61	Tahsis, B.C.	49°50'	126°40'	0	93	1.1
62	Big Qualicum, B.C.	49°23'	124°37'	0	67	0.9
03	Forks, Washington	48°04'	124°18'	135	96	0.9
12	Necanicum, Oregon	45°49'	123°46'	45	87	2.1
18	Brookings, Oregon	42°15'	124°23'	90	75	3.0

^a Survivals were above 90% except in No. 18 (38%).

^b 0 = no visible injury; 3 = severe winter injury (brown needles over two-thirds of the tree).

LODGEPOLE PINE SEED TRANSFER GUIDELINES

As provenance plots matured, it has been possible to review seed transfer guidelines and adjust the seed zone boundaries. Provenance test results after 10 growing seasons suggest a broad adaptation of lodgepole pine. Trees grow vigorously at sites 5° latitude north of, and 400 m above, their natural habitats (Ying *et al.* 1985). However, the trees were still young (14 years from seed). Prudence calls for conservative interpretation of the results in practical application, and this was considered when the seed transfer guidelines were being revised. To allow flexibility and administrative efficiency, the lodgepole pine seed transfer guidelines incorporate both the fixed boundary and floating principle approaches. The important changes to the guidelines were:

1. To enlarge the existing seed zones by reducing the number of zones from 51 to 21; and adjusting the boundaries more precisely to correspond to biogeoclimatic subzones.
2. To allow a maximum of 300 m upward elevational transfer within seed zones below latitude 56°, but above latitude 56°, allow only 100 m. Upward rather than downward transfer along the elevational gradient is recommended.
3. To allow 2° latitude northward and 1° latitude southward transfer beyond a seed zone boundary.
4. To avoid seed movement across major biogeoclimatic zones, e.g. dry to wet and *vice versa*, and from Coast-Interior transition zones into the Interior.

The guidelines will be re-examined in 5 years.

FLOWER PRODUCTION IN LODGEPOLE PINE

Flower production records in the past 15 years from the clonebanks and wind-pollinated progeny plantation (Ying and Illingworth 1985; Ying *et al.* 1985) suggest it should take about 10 years for lodgepole pine to produce commercial quantities of flowers (200 conelets per tree). Trees of northern latitude tend to produce flowers earlier, but will eventually be out-produced by the more southern ones. Provenance differences in flower production capability, particularly for male flowers, are large; the southern provenances can produce as much as 10 times more pollen clusters than the northern ones, and this differential capability for flower production is inherited rather than environmentally induced. It is recommended that:

1. selection of seed orchard location follow similar general guidelines as those for seed transfer;
2. for seed orchard planning purposes, the present geographic division of central from southern interior be maintained; and
3. seed orchards for lodgepole pine from the Yukon and northern B.C. not be located south of latitude 56°. (Ying and Illingworth 1985; Ying *et al.* 1985.)

REFERENCES AND PUBLICATIONS

- Ying, C.C. and E.K. Morgenstern. 1982. Hardiness and growth of western spruce species and hybrids in Ontario. Can. J. For. Res. 12:1017-1020.
- Ying, C.C., K. Illingworth, and M. Carlson. 1985. Geographic variation in lodgepole pine and its implications for tree improvement in British Columbia. In Proc. of the symp. Lodgepole pine: the species and its management. D.M. Baumgartner, R.G. Krebill, J.T. Arnott, G.F. Weetman, (editors). Spokane, Wn. May 8-10, 1984, Vancouver, British Columbia May 14-16 1984, Cooperative extension, Washington State University, Pullman, Wn. pp. 45-53.
- Ying, C.C., J. Murphy, and S. Andersen. 1985. Cone production and seed field of lodgepole pine grafts. For. Chron. 61:223-228.
- Ying, C.C. and K. Illingworth. [1985]. Variation in number of seeds per cone, seed weight, and seed- and pollen-cone production in lodgepole pine natural stands, wind-pollinated progeny plantation, and grafted clonebank. Symp. conifer tree seed in the Inland Mountain West. Aug. 5-7 1985, Missoula, Mo. in press.

CONE AND SEED RESEARCH AND SEED CERTIFICATION, PACIFIC FORESTRY CENTRE 1983-1984

D.G. Edwards, G.E. Miller, F.T. Portlock, J.R. Sutherland

*Pacific Forestry Centre
Canadian Forestry Service
Victoria, British Columbia
V8Z 1M5*

Keywords: Douglas-fir cone gall midge, Douglas-fir cone moth, seed certification, seed chalcids, seed moisture content, seed quality, seed sorting, spruce cone rust, spruce seed moth, western conifer seed bug.

This report describes research on seed quality, and the official seed testing and certification programs, as well as studies on cone and seed insects and diseases at the Pacific Forestry Centre.

IMPROVING THE USE-EFFICIENCY OF CONIFER SEEDLOTS

D.G. Edwards

Emphasis was placed on testing the applicability of the IDS (I = incubation; D = drying; S = separation) system for upgrading seedlot quality in western conifers. The basis of the method is that following hydration of a seedlot, vigorously germinable seeds are able to retain moisture within their tissues, while non-germinable (dead) or weak seeds lose their moisture, when they are subjected to drying conditions. Drying has to be carefully controlled since all seeds will give up their moisture if the temperature is too high or the duration is too long. Properly conducted, the drying step creates a moisture content, and hence weight or specific gravity, differential that can be utilized to sort the seeds. When placed in water, for example, the heavier, more moist (viable) seeds sink while lighter, drier (weak or dead) seeds float; the separation is almost instantaneous. Separation can also be obtained in an aspirator or pneumatic air device, and probably also on a gravity table although this has not yet been tested.

For *Picea glauca* (Moench) Voss, on which (as the major reforestation species in British Columbia) the work has concentrated, the procedure has been effective in upgrading the quality of many seedlots from the 45%-55% germination range to the 75%-85% range. The method does not appear to discriminate between live and dead filled seeds of this species as well as was hoped and most seedlots have not improved beyond the 80% level. However, at 80% these seeds meet the requirements for sowing in container nurseries, whereas before IDS processing they could not be used. It has further been established that IDS-sorted seeds can be

redried and returned to cold storage for at least 1 year without significant reduction in viability; after 6 months storage, several seedlots showed an increase in quality, both in seeds that floated as well as those that sank when sorted, suggesting that some form of osmotic priming or conditioning might be occurring. In most instances when spruce seeds were processed by IDS, the original bulk of the seeds was halved, that is about 50% of the seeds sank. Seeds that floated were usually less than 10% germinable.

For Pseudotsuga menziesii (Mirb.) Franco seeds, excellent results have been achieved; one seed lot improved from 17% to over 96% germination. While the seeds at 96% germination comprised only 5% of the original bulk, these results are indicative of the degree of improvement that can be obtained.

The method also works well on Pinus contorta L. seeds. Reasonably good quality lots, 77%-85% germination capacity, were improved to 92.5%-96.5% germination capacity, with 78% to 91.5% of the original bulk being retained. Seeds that floated germinated 9%-10%. There is some evidence that the procedure per se has some impact on seed quality; seeds submitted to the I and D stages, but not separated, germinated about 7% less than seeds not processed by IDS.

Efforts to develop the process for use on a practical scale are underway.

FLOWER ENHANCEMENT

F.T. Portlock

Work on enhancement of strobilus production in Tsuga heterophylla (Raf.) Sarg. was terminated at the end of fiscal year 1984/85. One report (Pollard and Portlock 1984) was published, but no further publications are anticipated.

OFFICIAL CERTIFICATION AND TESTING OF TREE SEEDS

D.G. Edwards and F.T. Portlock

As the Certifying Authority under the OECD Scheme for the Pacific and Yukon Region, 200 certificates of source-identification, for 3431 kg of seeds, were issued. Species certified included Abies grandis (Dougl.) Lindl., Picea sitchensis (Bong.) Carr., Pinus contorta Dougl., Pseudotsuga menziesii and Thuja plicata Donn. Most certificates were for Pinus contorta seed sources. A seed inspector's training workshop was held in Victoria in May 1985 and was attended by representatives from other regions of Canada.

In 1984, "Guidelines for approval and registration under the OECD Scheme of untested seed orchards in Canada" were adopted by the Canadian Forestry Service. Under these guidelines, three Pseudotsuga

menziesii seed orchards have been registered, from which surplus seeds will probably be certified for marketing in 1985/86.

International certificates of seed quality for 214 commercial seedlots, from 20 conifer and two broadleaved species were issued in 1983/84; an additional six seedlots were tested unofficially. This is less than the amount of commercial testing done in the previous two years, and is a reflection of the economic recession. Certificates for Pinus contorta seedlots increased markedly.

CONE AND SEED DISEASE RESEARCH

J.R. Sutherland

A paper (Can. J. Bot. 62:2441-2447) was published on the locality and spore states of Inland spruce cone rust, Chrysomyxa pirolata Wint., on an alternate host, Pyrola asarifolia Michx. The pathogen is systemic and perennial in both shoots and rhizomes of this alternate host. Also included in the publication are SEM pictures of the various spore states. This information is valuable in understanding and managing this most important disease of spruce cones. For example, it was shown that about one-third of diseased cones with spermatia (in early summer) do not produce aeciospores. Thus the traditional method of counting aeciospore-bearing cones in late summer or early fall underestimates cone losses by about one-third. Cone rust epidemiological studies to determine when cone-infecting basidiospores are produced on alternate hosts, and environmental factors affecting spore production and liberation, have been completed over a 3-year period at a white spruce seed orchard near Salmon Arm. Basidiospores are most abundant about cone pollination time. This and other information has been used to develop fungicidal control of the disease by applying one or two ferbam fungicide sprays (manuscript submitted to Can. J. For. Res.) during the pollination period. These sprays drastically reduce cone rust incidence but do not harm seed yield or germination.

Dr. L.A. Mitchell (NSERC PDF at our Centre) has obtained several hybridoma lines that produce monoclonal antibodies specific to the seed-borne pathogen Siroccocus strobilinus Preuss. These results should allow the use of much larger seed samples than the present detection-by-plating techniques, and thereby increase the accuracy with which this pathogen can be detected.

CONE AND SEED INSECT STUDIES

G.E. Miller

Relationships between slice and whole-cone counts are being quantified for filled seeds and insect damage for most of the commercially important conifers in British Columbia. Preliminary analyses have indicated that in some species, e.g. Thuja plicata and Pinus contorta, cross-sectioning cones gives better estimates than axial slicing, at least

for filled seeds.

Sampling schemes are being developed for estimating in Pseudotsuga menziesii seed orchards: i) seed efficiency, ii) numbers of conelets, and iii) egg populations of Douglas-fir cone moth (Barbara colfaxiana Kearfott). Effects of attractant concentration, lure type, trap spacing, and trap height on catches of cone moth in sex attractant-baited traps have been evaluated. Pheromone identification is continuing for Douglas-fir cone gall midge (Contarinia oregonensis Foote) and spruce seed moth (Cydia strobilella L.). Attempts to demonstrate a sex pheromone in a seed chalcid (Megastigmus pinus Parfitt) failed.

Consumption of Douglas-fir seeds by the western conifer seed bug (Leptoglossus occidentalis Heidemann) have been estimated for each developmental stage of the bug. Damage by the bug is similar in appearance to naturally aborted seeds and the two can be easily confused.

Artificial diets are being evaluated for use in rearing Douglas-fir cone moth. The effects of summer temperature on emergence of cone moth from prolonged diapause are also being evaluated.

PUBLICATIONS

Edwards, D.G.W. 1984. The role of seeds and seed research in combatting the exploitation of the world's forest resources. Seed Sci. and Technol. 3: 757-765.

Edwards, D.G.W., Portlock, F.T. and D.W. Taylor. 1983. The "Seed-Vac", a homemade vacuum device for transferring seed samples. Can. For. Serv. Res. Notes 3(4): 22-24.

Edwards, D.G.W. and D.W. Taylor. 1985. Germination of commercially-collected lodgepole pine seeds from British Columbia and the Yukon Territory. In, Proc. Lodgepole pine, the species and its management symposium. (Baumgartner, D.M., Krebill, R.G., Arnott, J.T., Weetman, G.F., compilers and eds.), University of British Columbia, Vancouver, May 14-16, 1984. Washington State University, Cooperative Extension: 375.

Edwards, D.G.W., Taylor, D.W. and E.C. McKendry. 1985. Enhancing seedlot quality in lodgepole pine by flotation sorting. In, Proc. Lodgepole pine, the species and its management symposium. (Baumgartner, D.M., Krebill, R.G., Arnott, J.T., Weetman, G.F., compilers and eds.), University of British Columbia, Vancouver, May 14-16, 1984. Washington State University, Cooperative Extension: 375-376.

Leadem, C.L. and D.G.W. Edwards. 1984. A multiple-compartment tree seed tumbler drier. Tree Planters' Notes 35(3):23-25.

Miller, G.E. 1984. Biological factors affecting Contarinia oregonensis (Diptera: Cecidomyiidae) infestations in Douglas-fir seed orchards on Vancouver Island, British Columbia. Environ. Ent. 13: 873-877.

- Miller, G.E. and J.H. Borden. 1984. Reproductive behavior of the Douglas-fir cone gall midge, Contarinia oregonensis (Diptera: Cecidomyiidae). Can. Ent. 116: 607-618.
- Miller, G.E., Hedlin, A.F. and D.S. Ruth. 1984. Damage by two Douglas-fir cone and seed insects: correlation with cone crop size. J. Entomol. Soc. Brit. Columbia 81: 46-50.
- Pollard, D.F.W. 1982. Canadian national list of seed orchards, 1981. Can. For. Serv., Ottawa, Inf. Rep. DPC-X-13. 12 pp.
- Pollard, D.F.W. and F.T. Portlock. 1984. The effects of photoperiod and temperature on gibberellin A₄, induced strobilus production of western hemlock. Can. J. For. Res. 14: 291-294.
- Pollard, D.F.W. and F.T. Portlock. 1985. Provenance variation in height of western hemlock on Vancouver Island, British Columbia, 10 years after planting. Submitted to Can. J. For. Res.
- Sahota, T.S., S.H. Farris and A. Ibaraki. 1983. Timing of initiation of pharate adult development in Barbara colfaxiana (Kft.) (Lepidoptera: Olethreutidae). Can. J. Zool. 61: 2305-2306.
- Sahota, T.S., A. Ibaraki and S.H. Farris. 1985. Pharate adult diapause of Barabara colfaxiana (Kft.): Differentiation of one-year and two-year dormancy. Can. Ent. In press.
- Sullivan, T.P., J.R. Sutherland, T.A.D. Woods, and D.S. Sullivan. 1984. Dissemination of the conifer seed fungus Calosypha fulgens by small mammals. Can. J. For. Res. 14: 134-137.
- Sutherland, J.R. 1983. Two seed-borne diseases of conifers: The seed or cold fungus and Sirococcus blight. Proc. West. Int. Forest Disease Work Conf. 31: 6-8.
- Sutherland, J.R. 1985. Spruce cone rusts. In Pests in second growth forests. BCMF/CFS Jt. Public. (5 page manuscript) submitted.
- Sutherland, J.R., S.J. Hopkinson and S.H. Farris. 1984. Inland spruce cone rust, Chrysomyxa pirolata, in Pyrola asarifolia and cones of Picea glauca, and morphology of the spore stages. Can. J. Bot. 62: 2441-2447.
- Sutherland, J.R., W. Lock, T.A.D. Woods and T. Suttill. 1982. Sirococcus blight: Not seed-borne on serotinous lodgepole pine. Can. For. Serv. Res. Notes 2(3): 20-21.
- Sutherland, J.R. and G.E. Miller. 1982. Insect and disease management in British Columbia seed orchards. Rept. 16th meeting, Study Group on Insects and Diseases. North Amer. For. Comm., FAO Fredericton, NB. 1 page each in English and Spanish (Appendix 4).

- Sutherland, J.R., T.A.D. Woods and G.E. Miller. 1984. Effect of dimethoate and oxydemeton-methyl insecticides and ferbam and potassium coconate fungicides on germination in vitro of Douglas-fir and white spruce pollen. Tree Planters' Notes 35(1): 22-24.
- Thomson, A.J., J.R. Sutherland, T.A.D. Woods and S.M. Moncrieff. 1983. Evaluation of seed disease effects in container-sown Sitka spruce. For. Sci. 29: 59-65.

WESTERN WHITE PINE IMPROVEMENT PROGRAM
FOR BRITISH COLUMBIA

M.D. Meagher and R.S. Hunt

*Government of Canada
Canadian Forestry Service
Pacific Forestry Centre
506 West Burnside Road
Victoria, B.C.
V8Z 1M5*

Keywords: Pinus monticola, blister rust, Cronartium ribicola,
resistance breeding.

In 1983 the Canadian Forestry Service and the British Columbia Ministry of Forests (BCMF) signed a Memorandum of Understanding to begin genetic improvement of western white pine (Pinus monticola Dougl.). White pine blister rust (Cronartium ribicola J.C. Fisch. ex Rabenh.) is the chief impediment to management of this vigorous, valuable tree. The goal of the agreement is to produce blister rust resistant seedlings for reforestation.

The program, which began in 1984, involves cooperation among Drs. Richard Hunt, Pathologist, Eleanor White, Biochemical Geneticist and Mike Meagher, Geneticist. The program will consist of selecting rust-free trees in heavily-rusted stands, the collection of their seeds for rearing and subsequent inoculation of progeny with rust under controlled conditions. Following methods developed by the U.S. Forest Service (Hoff and McDonald, 1980), progeny will be inspected for rust development for 3-5 years after inoculation. Selected seedlings will contain known resistance mechanisms and will be incorporated into seed orchards.

A Ribes garden, to produce large, regular crops of rust inoculum, is being developed in cooperation with C.I.P. Forest Products Inc. (Tahsis Pacific Region) at its Saanichton Forestry Centre near Victoria. An inoculation chamber will be provided by the BCMF at the Cowichan Lake Research Station on Vancouver Island. First inoculations are planned for fall, 1985.

Targets for parent trees will be set by locality so that broad geographic coverage will be ensured and the onerous selection work can be spread among cooperating agencies. Most selection will be conducted under contract to the BCMF under Forest Act Section 88 (1) funds. Due to past interest by many agencies, several parent trees have been nominated and some small progeny trials established. All are being checked for suitability to our program and will be used where our criteria are met.

Seeds were sown in 1985 from a small number of parents; the stock will be inoculated with blister rust in 1986 to provide experience in rust inoculation and some comparison of rust susceptibility of B.C. trees versus "improved" stock from the U.S. Inland Empire program.

Seeds were collected in 1984 from 30 parent trees in a natural coastal stand and examined by isozyme techniques in order to assess the enzymic inheritance, parental and progeny heterozygosity and outcrossing rate (Ritland and El-Kassaby, 1985). A stand average of 5% inbreeding was detected, but it reached 60% in some individuals. Although western white pine is known to be a fairly good selfer, the generally high filled-seed levels suggest that most of the inbreeding is due to consanguineous mating. If this inbreeding is true of other areas and years, the need for seed orchards with diversified geographic sources is strengthened.

REFERENCES

- Hoff, R.J. and G.I. McDonald. 1980. Improving rust-resistant strains of Inland western white pine. U.S.D.A. Forest Service Res. Pap. INT-245. 13 p.
- Ritland, K. and Y. A. El-Kassaby, 1985. The nature of inbreeding in a seed orchard of Douglas-fir as shown by an efficient multilocus model. Theor. Appl. Genet. (accepted).

PUBLICATION

- Meagher, M.D. and R.S. Hunt. 1985. Proposed western white pine tree-improvement program for British Columbia. Agriculture Canada. Canadian Forestry Service, Victoria, B.C. Unpub. document 35 p. plus Appen.

MACMILLAN BLOEDEL LIMITED PROGRESS REPORT 1984-1985

R.C. Bower

*MacMillan Bloedel Limited
Woodlands Services Division
65 Front Street
Nanaimo, B.C., Canada
V9R 5H9*

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 cedar (Chamaecyparis nootkatensis (D. Don) Spach)
- Sitka spruce (Picea sitchensis (Bong.) Carr.)

With the planting of the western redcedar and yellow cedar orchards in the spring of 1985, establishment of all orchards is essentially complete.

CONE INDUCTION STUDIES

The Company has been involved in four cone induction studies in cooperation with Dr. S. D. Ross (British Columbia Ministry of Forests):

- Comparisons of cone induction facilities for western hemlock containerized seed orchards.
- Evaluation of ULV Sprays for seed orchard application of GA_{4/7}.
- Evaluation of ULV Sprays for western hemlock seed orchard application of GA_{4/7}.
- Cone induction trials on yellow cedar.

Results of the cone induction facilities project are to be published in the Conifer Tree Seed in the Inland Mountain West Symposium

Proceedings. Results from the two studies evaluating ULV spray equipment are presented in a voluntary paper elsewhere in these proceedings.

The present yellow cedar study resulted from an earlier study on this species first reported by Bower (1984). In the previous study, significant male and female flowering responses were demonstrated, however, there was a drastic loss of cones from the female bud stage to the second year harvestable cone stage.

The present study was initiated in 1984 to test timing and rates of application of GA₃ on grafted ramets of 10 clones of yellow cedar. Three treatment periods (May 20-June 23, June 10-July 14, July 1-August 4) and three rates of application (100 mg/l weekly, 100 mg/l twice weekly, 200 mg/l weekly) were applied in a complete factorial. An untreated control was included.

Spring 1985 assessments showed significant response to treatments; Cone development will be closely monitored through harvest in 1986.

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, roguing inferior clones from existing seed orchards, and providing information to improve the adaptability of material coming from the orchards.

Seed production for the test material is through controlled pollination using 10-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; two will sample adjacent zones.

Due to lack of flowering on many clones, completion of crossing has been much slower than originally expected. Sufficient crossing should be accomplished by 1986 to allow an initial sowing in 1987.

PROVENANCE TRIALS

Western white pine (Pinus monticola Dougl.)

The test described here was established in 1972/73 to test F₂ resistant white pine progeny from Idaho. The objectives were to test the survival, growth, and blister rust resistance of this material on Vancouver Island.

The F₂ resistant white pine used in this study was grown from seed supplied by Dr. R. T. Bingham. It was from a 1968 collection from F₁ trees planted in the USDA Forest Service Blister Rust Resistance Arboretum near Moscow, Idaho.

The control seedlot was from wind-pollinated collections from apparently rust resistant white pine on southeastern Vancouver Island. Both seedlots were grown in Styroblock 415B containers.

The plantation was assessed for survival, height, and blister rust infection during October 1983 after eleven growing seasons in the field. Mean survival, height, and blister rust infection data are:

	<u>F₂</u>		<u>Control</u>
Survival %	Fall 1972	92	80
	Spring 1973	<u>98</u>	<u>95</u>
		95	88
Height (m)	Fall 1972	1.76	1.48
	Spring 1973	<u>1.77</u>	<u>1.72</u>
		1.76	1.60
Blister Rust %	Fall 1972	17	29
	Spring 1973	<u>9</u>	<u>2</u>
		13	16

The test has severe statistical limitations due to the limited number of control seedlings that were planted. Statistically significant differences were only seen for survival between provenances and between planting dates. It is interesting to note that, although the differences are not statistically significant, the F₂ material is better than the local control for survival, height, and blister rust resistance. It is not expected that material from interior provenances would perform as well as or better than a coastal provenance on the coast. However, Steinhoff (1981) has found a similar phenomenon in Idaho, where western white pine saplings from the Olympic Peninsula of Washington and from northern Idaho sources did not differ in survival when planted together in northern Idaho. As well, the height of the control saplings generally fell within the height range of the northern Idaho saplings. Hunt and Von Rudloff (1977) could detect no obvious differences between coastal and interior populations of white pine by comparing leaf-oil-terpene percentage. Apparently, western white pine has very little geographic variation in height and survival characteristics.

The low incidence of blister rust in both the F₂ and control material is not completely unexpected. This is a relatively flat site (15-20% slope). Based on the work of Hunt (1983), it would be considered a low hazard site. Very little natural Ribes species occur on the site.

Western Redcedar

A small provenance trial was installed as part of a redcedar stock-type trial (Dunsworth 1985). Three test sites were chosen as close as possible to the original collection sites of each provenance. Fifth year assessments of height and survival were made in 1984. Evidence from this study supports the view of many researchers (Minore 1969, Minore 1970, Von Rudloff 1962, Von Rudloff et al 1979, Copes 1981, and Yeh 1981)

that genetic variability among western redcedar populations is low, perhaps the lowest of any coastal conifer species. No significant differences in height growth or survival were noted among provenances; local seed sources were not consistently the best performers.

These results were unexpected, given the elevational range of the provenances and the differences in growing season conditions among the test sites. The uniformity of provenance performance in this test would suggest that western redcedar is not genetically diverse, but phenotypically plastic. This has been a successful adaptive strategy for western redcedar and may well explain its persistence as a minor stand component in almost all site types on Vancouver Island (Yeh, pers. comm.).

PUBLICATIONS AND REFERENCES

- Bower, R.C. 1984. MacMillan Bloedel Limited Progress Report 1982-1983. IN Proc. 19th Can. Tree Imp. Assoc. Part I, Toronto, Ont., Aug. 22-26, 1983. pp. 216-218.
- Copes, D.L. 1981. Isoenzyme uniformity in western redcedar seedlings from Oregon and Washington. *Can. J. For. Res.* 11(2):451-453.
- Dunsworth, B.G. 1985. Western Redcedar Five-Year Stock Type Trial, Final Report. MacMillan Bloedel Limited, Internal Report. 43 p.
- Hunt, R.S. 1983. White Pine Blister Rust in British Columbia II. *Can. Stands be Hazard Rated?* *For. Chron.* 59:30-33.
- Hunt and E. Von Rudloff. 1977. Leaf-oil-terpene variation in western white pine populations of the Pacific northwest. *For. Sci.* 23:507-516.
- Minore, D. 1969. Effects of high soil density on seedling root growth of seven northwestern tree species. *USDA, For. Serv., Res. Note PNW 112*, 10 p.
- Minore, D. 1970. Seedling growth of eight northwestern tree species over three water tables. *USDA, For. Serv., Res. Note PNW 115*. 8 p.
- Steinhoff, R.J. 1981. Survival and height growth of coastal and interior western white pine saplings in north Idaho. *USDA For. Serv. Res. Note INT-303*, 3 p. *Intermit. For. and Range Exp. Stn., Ogden, Utah.*
- Von Rudloff, E. 1962. Gas-liquid chromatography of terpenes II. The volatile oil of Thuja plicata Donn. *Phytochem.* 1(3):195-202.
- Von Rudloff, E. and M.S. Lapp. 1979. Population variation in the leaf oil terpene composition of western redcedar. *Can. J. Bot.* 57:476-479.
- Yeh, F. 1981. Isoenzyme diversity among coastal British Columbia populations of western redcedar: tree improvement implications. Submission to the Breeding Strategy Subcomm., Coastal Tree Improvement Cooperative, Victoria, B.C. 8 p.

CIP FOREST PRODUCTS' TREE IMPROVEMENT PROGRAM
AND FOREST GENETICS ACTIVITIES
1983-1985

Yousry A. El-Kassaby

*CIP Forest Products Inc., Tahsis Pacific Region
8067 E. Saanich Road,
R.R. #1
Saanichton, B.C.
V0S 1M0*

Keywords: Isozymes, X-ray energy-dispersive spectrometry, seed orchards, reproductive phenology, inbreeding, contamination.

During the period under review, I have worked as a Lecturer (Biometrics/Forest Genetics) at the Faculty of Forestry, University of British Columbia (1983/84) and as a Consultant and Forest Geneticist with CIP Forest Products Inc., Tahsis Pacific Region (formerly known as Pacific Forest Products Ltd.) (1983 - present). CIP Forest Products Inc. was created on January 1, 1985 by the amalgamation of Tahsis Company Ltd. and Pacific Forest Products Ltd. companies. Thus, this report contains a general description of the tree improvement activities of both "Tahsis" and "Pacific" companies as well as research accomplished during 1983/84 (U.B.C.) and 1983/85 (CIP).

CIP TREE IMPROVEMENT PROGRAM

The CIP Forest Products' tree improvement program is currently focused on the management of two seed orchard complexes (Saanichton and Nootka) located on the Saanich Peninsula on Vancouver Island to produce genetically improved seed for reforestation. A summary statistics and description of each orchard is given in Table 1.

The three private Douglas-fir seed orchards, the "Saanichton Complex" are the first seed orchards in Canada and possibly in North America, to be registered as meeting O.E.C.D. (Organization for Economic Cooperative Development) requirements for seed certification. With this registration, CIP will be able to sell seed surplus on the international market (Govt. Can., Can. For. Serv. P.F.R.C. Inf. For. Vol. II(I), 1985).

Breeding programs have been initiated to test the first generation seed orchards' parent trees and are at different stages. The disconnected diallel mating design was adopted for both low and high elevation Douglas-fir programs. For each elevation seven diallel units, each with six parents were completed (105 crosses). One of these will be outplanted at two test sites in 1985 while the second will be planted in 1986. Test sites involving wind-pollinated progeny from the three co-op orchards (Nootka complex) have been planted and assessment is in progress. The parent trees of the Nootka orchards were also included in the MOF programs.

Table 1. Seed Orchards Information List

Orchard Complex	Status	Type ¹	Species	Area # of clones (ha) or crosses	Establish- ment date	1983/84 (kg) production	Total pro- duction (kg)
Saanichton	Private	C/S	Douglas-fir	3.4	80	1966/69	105.4
	Private	C/S	Douglas-fir	1.3	72	1966/69	15.3
	Private	S	Douglas-fir	6.0	145	1974	17.8
Nootka	Co-op ²	C/S	Douglas-fir	3.3	120	1970	49.9
	Co-op	C	Sitka spruce	1.6	138	1971	2.3
	Co-op	C	Western hemlock	0.9	84	1977	0.4
	Private	C	Balsam fir	1.5	89	1978/80	-

1 C, Clonal; S, Seedling; C/S, Clonal Seedling

2 British Columbia Ministry of Forests/Industry Tree Improvement Co-operative Program.

RESEARCH

Seed Orchard

As seed orchards become a predominant source for the production of conifer seed, for ease and frequency of harvest of genetically improved seeds, the basic assumptions of seed orchards (i.e. isolation, synchronization, random mating, minimal selfing and equality of male and female strobili production) require increased scientific and managerial attention. A comprehensive research project was undertaken by myself and Anita Fashler to systematically address every assumption and assess the robustness of the seed orchard setting to any violation of these assumptions. The 3.4 ha Douglas-fir clonal/seedling orchard at Saanichton was studied due to the availability of the overhead irrigation system and the presence of clonal/seedling material. Reproductive bud phenology surveys were conducted on every tree to assess the extent of the pollination period under natural and cooled conditions (El-Kassaby *et. al.* 1984). Actual cone production data from 37 open-pollinated families from 1976 to 83 indicated the presence of consistently high and low cone producers. Considerable imbalance in the relative contribution of families to the cone crop was observed and attributed to differences in cone production among families and in number of trees within family. These data were used to develop several thinning scenarios including the spacing, genetic base constraints, and individual tree outcrossing rate. The rate of outside pollen contamination in the orchard was assessed under natural conditions using pollen traps placed on a transect parallel to the prevailing wind direction and under cooling conditions using allozyme polymorphisms (El-Kassaby and Ritland 1985). Fifteen and six percent contamination rates were estimated for the first and second study, respectively. The results from the two studies are not comparable due to different estimation procedures. A two-year study of the genetic composition of the orchard was initiated. Two theoretical models were developed for estimating the mating system parameters (Ritland and El-Kassaby 1985) and contamination rates (El-Kassaby and Ritland 1985). These models took advantage of the unique structure of coniferous seeds (i.e. haploid megagametophyte and diploid embryo). The study compares the rate of inbreeding in seeds collected from different crown segments (El-Kassaby *et. al.* 1985d), reproductive phenology classes (El-Kassaby *et. al.* 1985e), and clonal and seedling material (Ritland and El-Kassaby 1985). The second year data collection and analyses are in progress. The orchard planting arrangement (i.e. seedling, clonal and clonal/seedling blocks) also allowed the comparison between seedling, clonal and clonal/seedling seed orchard setting.

X-ray Energy Dispersive Spectrometry (XES)

A study was initiated to investigate the feasibility of using the XES technique as a potential tool for seed certification. Trace element profiles for Sitka spruce (10 IUFRO provenances; El-Kassaby and McLean 1983) and lodgepole pine (21 seedlots; El-Kassaby and McLean 1985) were determined. The generated data were subjected to several multivariate analyses and results indicated that the chemoprints were source specific. Identi-

fication of unknown sources was achieved with pinpoint accuracy. A second study was conducted to address the governing mechanism of those chemoprints. Seed samples were collected from ramets of clones located in two Douglas-fir and Sitka spruce seed orchards. Restricting seed collection to a seed orchard allowed holding the environmental factors constant while different clones represented different genotypes. Results indicated that the chemoprints of both Douglas-fir and Sitka spruce seed are under strong genetic control and the effect of soil chemistry appears to be minimal if non-existent (El-Kassaby et. al. 1985b; McLean and El-Kassaby 1985). The rapid non-destructive nature of this technique which requires minimal sample preparation presents a unique supporting tool for seed certification. The XES technique has been used to address the Sitka, white and Engelmann spruce hybridization problem.

Variation and Mating System in Natural Populations

During the period under review, projects completed include allozyme inheritance, heterozygosity and mating system in western white pine (El-Kassaby et. al. 1985c), allozyme inheritance and linkage as well as genic variation in black spruce (Yeh et. al. 1985a,b), cone and seed traits in Douglas-fir and Sitka spruce (Scagel et. al. 1985a,b), seedling traits in Douglas-fir (Scagel et. al. 1985c), height growth in juvenile Douglas-fir (El-Kassaby et. al. 1985a, Fashler et. al. 1985), and chromosome morphology among *Pseudotsuga* species (El-Kassaby et. al. 1983; Sziklai et. al. 1985). In collaboration with Dr. E.E. White (C.F.S., Victoria) an annotated bibliography on isozymes and forest trees has been completed (El-Kassaby and White 1985).

The CIP Forest Products' seed orchards and isozyme laboratory have continued to provide facilities for University students and B.C. Ministry of Forests researchers. Ms. R. Davidson, Ph.D. candidate, Faculty of Forestry, U.B.C. used our isozyme facilities to study the inheritance, heterozygosity and the mating system in eight natural stands of amabilis fir, Dr. J. Webber of the B.C. Ministry of Forests is using our Douglas-fir and western hemlock orchards for pollen viability studies, and Ms. A. Wolfe of the B.C. Ministry of Forests is studying flower induction in the operative management of western hemlock orchards.

PUBLICATIONS

- El-Kassaby, Y.A. 1983. Repeated relation between allozyme variation and a quantitative trait in Douglas-fir. *Egypt. J. Genet. Cytol.* 12:329-344.
- El-Kassaby, Y.A., A.M. Colangeli and O. Sziklai. 1983. A numerical analysis of karyotypes in the genus *Pseudotsuga*. *Can. J. Bot.* 61:536-544.
- El-Kassaby, Y.A. and J.A. McLean. 1983. Characterization of seeds from 10 IUFRO Sitka spruce provenances using trace element profiles as determined by X-ray energy-dispersive spectrometry. *Can. J. For.*

Res. 13:929-937.

- El Kassaby, Y.A. and O. Sziklai. 1983. Effect of sample size on the precision of the estimate of allozyme frequencies in a natural stand of Douglas fir. Egypt. J. Genet. Cytol. 12:345-360.
- El-Kassaby, Y.A., A.M.K. Fashler and O. Sziklai. 1984. Reproductive phenology and its impact on genetically improved seed production in a Douglas-fir seed orchard. Silvae Genet. 33:120-125.
- El-Kassaby, Y.A., A.M.K. Fashler and O. Sziklai. 1985a. Effect of family size and number on the accuracy and precision of the estimates of genetic parameters in the IUFRO Douglas fir provenance-progeny trial. (submitted, Forest Ecol. Manage.)
- El Kassaby, Y.A. and J.A. McLean. 1985. Identification of the origins of lodgepole pine seeds by X-ray energy spectrometric determination of mineral profiles. For. Sci. 31:in press.
- El-Kassaby, Y.A., J.A. McLean and A.M.K. Fashler. 1985b. Inter-clonal trace element profiles variation in Sitka spruce seed. (submitted, Biochem. Genet.)
- El-Kassaby, Y.A., M.D. Meagher, J. Parkinson and F.T. Portlock. 1985c. Allozyme inheritance, heterozygosity and outcrossing rate among *Pinus monticola* near Ladysmith, British Columbia. (submitted, For. Sci.)
- El Kassaby, Y.A., J. Parkinson and W.J.B. Devitt. 1985d. The effect of crown segment on the mating system in a Douglas-fir [*Pseudotsuga menziesii* (Mirb.) Franco] seed orchard. (submitted, Silvae Genet.)
- El Kassaby, Y.A. and K. Ritland. 1985. Lack of pollen contamination in a Douglas-fir seed orchard as revealed by allozyme markers. (submitted, Silvae Genet.)
- El-Kassaby, Y.A., K. Ritland, A.M.K. Fashler and W.J.B. Devitt. 1985e. The role of reproductive phenology upon the mating system of a Douglas-fir seed orchard. (submitted, For. Sci.)
- El-Kassaby, Y.A. and E.E. White. 1985. Isozymes and Forest Trees: An Annotated Bibliography. Govt. Can., Can. For. Serv., P.F.R.C. Inf. Rep. BC-X-267. 79 pp.
- Fashler, A.M.K., Y.A. El-Kassaby and O. Sziklai. 1985. Inter-provenance variation in the IUFRO Douglas-fir provenance/progeny trial. (In: Proc. IUFRO, Work. Party - S2.02.05, Vienna, Austria, in press.)
- McLean, J.A. and Y.A. El-Kassaby. 1985. Trace element profiles for Douglas-fir seeds: evidence of genetic control. (submitted, Can. J. For. Res.)
- Ritland, K. and Y.A. El-Kassaby. 1985. The nature of inbreeding in a

seed orchard of Douglas-fir as shown by an efficient multilocus model. Theor. Appl. Genet: in press.

- Scagel, R., R. Davidson, Y.A. El-Kassaby and O. Sziklai. 1985a. Variation of cone scale and seed morphology in Douglas-fir (Pseudotsuga menziesii). (In: Proc. IUFRO, Work. Party - S2.02.05, Vienna, Austria, in press.)
- Scagel, R., Y.A. El-Kassaby and J. Emanuel. 1985b. Assessing sample size and variable number in multivariate data, with specific reference to cone morphology variation of Picea sitchensis. Can. J. Bot. 63:232-241.
- Scagel, R., Y.A. El-Kassaby and J. Maze. 1985c. Multivariate variation within and between open-pollinated families of Douglas-fir (Psuedotsuga menziesii). (submitted, Theor. Appl. Genet.)
- Sziklai, O., Y.A. El-Kassaby and R. Scagel. 1985. Relationship of Pseudotsuga menziesii with other Pseudotsuga species inferred from karyotype reconstruction. (In: Proc. IUFRO, Work. Party - S2.02.05, Vienna, Austria, in press.)
- Yeh, F.C., Y.A. El-Kassaby, M.A.K. Khalil and D.C. Trust. 1985a. Inheritance and linkage relationships of allozyme variants in black spruce. (submitted, J. Hered.)
- Yeh, F.C., M.A.K. Khalil, Y.A. El-Kassaby and D.C. Trust. 1985b. Allozyme variation in Picea mariana: Genetic diversity, population structure and discriminant analysis of population differentiation. (submitted, Can. J. For. Res.)

MORPHOLOGICAL VARIATION IN SOME WESTERN CANADIAN CONIFERS

Jack Maze and R.K. Scagel

Department of Botany
University of British Columbia
Vancouver, B.C.
V6T 2B1

Keywords: sources of variation, morphology, multivariate analysis.

The primary objective of our research has been identifying the sources of variation in trees on the assumption that such is a prerequisite to the successful manipulation of trees to some desired end. We have been studying Picea sitchensis, P. engelmannii and Pseudotsuga menziesii. The variables emphasized have been morphological and anatomical as they allow for an assessment of within-individual variation. We have used multivariate analysis since such stresses covariation, a mathematical expression of organization which is the unique attribute of biological systems (Rosenberg 1985). The use of morphological and anatomical variables in a multivariate analysis is well established in studies of conifer variation and, contrary to Yeh's (1984) "personal judgement", has demonstrated useful results. Further, critical use of morphological and anatomical variables has a long and respected history of use in other organisms besides conifers. Through multivariate analysis of morphological and anatomical data, centroids as well as the nature of variation around those centroids can be examined.

MULTIVARIATE TECHNIQUES

R. K. Scagel et al. (1985b) produced a multivariate extension of univariate sample size estimation. The procedure was presented and illustrated by application to within- and between-individual variation of cone morphology in a population of Sitka spruce. The method involves the stabilization of a scalar estimate of the structure of the correlation matrix (the determinant) among variables for a given sample size. Further work has extended the methodology to evaluating the stabilization of Mahalanobis D^2 . The sample specific dependency of previously described methods is avoided by random selection of several replicates in non-structured and structured (nested) models. The procedure is best applied in pilot studies where it can aid in characterization of multivariate data prior to analysis.

SOURCES OF VARIATION

R. K. Scagel has completed a study of Picea in southwestern British Columbia (Scagel 1984), expanding on previous work (Klinka et al. 1982). Relations between individual trees hypothesized to represent Picea engelmannii, P. sitchensis, and putative hybrids were examined using 40 morphological and anatomical variables of cones, needles, and twigs measured on 640 trees.

The emphasis in this study was on differentiation detectable at different levels of organization and the relative amount of variation around the centroids that characterize the different levels of organization

Patterns of within-individual variation were detected regardless of the age of the tree, its environment, or the species, suggesting that within-individual variation (phenotypic plasticity) is likely an intrinsic quality. Further, the two hypothesized taxa were similar with respect to the pattern of within-individual variation. Within-species variation was greater than between-species variation as was within population variation. Between-species variation was only 25% larger than within-individual variation. Also, polarity of the data coincided with the extremes of a continuum of variation over a large, environmentally diverse geographic area and not with hypothesized taxa suggesting that recognition of the two taxa of Picea in southwestern British Columbia may not be appropriate or practically feasible. It was not possible to attribute the patterns of variation either to hybridization followed by introgression or to the differentiation of a single large polymorphic taxon.

The patterns of between-individual variation was only partially correlated with regional and local scales of geographic and environmental variation. Local patterns of variation were not coincident in 16 separate geographic areas. The relation of the regional pattern of geographic variation of nursery grown trees was not coincident with the patterns of variation in naturally grown trees from the same area of origin. This variability of relations suggests that between-individual variation may be attributable to processes operating at an extremely local scale.

A visiting scholar from the People's Republic of China, Mr. Zhong-yi Chen, participated in a study on population differentiation in Pseudotsuga menziesii in southwestern British Columbia (Chen et al. submitted). The conceptual approach was similar to that of Scagel (1984) except that the analysis of the variation around the centroids included an estimation of within-population variable intercorrelation. As well, this study used a set of data that emphasized population structure, an area of emphasis that Scagel (1984) was prevented from considering systematically due to the nature of the occurrence of spruces in southwestern B.C. The variation of principal components analysis (PCA) axis scores for needle and twig anatomy for 46 populations was apportioned into that due to: 1) taxonomic structure (the var. menziesii from coastal areas, the var. glauca from east of the Cascade crest, and intermediates from intervening areas); 2) the presence of populations; and 3) the presence of individual trees within populations. PCA was performed on both original (needle and twig) variables and

residuals from multiple regression analysis where elevation, latitude, and longitude were used as independent variables. The analysis of residuals removes the effect of allopatry and macroclimate. In both analyses, the lowest source of variation was that due to taxonomic structure. Most of the variation was within populations suggesting that the recognition of subspecific taxa in this portion of the geographic range is not appropriate. The PCA axis scores from the original variables and the residuals were highly correlated indicating relationships are not the result of allopatry and/or selection due to macroclimate. The nature of within-population intercorrelations varied but was unrelated to elevation, latitude or longitude. Similar trends were observed for a larger geographic collection based on cone traits (Scagel et al. 1985a).

A study of morphological variation amongst seedlings of a single wind-pollinated population of Pseudotsuga menziesii was submitted for publication (Scagel et al. submitted). Morphological variables were examined and related to maternal parentage (41 families) and selection imposed during the setting out of a common garden. The largest source of variation among seedlings was attributed to within-family (between-individual seedling) variation. Further, within-family variable intercorrelations differed suggesting that intrinsic causal factors, expressed as the unique development in different progeny, are important to the generation and organization of variation. Pooled within-family variation was shown to be related to between-family variation indicating a historical component in variation, a parent-offspring relationship. The apparent significance of developmental and historical factors related to variation and the apparently small impact of selection on the organization of variation identify limitations of neo-Darwinian explanations. It is suggested that the assessment of progeny trials be broadened to include sources of variation that will reflect a fuller assessment of the trees being tested.

The studies on spruce and Douglas-fir cited above indicate differences in centroid position and variation around that centroid vary in mature individuals. The studies of Scagel et al. (1985c) indicate the same kinds of changes occur with development. This similarity in phenomena between differences in mature plants (due to evolution) and during development (due to ontogeny) suggests that ontogeny and evolution share a common phenomenological basis. This demonstration implicates natural laws derived from non-equilibrium thermodynamics that relate to the tendency of all natural systems to increase in complexity with time.

CONCLUDING REMARKS

The recognition and characterization of the amount of variation and within-group intercorrelations identifies factors which may be of significance in forest renewal programs. The amount of variation around centroids would indicate those trees with high intrinsic variation which may produce highly variable offspring. The description of within-group intercorrelations would allow one to identify those features which parallel within-group variation and thus may be more amenable to response to selection in a multi-trait selection program. The identification of a common phenomenolo-

gical basis for ontogeny and evolution, as well, indicates that development may give new insights in assessing forestry practices.

PUBLICATIONS AND REFERENCES

- Chen, Z-y, RK Scagel, J Maze. (submitted). A study of morphological variation in Pseudotsuga menziesii in south western British Columbia. For Sci
- Klinka, K, MC Feller, RK Scagel. 1982. Characterization of the most productive ecosystems for the growth of Engelmann spruce Picea engelmannii Perry ex Engelm. in southwestern British Columbia. Prov BC, MOF Land Mng. rep 9.
- Rosenberg, H. 1985. The structure of biological science. Cambridge Univ. Press, Cambridge, MS.
- Scagel, RK. 1984. Morphological and anatomical variation of Picea in northwestern British Columbia. M Sc Thesis, Department of Botany, University of British Columbia.
- Scagel, RK, R Davidson, YA El-Kassaby, O. Sziklai. 1985a. Variation of cone scale and seed morphology in Douglas-fir (Pseudotsuga menziesii). IUFRO Proc., Vienna. In press.
- Scagel, RK, YA El-Kassaby, J Emanuel. 1985b. Assessing sample size and variable number in multivariate data with specific reference to cone morphology variation in a population of Picea sitchensis. Can. J. Bot 63:232-241.
- Scagel, RK, YA El-Kassaby, J Maze. (submitted) Multivariate variation in a population of Douglas-fir. I. Variation within and between open-pollinated families. TAG
- Scagel, RK, J Maze, NL Vogt, LR Bohm. 1985c. Quantitative studies in early ovule development. I. Intra-individual variation in Nothofagus antartica. Can J. Bot: in press
- Yeh, FC. 1984. Population genetics of forest trees, pp 203-206 in, Proceedings, Nineteenth biennial meeting of the Canadian Tree Improvement Association, Part 1. Toronto, August 23-26, 1983. ed. CW Yeatman. Canadian Forest Service.

FOREST GENETICS AND TREE BREEDING AT THE FACULTY OF FORESTRY,
UNIVERSITY OF BRITISH COLUMBIA, VANCOUVER, 1983-1985

O. Sziklai

*University of British Columbia
Faculty of Forestry
Vancouver, B.C.
V6T 1W5*

Keywords: education, foxtailing, variation, idiogram, seed orchard

UNDERGRADUATE PROGRAM

The elective undergraduate forest genetics course was taken by 15 and 17 students respectively during the last two years. The winners of the G.S. Allen Scholarship in Forest Genetics were Douglas J. Perdue in 1984 and Catherine A. Bealle in 1985 obtaining the highest mark in the forest genetics course. Due to the new 4-year curriculum program the enrollment was expected to drop for the elective courses. To provide an introduction to forest genetics, genetic principals are given during first year dendrology course, forest genetics methods are discussed in silviculture course during third year and practical exposures to selection, hybridization, propagation, seed orchard and progeny testing are explained and demonstrated during two days in the two field courses: at the beginning of third year at the Interior Field School, and at the end of the third year at the Field Work in Harvesting, Silviculture and Mensuration.

GRADUATE PROGRAM

Mr. Ibrahim Zakaria completed his requirements for Master of Forestry degree and submitted his thesis on "Foxtailing of Pinus caribaea var. hondurensis in Peninsular Malaysia: frequency, growth rate and specific gravity".

His study indicated that foxtailing is a common feature in the plantations of Pinus caribaea var. hondurensis Barrett and Golfari in Peninsular Malaysia. Frequency of foxtailing in Kemasul and Ulu Sedeli pine plantations, aged between 1 to 8 years, was found to vary between 4.3 to 36.0 percent. Ulu Sedeli plantation has 5.3 percent more foxtail than in Kemasul plantation. This study indicates that the occurrence of foxtailing varies with site and age. The most common form of foxtailing is the sub-terminal foxtail which constitutes about 60.0 percent of the foxtail population. The increasing proportion of sub-terminal to terminal foxtail with age of the trees suggests that foxtailing is a plastic trait.

Average total height of foxtailed trees was greater than normal trees at all ages, however, larger diameters were evident only during the juvenile stage. The specific gravity of foxtailed trees was found to be slightly less dense than that of normal trees though the difference was not significant.

Although breeding of true terminal foxtail trees may hold some promise of economic gains, the inherent limitations and foreseen problems render such proposition to be not feasible. Selection against foxtailing will continue to be a more practicable approach.

Some future research studies on foxtailing are proposed: juvenile-mature correlation studies, long-term growth and wood quality studies.

RESEARCH

Research activity covers a wide range of fields from chromosomes to progeny testing. Four projects were presented at the IUFRO Working Parties Meeting S.2.04-00 Seed Problems and S.2.02-05 Douglas-fir Improvement in Vienna, June 1985.

Relationship of Pseudotsuga menziesii with other Pseudotsuga species inferred from karyotype reconstruction:

Evaluation of chromosome morphology for seven of the eight species of Pseudotsuga suggests that Pseudotsuga menziesii departs strongly from other species in the genus. The karyotype of the two varieties of P. menziesii, var. menziesii and glauca, are shown to be poorly differentiated. Assuming that karyotype differentiation of P. menziesii is the result of a misdivision of a metacentric chromosome and the production of stable telocentrics, an ancestral karyotype is hypothesized and reconstructed. The reconstructed karyotype as well as the others, were submitted to multivariate analysis and suggests that P. menziesii is more similar to the North American P. macrocarpa than to any of the Asiatic species. The results further suggest that karyotypic differentiation amongst the Asiatic species is not as pronounced as might otherwise be expected based upon their present allopatric distribution. Indeed, the karyotypic differentiation amongst the Asiatic species is not as discrete as among the two varieties of P. menziesii.

Polyembryony of Pinus contorta Doug. in Central Yukon:

Polyembryony - a common phenomenon in Pinaceae - appears more frequently in marginal populations at the higher elevations. In connection with plus tree selection seed samples collected from six trees in central Yukon were compared with five trees originating from southern B.C., representing approximately 15° latitudinal difference. Polyembryony was frequent in each of the six Yukon trees and the frequency varied between 6% to 40% while only two southern B.C. trees showed polyembryony with a frequency of 1%.

Significance of polyembryony in relation to tree improvement programs was discussed.

Variation of cone scale and seed morphology in Douglas-fir (Pseudotsuga menziesii):

The nature of variation of 10 variables describing seed and cone morphology of Douglas-fir was examined using multivariate analyses. This variation was related to geography for 89 populations, primarily in the eastern range of the species. There was significant differentiation for population centroids, within-population variation, and within-population variable inter-correlations. Only population centroids could be shown to be related to geography. Varietal distinction was less pronounced than intra-population variation. Seed source differentiation was shown to account for a larger proportion of the total variation than varietal variation but it was still smaller than that attributed to individual populations. These observations argue for revised, or at least expanded, approaches to the study of variation in Douglas-fir and the derivation of recommendations concerning the utilization of such variation.

Inter-provenance variation in the IUFRO Douglas-fir provenance/progeny trial:

Height growth variation was studied for 384 open-pollinated families representing 48 provenances from the IUFRO Douglas-fir [Pseudotsuga menziesii (Mirb.) Franco] collections sampled from British Columbia in a progeny trial at the University of British Columbia Research Forest in Haney, B.C. in 1971. The study objectives were to estimate: a) the degree of genetic variation in height growth among and within provenances, b) the heritability of height growth, and c) the juvenile-mature height growth correlation. This information assists in selecting the best provenances and progenies for the test site.

Results from seed zone analyses showed that the most significant differences in the genetic variation in height growth of juvenile Douglas-fir trees were found in the relative sizes of the components of variance between provenances and between families within provenances. These differences were linked to the site adaptation of the provenance material. Estimates for additive genetic variance and heritability for seed zones were quite high. Low values for their respective standard errors indicated high reliability in results. High values of heritability indicated that there are opportunities for significant improvement by "triage tandem" selection.

Results from the juvenile-mature correlation analysis indicated that reliable selection of the best and deletion of the poorest provenances and families may begin at age five years. Estimates for genetic gain were made.

PUBLICATIONS

- Bulley, N.R., N. MacDonald and O. Sziklai. 1984. Utilizing image analysis for determining seed viability. American Society of Agriculture Engineers. St. Joseph, Michigan. PNP 84-501:1-18.
- Chen, Y. and O. Sziklai. 1985. Germination of Toona sinensis seed from eleven provenances. For. Ecol. and Mgt. 10:259-281.
- Chen, Y. and O. Sziklai. 1984. A preliminary study on the germination of Toona sinensis (A. Juss) Roem. seed from eleven Chinese provenances. Northwest Scientific Association Meeting in Missoula, Montana. 22 p.
- Davidson, R.E., D.G.W. Edwards and O. Sziklai. 1984. Treatment and temperature effects on the germination of Pacific silver fir. Association meeting in Missoula, Montana. 12 p.
- El-Kassaby, Y.A., A.M.K. Fashler and O. Sziklai. 1984. Reproductive phenology and its impact on genetically improved seed production in a Douglas-fir seed orchard. Silvae Genetica 33:120-125.
- El-Kassaby, Y.A., A.M.K. Fashler and O. Sziklai. 1985. Effect of family size and number of accuracy and precision of the estimates of genetic parameters in the IUFRO Douglas-fir provenance-progeny trial. (Submitted Forest Ecol. Manage).
- El-Kassaby, Y.A., A.M.K. Fashler and O. Sziklai. 1984. Accuracy and precision varies with family size and number in the IUFRO Douglas-fir [Pseudotsuga menziesii (Mirb.) Franco] provenance-progeny trial. (Submitted).
- El-Kassaby, Y.A., R.K. Scagel and O. Sziklai. 1984. Relationship of Pseudotsuga menziesii with other Pseudotsuga species inferred from karyotype reconstruction. (Submitted).
- Fashler, A.M.K., Y.A. El-Kassaby and O. Sziklai. 1985. Inter-provenance variation in the IUFRO Douglas-fir provenance/progeny trial. In: Proc. IUFRO, Work Party S2.02.05, Vienna, Austria. (In press).
- Scagel, R., R. Davidson, Y.A. El-Kassaby and O. Sziklai. 1985. Variation of cone scale and seed morphology in Douglas-fir (Pseudotsuga menziesii). In: Proc. IUFRO, Work Party S2.02.05, Vienna, Austria. (In press).
- Sziklai, O. 1985. Biotechnology at tree level. In: Biotechnology Workshop in Forest Sciences, U.B.C. Feb. 21-22, 1985. Moderator and Editor of Section III. Will be published as Supplement to the Forestry Chronicle, Fall, No-85.

Sziklai, O., Y.A. El-Kassaby and R. Scagel. 1985. Relationship of Pseudotsuga menziesii with other Pseudotsuga species inferred from karyotype reconstruction. In: Proc. IUFRO Work Party S2.02.05, Vienna, Austria. (In press).

WORKSHOP ABSTRACTS
RÉSUMÉS DES ATELIERS

SAMPLING AND WOOD QUALITY ASSESSMENT METHODS - DO WE HAVE THE TOOLS?

Balatinecz, J.J., Faculty of Forestry, University of Toronto, and J. Poliquin, Faculté de Foresterie et de Géodesie, Université Laval.

Wood quality is best defined in terms of anatomical, physical and chemical characteristics with a view to end products and uses. Sampling involves the systematic collection of test specimens from standing trees and/or logs. Prior to sampling the following issues should be considered: purpose of work, quality parameters to be assessed, destructive vs. non-destructive sampling, statistical matters, cost and economic constraints, standardization. Relevant field data, such as geographic location, forest and soil types, stand history, etc. should also be recorded. Specimens for wood quality measurements may include stem disks, wedges, plugs or increment cores. For within tree variation, the number of height levels, radial and radial positions should be considered.

Relative density is still the most widely determined wood quality parameter. Among anatomical characteristics, fibre length, cell cross-sectional dimensions, fibril angle and tissue ratios may be reported. Chemical composition is often determined. With the availability of microprocessors, image analysis and a wide range of analytical instruments, the acquisition, recording and analysis of vast amounts of data can be done efficiently. Thus, the "tools" are available, and the task is to improve understanding and information transfer.

HERITABILITY AND GENETIC RELATIONSHIPS FOR WOOD QUALITY CHARACTERISTICS - THE KEY

Jefferson, P., University of Alberta, Edmonton, Alberta, T6G 2H1 and A. Yanchuk, Alberta Forest Service, Edmonton, Alberta, T5K 2G6.

Most studies have shown that the heritabilities of wood quality traits are approximately the same or greater than those for growth traits. Although wood quality traits tend to have lower coefficients of variation, substantial gains can still be achieved in most quality traits. Correlations among traits affecting wood quality can be of an undesirable type. The extent of these undesirable correlations is still relatively unknown, but until better information is available, the correlation between the two traits specific gravity and volume growth should be considered negative. Assuming the worst correlation in this situation ($r_g = -4$), rejecting 20-30% of parent trees based on parent tree specific gravity theoretically should negate the genetic loss in specific gravity. However, combating the expected overall loss in specific gravity from reduced rotation ages will require substantial selection for specific gravity, which may not be practical in a multiple-trait breeding program.

Many strategies are available to improve overall wood quality, however better economic information must be made available so that each trait affecting wood quality can be given an appropriate weight of economic importance.

THE CONSIDERATION OF QUALITY IN CANADA'S FUTURE FOREST RESOURCE

Kellogg, R.M. and C.T. Keith, Forintek Canada Corp., 6620 N.W. Marine Drive, Vancouver, B.C. V6T 1X2.

In 1984, Forintek Canada Corp. conducted a survey to determine the national interest in wood quality research of the type presently being carried out by Forintek in British Columbia. This includes both the study of potential wood quality problems in fast-grown, intensively managed species as well as technical support to tree improvement workers incorporating wood quality considerations into their program.

Consideration of the national interest in wood quality and the impact of that interest on the future resource must include an appreciation of the nature of the resource. Such factors as the productive forest area, the proportion of the land that is non-reserved, the ownership pattern, and the species occupying the land lease may all have an important effect on the impact that wood quality research will have on the gains in forest management practices. Such information is summarized in the report.

A province-by-province analysis of the planting plans, tree improvement programs, and the interest expressed in wood quality considerations reveal that there is planned tree improvement activity and an interest in wood quality considerations in every province. The degree to which these needs are being fulfilled varies from province to province, but in no case is the present technical support level adequate.

DEFINING WOOD QUALITY - WHAT'S IMPORTANT?

Keith, C.T., Forintek Canada Corp., 800 Montreal Road, Ottawa, Ont. K1G 3Z5.

Attempts to define wood quality have been made by a number of researchers in the field. One of the things that these definitions tend to have in common is a view that wood quality cannot be defined without reference to specific end products or uses. Determining "what's important" with respect to wood quality characteristics depends to a great extent on the intended end product or use. With this concept in mind, relevant wood characteristics are discussed under three categories: (1) Anatomical, (2) Chemical, and (3) Physical-Mechanical.

Important anatomical characteristics include individual fibre properties such as length, width, wall thickness and microfibril angle. Also important is the proportion of the various types of cells and tissues present, including the proportions of earlywood and latewood. Where decay resistance is required, the extent and nature of heartwood is significant as is the width and permeability of sapwood.

Chemical composition can affect the yield and quality of pulp and paper products as well as the suitability of wood wastes for bioconversion to organic chemicals. The quality of solid wood products may be influenced by a host of physical and mechanical characteristics that affect dimensional stability, stiffness, strength and working qualities. Specific gravity of wood is a useful indicator of many of its important characteristics.

STATUS AND FUTURE OF SEED ORCHARDS IN CANADA

Morgenstern, E.K., Faculty of Forestry, University of New Brunswick, Fredericton, N.B. E3B 6C2.

There were 364 ha of seed orchards in Canada in 1981. The survey reported here found that by 1984 the orchard area had increased to 618 ha, with 19% of the area in British Columbia, 4% in the Prairie Provinces, 28% in Ontario, 21% in Quebec, and 28% in the Maritime Provinces. Of the 17 species involved, jack pine, black spruce, white spruce and white spruce hybrids, Douglas-fir and white pine made up 89%. By 1988, plans call for the inclusion of 3 more species or hybrids and an expansion to 2,036 ha. This seemingly ambitious goal is not unrealistic in view of the predicted requirements of 7 billion seeds by 1987. Most of the expansion is anticipated in the Prairie Provinces, Quebec, and Newfoundland. If the plans can be realized, species contributions in percent will be: black spruce - 47, jack pine - 19, white spruce and hybrids - 16; eastern larch, Douglas-fir, lodgepole, eastern white and red pine, and red spruce - 2-3 each; the remaining 11 species will each contribute 1% or less.

SEED ORCHARD ESTABLISHMENT GUIDELINES

Rauter, R.M. and C.M. Graham, Ontario Ministry of Natural Resources, Forest Resources Branch, Toronto, Ontario.

Numerous seed orchards are being established throughout Canada. The establishment of these orchards is a dynamic art with the ultimate objective of producing large volumes of consistently high quality seed. Production orchards may be clonal or seedling depending upon the method of propagation. The type of orchard utilized is dependent upon the species, variability of the species, and the heritability of its characteristics. Prior to establishment, it is necessary to determine the number of parents to be included, size of orchard required, spacing and planting design. Characteristics of an ideal site include relatively level, well-drained sandy loams; located near water and labour sources; and protected from unwanted pollen sources, pests and diseases. In addition, many orchards have been located in climatic zones characterized by warm temperatures and low precipitation to ensure optimum flowering conditions.

THE PESTS OF PINE CONES

Syme, P.D., Canadian Forestry Service, Great Lakes Forest Research Centre, 1219 Queen Street East, Sault Ste. Marie, Ontario P6A 5M7.

The major pest organisms affecting seed and cone production of eastern white, red and jack pines are reviewed. Surveys made by the Forest Insect and Disease Survey Unit of the Great Lakes Forest Research Centre are described, discussed and summarized.

For red pine, the major damaging species were red pine cone borer, Eucosma monitorana Heinrich, the red pine cone beetle, Conophthorus resinosae Hopkins, the webbing coneworm, Dioryctria disclusa Heinrich, and undetermined lepidoptera. Percent damaged cones ranged from 2% to 59%, and seed loss ranged from 6% to 97%.

For white pine, major factors were the white pine cone beetle, Conophthorus coniperda (Say), the white pine coneworm, Eucosma tocullionana Heinrich, the webbing coneworm, the fir coneworm, D. abietivorella Grote and unidentified lepidoptera. Damaged cones ranged from 1% to 56% and seed loss ranged from nil to 100%.

For jack pine, the main seed destroyers were the webbing coneworm, unidentified lepidoptera, and unknown damage. Damaged cones ranged from 2% to 38% and seed loss from nil to 100%.

INSECT PESTS AFFECTING SEED PRODUCTION ON DOUGLAS-FIR

Summers, D.W., British Columbia Ministry of Forests, Silviculture Branch, Victoria, B.C. V8W 3E7.

The primary pests of Douglas-fir cones and seed are Contarinia oregonensis Foote (Diptera: Cecidomyiidae) and Barbara colfaxiana (Kearfott) (Lepidoptera: Olethreutidae). Other common pests include Leptoglossus occidentalis Heidemann (Hemiptera: Coreidae), Dioryctria sp. (Lepidoptera: Pyralidae), Choristoneura occidentalis Freeman (Lepidoptera: Tortricidae), Contarinia washingtonensis Johnson (Diptera: Cecidomyiidae) and Megastigmus spermatrophus Wachtl (Hymenoptera: Torymidae). Damage by any one species varies considerably from site to site and from year to year.

While the general life histories of most of these pests are known, more biological and ecological information is required in order to identify, predict and quantify damaging population levels in seed orchards and seed production stands.

RECENT ADVANCES IN SPRAY TECHNOLOGY OF PESTICIDES IN APPLE ORCHARDS

Vincent, Charles and Marcel mailloux, Station de Recherche, Agriculture Canada, Saint-jean-sur-Richelieu, Quebec J3B 6Z8.

The spray technology used in Quebec apple orchards has greatly changed since 1945. After a discussion on the conditions prevailing in apple orchards, we will then describe the current machinery used in commercial plantations to spray against apple scab, mites and insects, with respect to technical and practical aspects. Finally, the results of a two year trial with a concentrate sprayer equipped with an electrostatic attachment will be discussed. Effectiveness of the two types of sprays with fungicides, miticides and insecticides are reported.

USE OF INSECT PHEROMONES NI CONE AND SEED RESEARCH

G.G. Grant, Forest Pest Management Institute, Canadian Forestry Service, P.O. Box 490, Sault Ste. Marie, Ontario P6A 5M7.

Sex pheromones offer a variety of methods for monitoring and controlling cone and seed pests that are readily incorporated into integrated pest management programs. Traps baited with pheromones are used for early warning detection of pests, for determining the extent and degree of an infestation, for determining population trends and predicting potential damage, for timing insecticidal sprays, and for providing post-spray population assessments. Trap design, trap placement, the "life style" of the insect along with other factors must be considered to produce optimum monitoring results.

Direct control of insect pests can be achieved by mass trapping and mating disruption. These control techniques can be used alone or integrated with other practices. Although not yet operational and subject to some limitations, mass trapping and mating disruption offer excellent prospects for success in seed orchards. However, sex pheromones and synthetic attractants are available for only one third of the major Canadian cone and seed pests. Thus additional work is needed to identify the pheromones of the remaining species and considerably more research is needed to make them practical, operational tools.

THE PESTS OF SPRUCE CONES

Syme, P.D., Canadian Forestry Service, Great lakes Forest Research Centre, 1219 Queen Street East, Sault Ste. Marie, Ontario P6A 5M7.

The major pest organisms affecting seed and cone production of black spruce and white spruce are reviewed. Surveys of cones are described and summarized.

For black spruce, the major flower destroyers were the spruce budworm, Choristoneura fumiferana (Clem.) and the spruce coneworm, Diorystria reniculelloides Mut. and Mun. Major pests of cones included the spruce cone maggot, Hylemya anthracina (Czerny), the spruce cone axis midge, Dasineura rachiphaga Tripp, the fir coneworm, Diorystria abietivorella Grote and several unidentified lepidoptera. Bothy percent damaged cones and seed loss ranged from 8% to 88%.

For white spruce, flowers were damaged by both spruce budworm and spruce coneworm. Percent damage to flowers was of the order to 25% to 30%.

Major damagers of cones and seeds were the spruce cone maggot, the spruce seed moth, Laspeyresia (Cydia) youngana (Kft.), a spruce cone rust, Chrysomyxa pirolata Wint. and unidentified lepidoptera. Percentage cone damage ranged from 31% to 72% and seed loss within damaged cones ranged from 18% to 56%.

LARCH CONE AND SEED PROBLEMS IN MAINE

Eavy, A.L., Coop. Forestry Research Unit, Univ. Maine, Orono, ME 04469

Intensive investigations of larch seed crops from 1982-1985 have recorded damage levels ranging from 40-90% in tamarack [L. laricina (Du Roi K. Koch)], and about 5% of the 1983 exotic hybrid larch seed crop.

The principal damaging agent of hybrid larch was spruce budworm. The principal damaging agents of tamarack were the anthomyiid cone maggots, Lasiomma spp., and larvae of the cecidomyiid seed midge, Resseliella sp. Cone maggots attack singly, from mid-May to early June, completing the larval stage by early July. Seed midges attack in numbers (i.e. 10-20 larvae per cone) in mid-June, and feed in the cone until early August.

Cone maggot attack results in almost complete loss of a cone's seed. Feeding begins at the basal seeds, spiraling upward through the seed and seed scales. Seed midge damage averaged 10-20% and occurs as direct feeding on and in the developing seed.

Early season Lepidoptera mine out conelet buds and late season larvae cause low levels of damage to the maturing seed. X-ray analysis showed 3-5% shrunken seeds, indicating possible seed bug damage; the seed chalcid, Megastigmus laricis, was detected at 1-3% in 1983 and 1984.

Parallel investigations show the unknown (breeding) problems of tamarack cause 50-60% of all seed to be empty. Management priorities for tamarack seed production should emphasize breeding management and protection from cone maggots and seed midges.

CONE AND SEED INSECT MANAGEMENT ON EASTERN LARCH

Amirault, P.A. Department of Forest Resources, Bag Service Number 44555, University of New Brunswick, Fredericton, N.B. E3B 6C2.

It was estimated that insects destroyed 88% of the seeds in a 23-year-old eastern larch, Larix laricina (Du Roi) K. Koch, stand in central New Brunswick in 1982. The following year the insecticides carbofuran and dimethoate were tested in the stand for their efficacy in controlling the insects involved. Two of three treatments employing carbofuran and one of three treatments using dimethoate significantly reduced insect damage, principally by reducing damage caused by the main internal-feeder, Lasiomma viarium (Huckett) (Diptera: Anthomyiidae). All treatments were ineffective against the main external-feeder, the spruce budworm Choristoneura fumiferana (Clemens) (Lepidoptera: Tortricidae). Further trials with the objective of reducing spruce budworm caused damage by employing the insecticides fenitrothion and permethrin were conducted in 1984. Subsequent examination of control trees revealed that the percentage of seeds destroyed by the spruce budworm dropped from 28.7 in 1983 to 5.7 in 1984. Thus the treatments could not have been expected to significantly reduce spruce budworm damage, but two were successful in reducing damage by all insects combined.

INSECT MANAGEMENT ON DOUGLAS-FIR

Miller, G.E. Canadian Forestry Service, Pacific Forestry Centre, Victoria, B.C. V8Z 1M5.

Seed losses in Douglas-fir seed orchards in British Columbia have ranged from less than 10% to more than 90%. The Douglas-fir cone gall midge, Contarinia oregonensis Foote, is the key pest in the orchards; several other insects have also caused economic damage.

A system for predicting damage by the gall midge, based on egg counts, is used to determine the need for an application of dimethoate. One conelet which has closed and is turning down, after midge oviposition is completed, is collected from each sample tree. The maximum number of sample trees is 254, although 100 conelets has usually been adequate. These conelets are dissected and the number of egg-infested scales summed continuously. A sequential sampling graph, based on a critical density of 2.6 infested scales per conelet (10% seed loss), is used to classify the infestation.

If application is warranted, dimethoate (0.5% a.i.) is applied to conelets before they become pendant. Hydraulic sprays have been used successfully, although rain has frequently reduced efficacy. Mistblower applications have been tested recently but have apparently been less effective. The pest management system must be expanded to include other insects because seed losses have occurred even where gall midge has been controlled.

INSECT MANAGEMENT ON SPRUCE AND PINE

Fogal, W.H., Petawawa National Forestry Institute, Canadian Forestry Service, Chalk River, Ontario, K0J 1J0.

Chemical, biological, cultural and management tactics have been suggested and tested for control of seed and cone insects on white spruce Picea glauca (Moench) Voss, black spruce, Picea mariana (Mill.) B.S.P., red pine, Pinus resinosa Ait., eastern white pine, Pinus strobus L., and western white pine, Pinus monticola Dougl. Control of insects with insecticides applied as foliar sprays, stem injections or soil incorporation is possible. Insecticides include systemics such as dimethoate, orthene, lannate, metasystox-R, bidrin, carbofuran, and permethrin, a contact insecticide. A fungus, Beauveria bassiana (Bals.) Vuill., is a promising microbial control agent for the spruce cone maggot, Lasiomma anthracina (Czerny) and prescribed fire can be used for control of the red pine cone beetle, Conophthorus resinosae Hopkins. Cone crop size and other pests influence the efficacy of treatments and factors such as timing, crop size, potential insect damage, and seed requirements should be considered before implementing a treatment.

APPENDICES:

TABLE OF CONTENTS FOR PROCEEDINGS PART 2:
NEW WAYS IN FOREST GENETICS

ATTENDEES

ANNEXES:

TABLE DES MATIÈRES POUR LES PROCÈS-VERBAUX
2^E PARTIE ;
VOIES NOUVELLES EN GÉNÉTIQUE FORESTIÈRE

ASSISTANTS

PROCEEDINGS, PART 2

SYMPOSIUM:

NEW WAYS IN FOREST GENETICS/

VOIES NOUVELLES EN GÉNÉTIQUE FORESTIÈRE

CONTENTS

SESSION I

- | | |
|--------------------------|--|
| E.G. Kirby | Genetic engineering and protoplasmic fusion. Where are we? |
| R.P. Pharis
S.D. Ross | Floral induction: Assessment for the Canadian species |
| F.C. Yeh | Isoenzymes analysis and other biochemical testings for early selection |

SESSION II

- | | |
|--------------|---|
| M. Lalonde | Micropropagation et culture de tissus: bilan pour les espèces canadiennes |
| A. Fortin | Sélection d'organismes symbiotiques en fonction des génotypes d'arbres |
| D. Cornu | Programme de micropropagation réalisé à la station d'amélioration des arbres forestiers de l'I.N.R.A. |
| S.L. Krugman | Relation Between Forest Genetics and Biotechnical and Physiological Methods |

TECHNICAL PAPERS

SESSION I

- | | |
|---------------------------|--|
| A.Y. Raj
R.H. Ho | <u>In Vitro</u> Propagation of Some Conifers by Cotyledon and Epicotyl Culture |
| S.K. Hall
C.A. Maynard | Initiation of Callus and Shoot Production in <u>Prunus serotina</u> |

- R.H. Ho Micropropagation of American Elm
- T.L. Ettinger Development of Resistance in Populus to Septoria
P.E. Read musiva Utilizing Somaclonal Variation
- N.P. Hackett
M.E. Ostry
D.D. Skilling
- S.S. Baker Testing an In Vitro Assay for Disease Resistance to
F.A. Valentine Hypoxylon Canker in Populus tremuloides

SESSION II

- H.B. Kriebel The Application of molecular Biology to Mass Cell
F.W. Whitmore Cloning of Conifers
- J.N. Owens Development of Douglas-Fir Apices Under Natural
and Cone-Inducting Conditions
- R.H. Ho Cone Induction in White and Norway Spruce
- R.C. Bower Evaluation of ULV Sprays for Seed Orchard Application
S.D. Ross of Ga 4/7
- K. Jech Estimating Supplemental Mass Pollination Success
N. Wheeler Electrophoretically

SESSION III

- B.C. Bongarter The Relationship Between Isozyme Heterozygosity
N.C. Wheeler and Growth Rate in Full-Sib Families of Douglas-Fir
K. Jech
- J. Bousquet Genetic Variation in a Nitrogen Fixing Shrub, Alnus
M. Lalonde crispa (Ait.) Pursh.
W.M. Cheliak
- M. Tremblay Variation du patron des protéines au cours de
M. Lalonde l'acclimatation au froid d'Alnus
- O.P. Rajora Evidence for Common Domain of Sporophytic and
Gametophytic Gene Expression in Populus deltoides
Marsh. and P. nigra L. and P. maximowiczii
- O.P. Rajora Mating Systems and Fertilizing Pollen Gene Pools of
P. deltoides Marsh. and P. nigra L. Clones Located in
Different Compatible Species Neighbourhoods as Inferred
from Isozyme Analysis

- | | |
|---------------|---|
| R.K. Dixon | Growth and Ectomycorrhizal Development of <u>Pinus taeda</u> |
| H.E. Garrett | Progenies Inoculated with Three Isolates of <u>Pisolithus</u> |
| H.E. Stelzer | <u>tinctorius</u> |
| R.R. Belanger | Testing of a Method For Screening Aspen For Hypoxylon |
| P.D. Mannion | Canker Resistance |
| R.A. Savidge | Prospects for Genetic Manipulation of Wood Quality |
| J.F. Kraus | Disease Resistance from Hybrids of <u>Pinus echinata</u> |
| | and <u>Pinus taeda</u> |
| J.B. Genys | Stem Quality and Volume of Different Strains of White |
| | Spruce from Canada Studied in Maryland |

LISTE DES PARTICIPANTS AU 20IEME CONGRES BIENNAL
DE L'ASSOCIATION CANADIENNE POUR L'AMELIORATION DES ARBRES,
TENU DU 19 AU 22 AOUT 1985 A L'UNIVERSITE LAVAL,
SAINTE-FOY, QUEBEC

ACKERMAN R.F.
Petawawa Nat. Forestry Institute
Chalk River, Ont.
K0J 1J0

ADAMS GREG
J.D. Irving Ltd.
Sussex Nursery
New Brunswick
EOE 1P0

AKERLEY BRIAN J.
New Brunswick Tree Improvement
Council
P.O. Box 4000
Fredericton, N.B.
E3B 5P7

AMIRAUT PETER
Northern Forest Research Centre
5320-122nd St.
Edmonton, Alta.
T6J 4A9

APRIL REGIS
941 Bordeaux
St-Jean-Chrysostome, Qué.
G6Z 1M2

BAKER BILL
Ontario Ministry of Natural Resources
P.O. Box 5160
Kenora, Ont.
P9N 3X9

BAKER STOKES S.
SUNY-ESF
350 Illick Hall
Syracuse NY
13210 U.S.A.

BALATINECZ JOHN J.
Faculty of Forestry
University of Toronto
203, College St.
Toronto, Ont.
M5S 1A1

BEALLE CATHERINE
4531, Nanaimo St.
Vancouver, B.C.
V5N 5J2

BEATSON BETH
88 Bernard Ave., Apt 603
Toronto, Ontario
M5R 1R7

BEAUDOIN MICHEL
Université Laval
Sainte-Foy, Qué.
G1K 7P4

BEAUDOIN ROGER
M.E.R.
Service de la recherche
2700 Einstein
Sainte-Foy, Qué.
G1P 3W8

BEAULIEU JEAN
Service canadien des forêts
1055, rue du P.E.P.S.
C.P. 3800
Sainte-Foy, Qué.
G1V 4C7

BEGIN JACQUES
1155 Metcalfe, 14e étage
Montréal, Qué.
H3B 2X1

BELANGER RICHARD
SUNY-ESF
350 Illick
Syracuse NY
13210 U.S.A.

BETTLE ROBERT D.
New Brunswick Department
Natural Resources
Provincial Forest Nursery
R.R. #6
Fredericton, N.B.
E3B 4X7

BISOFFI S.U.
Soc. Agri. For.
1-15033 Casale Monferrato
Strada Frassineto 32
C.P. 116
Roma, Italy

BLAKE MARGARET
Biology Department
University of Victoria
P.O. Box 1700
Victoria, B.C.
V8W 2Y2

BONGARTEN BRUCE
School of Forest Resources
University of Georgia
Athens, GA
30602 U.S.A.

BONNEAU GILLES
M.E.R.
2700 Einstein
Sainte-Foy, QC
G1P 3W8

BOUDOUX MICHEL
Service canadien des forêts
1055 rue du P.E.P.S.
C.P. 3800
Sainte-Foy, Qué.
G1V 4C7

BOURCHIER R.J.
R.R. #1, Box 255
Cantley, Qué.
J0X 1L0

BOYLE TIM
Petawawa Nat. Forestry Institute
Chalk River, Ont.
K0J 1J0

BOWSER G.K.
c/o Fraser Inc.
27 Rice St.
Edmundston, N.B.
E3V 1S9

BOUSQUET JEAN R.
1205, 2e Avenue, Apt. 5
Québec, P.Q.
G1L 3C8

BRAULT NORMAND
Pépinière forestière de Berthierville
1690 Grande-Côte
C.P. 540
Berthierville, Qué.
J0K 1A0

BRETON PIERRE
Service canadien des forêts
1055 rue du P.E.P.S.
C.P. 3800
Sainte-Foy, Qué.
G1V 4C7

BRYM PETR
Department of Forest Resources
University of New Hampshire
Durham, N.H.
03824 U.S.A.

BULLEY EDWARD
Bowater Mersey Paper Co. Ltd.
P.O. Box 1150
Liverpool, N.S.
BOT 1K0

BUSSIERES GUY
1487 de la Colline
Cap-Rouge, Qué.
G1Y 2Z9

BUTLER MIKE
Department Energy and Forestry
P.O. Box 2000
Charlottetown, P.E.I.
C1A 7N8

CARSON MIKE
R.R. #1
Thurso, Qué.
J0X 3B0

CARTER KATHERINE
Department of Forest Biology
University of Maine
Orono, ME
04469 U.S.A.

CHARLEBOIS NORMA
23 Herrick St.
S.S. Maple, Ont.
P6A 2T1

CHAGALA EBBY
University of Toronto
Ontario
M1L 3E9

CHELIAK WILLIAM M.
Petawawa Nat. Forestry Institute
Chalk River, Ont.
K0J 1J0

COLANGELI M. ANNA
Department of Biology
University of Victoria
Box 1700
Victoria, B.C.
V8W 2Y2

COLES JIM
Ontario Tree Improvement Council
Johnston Hall
University of Guelph
Guelph, Ont.
N1G 2W1

CORNU DANIEL
I.N.R.A.
Centre de Recherches Forestières
Station d'amélioration des
arbres forestiers
Ardon
45160 Olivet
France

CORRIVEAU ARMAND
Service canadien des forêts
1055 rue du P.E.P.S.
C.P. 3800
Sainte-Foy, Qué.
G1V 4C7

CROOK GREGORY
C.I.P. Inc.
R.R. #2
Calumet, Qué.
J0V 1B0

DANCIK BRUCE P.
Department of Forest Science
University of Alberta
Edmonton, Alta.
T6G 2H1

DAOUST GAETAN
Service canadien des forêts
1055 rue du P.E.P.S.
C.P. 3800
Sainte-Foy, Qué.
G1V 4C7

DAVIAULT PIERRE
622 Frontenac
C.P. 600
Berthierville, Qué.
J0K 1A0

DE GROOT PETER
66 Cedar St.
Hilton Beach, Ont.
P0R 1B0

DEHAYES D.
School of Natural Resources
UVM
Burlington, VT
05405 U.S.A.

DESCHENES E.
c/o Fraser Inc.
27 Rice St.
Edmundston, N.B.
E3V 1S9

DHIR N.K.
39, 10160 0 119 Street
Edmonton, Alta.
T5K 1Y9

DION ANDRE
C.I.P. Inc.
1053 boul. Ducharme
La Tuque, Qué.
G9X 3P9

DIXON ROBERT
College of Forestry
University of Minnesota
1530 N. Cleveland Ave.
St. Paul, MN
55438 U.S.A.

DOJACK J.
Ontario Ministry of Natural Resources
North Central Region
Ontario Government
435 James Street
P.O. Box 5000
Thunder Bay, Ont.
P7C 5G6

DUBE LOUIS-RENE
5165 Route 112
Ascot Corner, Qué.
J0B 1A0

EAVY A. LEE
Cooperative Forestry Research Unit
116 Nutting Hall
University of Maine
Orono, ME
04469 U.S.A.

ETHERIDGE PETER
J.D. Irving Ltd.
Sussex Tree Nursery
R.R. #4
Sussex, N.B.
E0E 1P0

ETTINGER, TERRY I.
Department of Horticultural Science
and Landscape Architecture
University of Minnesota
St. Paul, MN
55108 U.S.A.

FARMER ROBERT
School of Forestry
Lake head University
Thunder Bay, Ont.
P7B 5E1

FRAME HOWARD M.
N.S. Dept. of Lands and Forests
Tree Breeding Centre
Debert, N.S.
BOM 1G0

FAST WILLI
102 10530 83 Avenue
Edmonton, Alta.
T6E 2C9

FRANCOEUR RAYMOND
109, boul. St-Vincent
Ancienne-Lorette, Qué.
G2G 1E4

FLEMING RICH
79 Ashgrove
Sault Ste.Marie, Ont.
P6A 5M7

FRISQUE GILLES
Directeur
Centre multirégional de rech. en
sciences et technologies forestières
Université du Québec
2875 boul. Laurier
Sainte-Foy, Qué.
G1V 2M3

FOGAL WILLARD
Petawawa Nat. Forestry Institute
Chalk River, Ont.
K0J 1J0

FUERNKRANZ HANS
School of Forestry
State University of New York
College of Env. Science and Forestry
Syracuse, N.Y.
13210 U.S.A.

FORTIN ANDRE
Faculté de Foresterie
Université Laval
Sainte-Foy, Qué.
G1K 7P4

GENYS JOHN B.
University of Maryland
AEL,CEES
Frostburg, MD
21532 U.S.A.

FORTIN YVES
Département des Sciences du Bois
Université Laval
Sainte-Foy, Qué.
G1K 7P4

GILBERT RENALD
1023 Pouliot
Baie-Comeau, Qué.
G5C 2P5

FOWLER DONALD P.
Canadian Forestry Service
P.O. Box 4000
Fredericton, N.B.
E3B 5P7

GONZALEZ JOSEFINA S.
6620 NW Marine Drive
Vancouver, B.C.
V6T 1X2

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

GRANT GARY
Canadian Forestry Service
P.O. Box 490
Sault Ste. Marie, Ont.
P6A 5M7

GRENIER JACQUES
200-B Chemin Ste-Foy
Québec, P.Q.
G1R 4X7

HAKMAN INGER
Inst. Physiological Botany
University of Uppsala
Box 540
S-751 21 Uppsala, Sweden

HALL SIMON
School of Forestry
State University of New York
College of Env. Sci. and Forestry
Syracuse, N.Y.
13210 U.S.A.

HARDY YVAN
Service canadien des forêts
1055 rue du P.E.P.S.
C.P. 3800
Sainte-Foy, Qué.
G1V 4C7

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

HOLLINGSWORTH BRIAN
Fast Growing Hardwoods Program
Ministry of Natural Resources
R.R. No. 1
Brockville, Ont.
K6V 5Y8

IKEMORI YARA KIEMI
Aracruz Florestal s/a
RVA Professor LoBo 1138
Aracruz - Espirito Santo-Brasil
CEP: 29190

IMADA S.E.
Abitibi-Price Research
Mississauga, Ont.
L5K 1A9

JANAS PETER
Petawawa Nat. Forestry Institute
Chalk River, Ont.
K0J 1J0

JOBIN GUY
151 avenue Parent, Apt. 3
Québec, P.Q.
G1K 1H5

KANAK KAREL
Arboretum Sofronva
P.O. Box 125
CS-30425 PL2EN-1

CLAYTON KEITH
Forintek Canada Corp.
800 Montreal Road
Ottawa, Ont.
K1G 3Z5

KELLOGG R.M.
Forintek Canada Corp.
6620 N.W. Marine Drive
Vancouver, B.C.
V6T 1X2

KEMPTON STANLEY
Bowater Mersey Paper Co. Ltd.
Box 1150
Liverpool, N.S.
BOT 1K0

KENNY J.R.
1512 109 St.
Edmonton, Alta.
T6J 5W8

KEYS ROY N.
West Virginia University
Division of Forestry
P.O. Box 6125
Morgantown WV
26506-6125 U.S.A.

KIRBY EDWARD G.
Department Botany
Rutgers University
Neward, New Jersey
07102 U.S.A.

KLEIN JEROME L.
Northern Forest Research Centre
5320-122 Street
Edmonton, Alta.
T6H 3S5

KOLOTELO DAVID
623 Albert St.
Fredericton, N.B.
E3B 2C2

KRAUS JOHN F.
U.S. Forest Service
Southeastern Forest Experiment Station
Route 1
Box 182 A
Dry Branch, GA
31020 U.S.A.

KRIEBEL H.B.
Ohio State University - OARDC
Department of Forestry
Wooster, OH
44691 U.S.A.

KRUGMAN S.L.
U.S.D.A. Forest Service
Timber Management Research
P.O. Box 2417
Washington, DC
U.S.A.

LABRECQUE MICHEL
4101 E. Sherbrooke
Jardin Botanique de la Ville
de Montréal
Montréal, Qué.
H1X 2B2

LALONDE MAURICE
Faculté de Foresterie
Université Laval
Sainte-Foy, Qué.
G1K 7P4

LAMONTAGNE YVES
Ministère Energie et Ressources
Service Pépinières et Reboisement
200B, Chemin Ste-Foy
Québec, P.Q.
G1R 4X7

LAVALLEE ROBERT
Service canadien des forêts
1055 rue du P.E.P.S.
C.P. 3800
Sainte-Foy, Qué.
G1V 4C7

LAVERGNE ETIENNE
56 rue Cayer
C.P. 206
Lanoraie, Qué.
J0K 1E0

LEBLANC RAY
University of New Brunswick
Department of Forest Resources
Fredericton, N.B.
E3B 6C2

LEVESQUE DENIS
880 Marie-Victorin
St-Nicolas Est, Qué.
G0S 3L0

LOPUSHANSKI S.M.
Petawawa Nat. Forestry Institute
Chalk River, Ont.
K0J 1J0

MACKAY JOHN
3409 Sarnia
Québec, P.Q.
G1X 2K5

MAGNUSSEN STEEN
Petawawa Nat. Forestry Institute
Chalk River, Ont.
K0J 1J0

MAILLOUX F.
721 Ste-Madeleine
Québec, P.Q.
G1R 3M5

MALENFANT DENIS
320 Dubuc
Duberger, Qué.
G1P 3R8

MANGOLD ROBERT
2427 N. Wygant
Protland Ore
97218

MATYAS C.
35 Charles St. W., Apt. 2109
Toronto, Ont.
M4Y 1R6

MAYNARD CHARLES
School of Forestry
State University of New York
College of Env. Sci. and Forestry
Syracuse, N.Y.
13210 U.S.A.

MENETRIER JEAN
2700 Einstein
Sainte-Foy, Qué.
G1P 3W8

MERCIER J.D.
Canadian Forestry Service
930 Carling Avenue
9th Floor, Room 953
Ottawa, Ont.
K1A 0C5

MILLER GORDON
Canadian Forestry Service
506 West Burnside Road
Victoria, B.C.
V8Z 1M5

MONGEAU ROGER
1050 St-Roch Nord
Rock Forest, Qué.
JOB 2J0

MORGENSTERN E.K.
Faculty of Forestry
University of New Brunswick
Fredericton, N.B.
E3B 6C2

MORISSETTE JACQUES
Service canadien des forêts
1055 rue du P.E.P.S.
C.P. 3800
Sainte-Foy, Qué.
G1V 4C7

MORISSETTE THOMAS
833 Ernest Gagnon
Québec, P.Q.
G1S 3R1

MOSSELER ALEXANDER
University of Toronto
Faculty of Forestry
Toronto, Ont.
M5S 1A1

MOTHE FREDERIC
51 rue du Bois
Fille d'Auray, France
92610

MUGHINI G.
Soc. Agri. For.
Centro di sperimentazione
Agricole & Forestale Roma
Via Casalotti 300 Italy

MULLIN TIM J.
N.S. Department Lands and Forests
Tree Breeding Centre
Debert, N.S.
BOM 1G0

MURRAY GORDON
Petawawa Nat. Forestry Institute
Chalk River, Ont.
K0J 1J0

NOREAU RICHARD
1948 Fesnez
Sainte-Foy, Qué.
G2G 1V8

OWENS JOHN N.
Biology Department
University of Victoria
Victoria, B.C.
V8W 2Y2

PANDILA MADAN M.
Dept. Parks & Renewable Resources
Box 3003
Prince Albert, Sask.
S6V 6G1

PARE DIANE
2035 Costebelle
Les Saules, Qué.
G1P 1A3

PARROT LOUIS
Faculté de Foresterie
Université Laval
Sainte-Foy, Qué.
G1K 7P4

PERINET PIERRE
Laboratoires Rhizotec Inc.
C.P. 797
St-Jean-Chrysostome, Qué.
G6Z 2L9

PHARIS R.P.
Department of Biology
University of Calgary
2920 24th avenue N.W.
Calgary, Alta.
T2N 1N4

PITEL JACK A.
Petawawa Nat. Forestry Institute
Chalk River, Ont.
K0J 1J0

POLIQUEIN JEAN
Faculté de Foresterie
Université Laval
Sainte-Foy, Qué.
G1K 7P4

POLLARD DOUG
Canadian Forestry Service
Agriculture Canada
351 boul. St-Joseph
Hull, P.Q.
K1A 1G5

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

PRAT DANIEL
E.N.G.R.E.F.
14 rue Girardet
54042 Nancy Cedex
France

PRINCE FRED
37069 Charter Oaks Blvd.
Mt. Clemens, Michigan
48043 U.S.A.

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

RAJORA OM PRAKASH
Faculty of Forestry
University of Toronto
203 College St.
Toronto, Ont.
M5S 1A1

ROCHON MICHEL
Service canadien des forêts
1055 rue du P.E.P.S.
C.P. 3800
Sainte-Foy, Qué.
G1V 4C7

RODDY DIANE
Woodlands Enterprises Ltd.
P.O. Box 1720
Prince Albert, Sask.
S6V 5T3

ROSS HUGH
Stora Forest Industries
P.O. Box 59
Port Hawkesbury, N.S.
B0E 2V0

ROSS STEVEN D.
British Columbia
Ministry of Forests
Research Branch
1450 Government Street
Victoria, B.C.
V8W 3E7

SAMSON GASTON
1565, 34e Rue
Sainte-Prosper
Beauce-Sud, Qué.
G0M 1M0

STILES SUE
402 James Hall
Dept. Forest Resources
University of New Hampshire
Durham, N.H.
03824 U.S.A.

SAVIDGE R.A.
Dept. of Forest Resources
U.N.B.
Fredericton, N.B.
E3B 6C7

STIPANICIN ANTE
C.P. 105
Cap Rouge, Qué
G1Y 3C6

SCHLARBAUM SCOTT E.
Dept. of Forestry
Wildlife and Fisheries
University of Tennessee
P.O. Box 1071
Knoxville, TN
37901-1071 U.S.A.

STOEHR MIKE
University of Toronto
Faculty of Forestry
203 College Street
Toronto, Ontario
M5S 1A1

SCHOOLEY HUGH O.
Petawawa Nat. Forestry Institute
Chalk River, Ontario
K0J 1J0

SUMMERS D.
Sylviculture Branch
B.C. Ministry of Forests
1450 Government Street
Victoria, B.C.
V8W 3E7

SEGARAN SANDY
Manitoba Natural Resources
305 - 530 Kenaston Blvd
Winnipeg, Manitoba
R3N 1Z4

SWEETING KEVIN
273 Pharmacy Ave., Apt. 607
Toronto, Ontario
M1L 3E9

SIGURGEIRSSON ADALSTEINN
Box 247 Sub. P.O. 11
Edmonton, Alberta
T6G 2E0

SYME PAUL
Canadian Forestry Service
P.O. Box 490
Sault Ste. Marie, Ontario
P6A 5M7

SIMPSON DALE
Canadian Forestry Service
Box 4000
Fredericton, N.B.
E3B 5P7

THOMPSON BRENT
J.D. Irwing Ltd.
300 Union Street
Saint-John, N.B.
E2L 4Z2

TURGEON JEAN
Canadian Forestry Service
P.O. Box 490
Sault Ste.Marie, Ont.
P6A 5M7

THOR ARC
Stora Forest Industries
P.O. Box 59
Port Hawkesbury, N.S.
BOE 2V0

VALENTINE FREDRICK A.
State University of New York
College of Environmental Science
and Forestry
Syracuse, New York
13210 U.S.A.

TIMMIS ROGER
Weyerhaeuser Company
WTC 2C2
Tacoma, WA
98477 U.S.A.

VALLÉE GILLES
Gouvernement du Québec
Ministère de l'Énergie et des
Ressources
Service de la Recherche
2700 Einstein
Sainte-Foy, Qué.
G1P 3W8

TODHUNTER MICHAEL N.
International Paper Company
Southlands Experiment Forest
Gainbridge, GA
31717

VILLENEUVE MICHEL
Faculty of Forestry
University of New Brunswick
Bag Service #44555
Fredericton, N.B.
E3B 6C2

TOSH KATHLEEN J.
Faculty of Forestry
University of New Brunswick
Bag Service #44555
Fredericton, N.B.
E3B 6C2

VON ADERKAS P.
Research and Productivity Council
P.O. Box 6000
Fredericton, N.B.
E3B 5H1

TREMBLAY FRANCINE
Petawawa Nat. Forestry Institute
Chalk River, Ont.
K0J 1J0

WANYANCHIA JAMES
Department For. Resources UNB
Fredericton, N.B.
E3B 6C2

TREMBLAY JACQUES R.
CEGEP Sainte-Foy
2410 Chemin Ste-Foy
Sainte-Foy, Qué.
G1V 1T3

WANG B.S.P.
Petawawa Nat. Forestry Institute
Chalk River, Ont.
K0J 1J0

WASSER RONALD
J.D. Irving Ltd.
Sussex Tree Nursery
R.R. 4 Aiton Road
Sussex, N.B.

WEBB DAVID
Biology Dept.
Queen's University
Kingston, Ont.
K7L 3N6

WEST R.J.
Box 6028
St. John's, Nfld.

WHEELER NICHOLAS
Weyerhaeuser Research
P.O. Box 420
Centralia, WA
98531 U.S.A.

WINSTON DAVE
Canadian Forestry Service
Ottawa, Ont.
K1A 1G5

WOLFE ANITA
B.C. Ministry of Forests
Coastal Seed Orchards
Box 816
Duncan, B.C.
V9L 3X1

YANCHUK ALVIN
Reforestation and Reclamation Branch
Alberta Forest Service
9920-108 Street, 9th Floor
Edmonton, Alta.

YEATMAN CHRISTOPHER W.
Petawawa Nat. Forestry Institute
Chalk River, Ont
K0J 1J0

YEH FRANCIS
Research Branch
B.C. Ministry of Forests
1450 Government Street
Victoria, B.C.
V8W 3E7

ZSUFFA LOUIS
University of Toronto
Faculty of Forestry
203 College St.
Toronto, Ont.
M5S 1A1