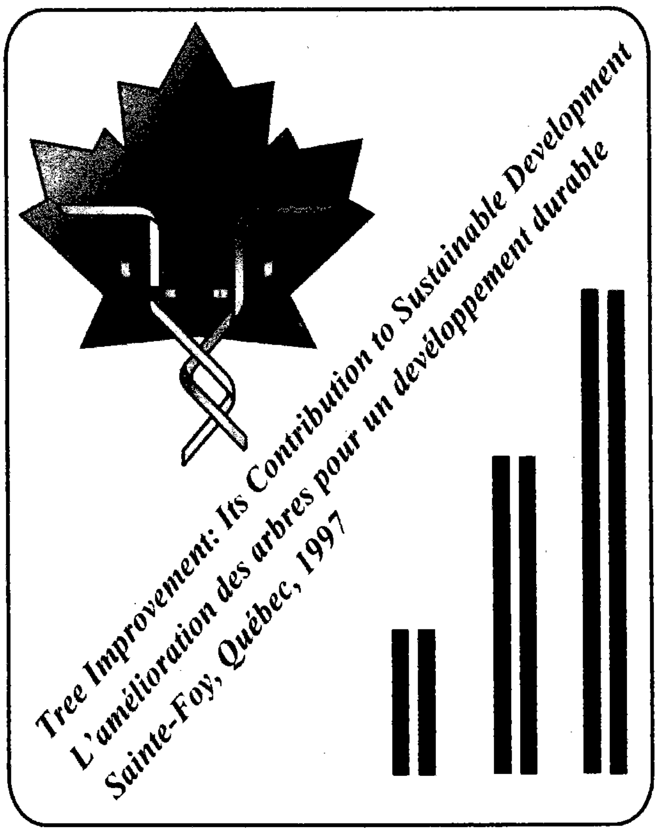
PROCEEDINGS OF THE TWENTY-SIXTH MEETING

OF THE

CANADIAN TREE IMPROVEMENT ASSOCIATION

PART 1 Minutes and Members' Reports
PART 2 Symposium



COMPTES RENDUS DU VINGT-SIXIÈME CONGRÈS

DE

L'ASSOCIATION CANADIENNE POUR

L'AMÉLIORATION DES ARBRES

1ere PARTIE Procès-verbaux et rapports des membres
2e PARTIE Colloque

PROCEEDINGS

OF THE

TWENTY-SIXTH MEETING

OF THE

CANADIAN TREE IMPROVEMENT ASSOCIATION

PART 1

Minutes and Members' Reports

TREE IMPROVEMENT: ITS CONTRIBUTION TO SUSTAINABLE DEVELOPMENT

Sainte-Foy, Québec
August 18-21, 1997

Editor
J.D. Simpson

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COMPTES RENDUS

DU

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1ere PARTIE

Procès-verbaux et rapports des membres

L' AMÉLIORATION DES ARBRES POUR UN DÉVELOPPEMENT DURABLE

Sainte-Foy, Québec
18-21 août 1997

Rédacteur
J.D. Simpson

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PROCEEDINGS OF THE TWENTY-SIXTH MEETING OF THE CANADIAN TREE IMPROVEMENT ASSOCIATION

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CTIA/ACAA 26th BUSINESS MEETING MINUTES

C.T.I.A./A.C.A.A
26th Business Meeting
Minutes

Michel Villeneuve chaired the 26th Business Meeting of the CTIA/ACAA held in the Multimedia Room, Pavillon Desjardin, Québec City, Québec on Wednesday August 20, 1997. Twenty-two members were present.

296 Minutes of the 25th Meeting

(as printed in the proceedings from the 25th meeting, Part I)

Motion: The minutes of the 25th Business Meeting be approved as published.
Moved by: Kathy Tosh
Seconded by: Jerry Klein
Carried.

297 Membership

297.1 Honourary Membership

Motion: That the following members of the CTIA/ACAA be nominated for "honourary" membership for the outstanding contributions to the field of genetics and tree improvement in Canada during their career.

Jim Coles	Consultant
Alan Gordon	Ontario Ministry of Natural Resources
Gyula Kiss	BC Ministry of Forests
Jerry Klein	Consultant
Yves Lamontagne	Ministère des Ressources naturelle du Québec
Gordon Murray	Natural Resources Canada-Petawawa
Louis Parrot	Université Laval
Hugh Schooley	Natural Resources Canada-Petawawa
Gilles Vallée	Ministère des Ressources naturelle du Québec

Moved by: Jean Beaulieu
Seconded by: Gaétan Daoust
Carried.

297.2 Active Membership

The names of nominated active members were presented as follows:

Tannis Beardmore	Canadian Forest Service Fredericton, NB
Francine Bigras	Service canadien des forêts Sainte-Foy, Qc

Anne-Christine Bonfils	Canadian Forest Service Ottawa, ON
Peter Copis	Canadian Forest Service Chalk River, ON
Nathalie Isabel	Service canadien des forêts Sainte-Foy, Qc
Sylvie Laliberté	Université du Québec à Montréal Montréal, Qc
Wade MacKinnon	Dept. Agriculture and Forestry Charlottetown, PEI
Bryce MacInnis	New Brunswick Tree Improvement Council Fredericton, NB
Jon Sweeney	Canadian Forest Service Fredericton, NB
Rong-cai Yang	University of Alberta Edmonton, AB
John Quinn	Alberta Land and Forest Service Smoky Lake, AB

Motion: That the nominated active members be duly elected.
Moved by: Jean Beaulieu
Seconded by: John Dojack
Carried.

298 Chair's Report

Organizing the 26th meeting of the association was a challenge that could not be met without the support of numerous people from the Ministère des Ressources naturelles, Ressources naturelles Canada, Université Laval, Forintek Canada Corporation, and I.U.F.R.O.-S5.01(wood quality). The 1995/1997 executive committee (Jean Beaulieu, Jean Bousquet, André Rainville and myself) particularly appreciated the efforts of Pierre Bélanger (logistics coordinator) and François Larochelle (on-site arrangements).

Two excellent workshops were presented by the Tree Seed Working Group (chaired by Stéphan Mercier) and the Wood Quality Working Group (chaired by Tony Zhang, with the contribution of IUFRO-S5.01). Proceedings of the first will be published in the Forestry Chronicle; for the latter, they were included in the registration package (copies may be obtained by contacting Forintek Canada Corp.).

Thanks to the voluntary contribution of Jean Ménétrier, the logo of the CTIA/ACAA is now available in digitized formats for use on letterheads and other official documents. Designer of the cover page on the program and the proceedings, Jean is a biologist, tree lover and artist who works as a researcher for the Ministère des Ressources naturelles du Québec.

299 Treasurer's Report

The financial statement for the period of July 30, 1995 to July 30, 1997 was prepared by Treasurer Linda DeVerno and tabled for information and acceptance by the membership (see Attachment #1). The statement shows a balance of $4,539.99 in the Association's account and GIC's totalling $23,000.00.

Motion: That the financial statement be accepted as presented.
Moved by: Jean Bousquet
Seconded by: Alvin Yanchuk
Carried.

300 Financial Contributions

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Harnois Inc.
Industries James Maclaren Ltée
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Quebec Balsam Export Inc.
an anonymous contributor

Motion: That the CTIA/ACAA executive of the 26th meeting express our sincere appreciation to these contributors.
Moved by: Om Rajora
Seconded by: Gilles Vallée
Carried.

301 Editor's Report

The proceedings were printed and distributed during April 1996 to all active members, honourary members, Canadian universities and libraries, and all participants of the 25th meeting. Three hundred and forty-six proceedings were mailed.

A form letter advising the theme of the 25th biennial meeting, the proceeding context, and a request for a twenty dollar donation to obtain a copy was sent to all corresponding members, USA addresses and international addresses. There were 11 donations from Canadian addresses, 13 from USA and 19 international.

302 Education Committee

To promote students' knowledge and understanding in tree improvement activities and forest genetics research, the forestry faculties of Canadian universities were encouraged to nominate a student to attend the 26th CTIA/ACAA meeting. Sponsorship of these students is paid by the executive committee of each biennial meeting through registration fees. Students received an autographed copy of Kris Morgenstern's book "Geographic Variation in Forest Trees." Jean Beaulieu reported that the following students received the award which provided all meeting costs including registration, accommodation, tours, and travel:

Andy Benowicz	University of British Columbia
Changxi Li	University of Alberta
Daniel Rouillard	Lakehead University
Christina Idziak	University of Toronto
Sauphie Senneville	Université Laval
Frédéric Poirier	Université de Moncton
Yijun Xu	University of New Brunswick

303 Working Group Reports

303.1 Tree Seed Working Group

André Rainville moderated the Tree Seed Working Group's (TSWG) morning workshop "Artificial Pollination in Seed Orchards" on August 18, 1997. The workshop was dedicated to Dr. Guy-Etienne Caron, chairperson of the TSWG (1991-1997).

Immediately following the workshop, the Tree Seed Working Group held its regular Biennial Business Meeting. Three issues of the TSWG News Bulletin (Nos. 24-26) were produced since our last meeting on August 28, 1995 in Victoria. Editor Ron Smith (CFS - Atlantic) reiterated that he intends to maintain the traditional two issues per year, but due to 'technical difficulties' there was one fewer issue printed over the last two-year period. A suggestion was forthcoming that due to more and more people now able to use electronic mail that this avenue should be explored. Ron is in the process of updating addresses and is also expecting to have a web site for the TSWG at CFS - Atlantic in the near future. So, the News Bulletin will be available to the Discussion Group on the Internet soon.

Thanks go to Ron for editing, printing, and mailing of our News Bulletin. There were no further changes noted with respect to working parties; Dave Kolotelo remains as Coordinator of the Tree Seed Processing and Testing Working Party and Peter de Groot stays on as Coordinator of the Cone and Seed Insects Working Party. Howard Frame agreed to take on the role of Chairperson for the TSWG.

The question of when and where our next meeting will be, was left unanswered. The CTIA business meeting on Wednesday may shed some light on this topic, but the News Bulletin will keep everyone apprised on this subject.

Howard M. Frame
NS Dept. Natural Resources
Chair, CTIA Tree Seed Working Group

303.2 Wood Quality Working Group

No formal workshop was specifically organized for the 1997 CTIA Wood Quality Working Group (WQWG) due to an excellent wood quality meeting organized by Forintek Canada Corporation and sponsored by the IUFRO and CTIA. Tony Zhang and I discussed several approaches and it was decided that the wood quality papers related to tree improvement could be incorporated into one session and that would represent the objectives of the WQWG more than adequately. On behalf of

CTIA members who are involved in wood quality research, I'd like to thank IUFRO and Forintek for an excellent meeting and the 14 papers published in Chapter IV of the proceedings "Timber Management Toward Wood Quality and End-Product Value" are an excellent contribution to the literature on this topic. The effort far exceeded that which could have been organized by the WQWG alone, and much of this credit goes to Tony. The excellent international participation and the papers by Drs. Zobel and van Buijtenen provided for a truly world class meeting.

No business meeting was held. It would be appropriate, considering the renewed interest in wood properties breeding in many programs across Canada, to review and update the objectives and mandate of the WQWG at the next CTIA meeting. Renewing our interest in the newsletter would also be important. I will coordinate this matter with the executive of the CTIA for the next meeting.

Alvin Yanchuk
BC Forest Service, Victoria
Chair, CTIA Wood Quality Working Group

304 Business Arising from Previous Meetings

304.1 Funding for History of Forest Genetics in North America

Motion 292.4: That the CTIA/ACAA support Lauren Fins with two thousand Canadian dollars, for the proposed manuscript "A History of Forest Genetics and Tree Improvement in North America" on the condition, that L. Fins receive five supporting offers from other sectors.

In a letter dated March 29, 1996 Lauren Fins confirmed she was able to secure funding from two other sources. However, she stated she intended to continue her efforts to raise the additional funds. As such, until she receives five supporting offers the CTIA/ACAA will not advance any funds.

305 New Business

305.1 University of Northern British Columbia

Chairman Michel apologized that the university had not been contacted to send a student to the CTIA/ACAA meeting. It was realized too late that it might have been appropriate. He asked why there was no student from this university at the Victoria meeting. Alvin Yanchuk stated that the forestry program is new and it was an oversight in not inviting them to send a student to the last meeting. Concern was raised that with more universities offering forestry/environmental courses it may be difficult to draw the line on which ones to invite to send students. Kathy Tosh suggested that only universities offering an accredited forestry degree program should be contacted.

305.2 Constitution and Bylaws

Last summer, Narinder Dhir brought to the attention of Chairman Michel that several amendments have been made to the Constitution and Bylaws since they were last published. Dale agreed to re-publish them and distribute them to Active members with the copy of the Proceedings from this meeting.

305.3 Registration of CTIA/ACAA

The CTIA/ACAA is currently registered in Ontario as a society. Since the business affairs have been transferred to New Brunswick it is logical to become registered there. Jim Richardson pointed out that the Poplar Council of Canada is registered nationally and such a registration status may also be appropriate for CTIA/ACAA. The Executive Secretary will examine the situation and register the organization where most appropriate.

305.4 Bursary

Chairman Michel suggested the Association should consider a recognition award to students who write a paper or essay on their research results or any tree improvement/genetics topic. Honorary members could be selected to review the papers and recommend up to three names for awards. The awards would be presented at the CTIA/ACAA meeting. Michel agreed to form a small committee to develop a terms of reference for this award program.

306 Future Meetings

306.1 Location of 1999 Meeting

Weyerhaeuser Canada of Saskatchewan is unable to host the 1999 CTIA/ACAA meeting. Ontario Ministry of Natural Resources suggested they were willing to host the next meeting in Sault Ste. Marie. Dennis Joyce pointed out this is a good location because of its close proximity to the USA allowing the option for Americans to obtain accommodation in Sault Ste. Marie, Michigan and travel to Canada daily to attend the meeting. He further suggested teaming up with the Southern Forest Tree Improvement Conference (SFTIC) and Western Forest Genetics Association (WFGA) in order to have a larger, more dynamic meeting. It was pointed out that SFTIC and WFGA have already determined where they will meet in 1999. Dennis suggested to delay a year and have it in 2000. It was pointed out that the Constitution and Bylaws state the CTIA/ACAA must meet every two years. After considerable discussion the following motion to **amend** "Article VI, Section a" of the Constitution was tabled.

Motion: Meetings of the Association shall be held at least once every third year.
Moved by: Jerry Klein
Seconded by: Jean Beaulieu
Carried

This allowed a motion on when the next meeting should be held.

Motion: CTIA/ACAA hold its next meeting in Sault Ste. Marie, Ontario in the year 2000.
Moved by: Jerry Klein
Seconded by: Kathy Tosh
Carried.

306.2 Location of the Next Meeting

Motion: Alberta will explore the feasibility of hosting a meeting in 2002 or 2003.
Moved by: Om Rajora
Seconded by: Jean Beaulieu
Carried.

306.3 Location of Subsequent Meeting

No suggestions were forth coming.

307 Election of New Executive

The following slate of officers will serve as the executive for the next CTIA/ACAA meeting:

Chairperson:	Dennis Joyce Ministry of Natural Resources
Vice-Chairperson: Symposium	to be confirmed
Vice-Chairperson: Local arrangements	to be confirmed
Treasurer:	Linda DeVerno Canadian Forest Service
Editor:	Dale Simpson Canadian Forest Service
Executive Secretary:	Dale Simpson Canadian Forest Service

308 Adjournment

Motion: That the members of the CTIA/ACAA thank the executive for their efforts over the past two years for an exciting and successful meeting.

Motion: That the 26th business meeting of the CTIA/ACAA be adjourned
Moved by: Om Rajora

Attachment # 1

CTIA/ACAA
Financial Statement
July 30, 1995 to July 30, 1997

Cash Balance July 30, 1995	**$7 175.53**
Credit:	
Interest earnings (GIC, Account)	3 058.34
Purchase of 25th Meeting Proceedings	940.85
Donation for the 26th Meeting Proceedings from CFS Headquarters	4 817.84
Total Credit:	**$8 817.03**
Guaranteed Investment Certificates: (as of July 30, 1995)	
GIC Principal	10 000.00
GIC Principal	7 000.00
GIC Principal	6 000.00
Total GICs	**$23 000.00**
Guaranteed Investment Certificates: (as of July 30, 1997)	
GIC Principal	10 000.00
GIC Principal	8 000.00
GIC Principal	5 000.00
Total GICs	**$23 000.00**
Debit:	
Labels	36.74
Bank Service Charge	20.00
26th CTIA Meeting advance	5 000.00
Film Processing	17.46
Envelopes & Letterhead	495.83
Envelopes	58.20
Student Recognition Awards	1 000.00
Money Order Fees	6.50
26th CTIA Meeting Proceedings Advance	4 817.84
Total Debit:	**$11 452.57**
Cash Balance July 30, 1997	**$4 539.99**
Invested GIC Balance	**$23 000.00**
Total Holdings	**$27 539.99**

ACTIVITY REPORTS
FROM ACTIVE CTIA/ACAA
MEMBERS

THE NEWFOUNDLAND AND LABRADOR TREE IMPROVEMENT PROGRAM: AN UPDATE

B. J. English

Dept. of Forest Resources & Agrifoods
P. O. Box 2006, Fortis Building
Corner Brook, NF
A2H 6J8

The Newfoundland Forest Service has in place tree improvement programs for three native conifers: black spruce, white spruce, and eastern larch. Six first generation seed orchards have been established, two per species. One orchard per species will serve the reforestation needs of the Northern Peninsula/Labrador breeding zone. The second orchard will produce seed for the southern part of insular Newfoundland (i.e., the Main Island breeding zone).

In 1997, emphasis shifted from plus tree selection/first generation establishment to preparations for first generation roguing and second generation plus tree selection. In the case of black spruce, family tests have been in place since 1993. Remeasurement of these at ages 10 and 15 will serve as a basis for roguing the existing black spruce orchards and making selections for the second generation orchards and breeding program. To augment the limited number of trees in the current program, in 1997 we made an additional 40 selections (20 per breeding zone) from several 1970's era Canadian Forest Service all-range black spruce provenance trials. These 40 new selections will advance into the second generation program. In preparation for the breeding work/progeny testing required in the second generation program, black spruce polycross sources were also identified. These also came from the all-range provenance trials mentioned above. Scion collection and grafting will be carried out during the winter of 1998 to establish these polycross pollen donors and additional plus trees in our clone banks.

In 1998, we will also be selecting polycross pollen donors in our white spruce program. Although we will probably have to collect pollen directly from these selections for several years to come, we also intend to establish a polycross clone bank at our main tree improvement facility, Wooddale Provincial Tree Nursery. Scion collection and grafting will commence the winter of 1998. It is our expectation that many of the clones in the first generation white spruce orchards will begin to bear substantial numbers of female flowers over the next several years. We hope to begin specific crossing and polycrossing as soon as possible. In preparation for this, several staff involved with the Tree Improvement Program toured Provincial tree improvement facilities in the Maritimes earlier this year. The focus of the tour was pollen monitoring, collection, handling, storage, testing, and application (i.e., controlled crossing).

Due to a limited demand for eastern larch planting stock and a need to focus our limited tree improvement resources on the more economically important spruces, we have made a decision this year to put our eastern larch tree improvement program on hold. Basic maintenance activities will continue but otherwise we have no plans to move this program forward at this time.

A growing interest in white pine reforestation in recent years, coupled with a chronic shortage of local seed, has resulted in a decision to establish a clonal white pine seed orchard. Beginning in 1998 up to 200 well formed, disease-free pine will be selected from across the Island. Scions will be collected and grafting will commence. The orchard will serve the dual purpose of providing seed for reforestation and preserving the local white pine gene pool.

After a somewhat shaky start in the 1980's, Newfoundland's tree improvement program is now well established. We feel we have the proper infrastructure in place to move foward, making substantial genetic gains in the process.

COOPERATIVE TREE BREEDING IN NOVA SCOTIA

Howard Frame and David Steeves

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Tree Breeding Centre
P. O. Box 190
Debert, NS
B0M 1G0

Keywords: *Picea mariana, P. glauca, P. rubens, P. abies, Pinus strobus,* seed orchards, breeding

The Tree Improvement Working Group (TIWG) was established in 1977 and is the coordinating body for tree improvement in Nova Scotia. Active members include the Provincial Government, Bowater Mersey Paper Company Limited, Kimberly-Clark Nova Scotia Inc., Stora Forest Industries, and J.D. Irving, Limited. Meetings are held in the spring and fall of each year to review progress and plans, while day-to-day activities are coordinated by the Department of Natural Resources. Species of interest include *Picea mariana, P. glauca, P. rubens, P. abies and Pinus strobus.*

SEED ORCHARD ESTABLISHMENT

First generation orchard establishment was completed in 1993. The summer of 1996 saw the first planting of second generation black spruce orchards, with additional material established in 1997. Total second generation black spruce orchard area stands at 1.5 ha.

SEED ORCHARD PRODUCTION

White spruce clonal orchards have produced so many cones that they were left unharvested in 1996. Two red spruce clonal orchards have been able to supply all seed requirements for the reforestation effort in the province. Sufficient seed is produced within the black spruce seedling seed orchards to meet reforestation requirements with rogued orchards providing a large portion of this seed. In 1996, renewed interest in the planting of white pine has tightened the supply of orchard seed, with some wild collections augmenting the supply of orchard seed. Clonal Norway spruce orchards supplied 60 percent of the 1997 seed requirement at the provincial government nursery, yet seed production is generally disappointing in the Norway spruce orchards.

ORCHARD MAINTENANCE

Additional roguing in two black spruce first generation seedling seed orchards occurred during the spring of 1997. Crown management by 'topping' was carried out in black, red, white and Norway spruce orchards, with 11 576 trees topped for the first time and 7 141 trees receiving a repeat topping.

BREEDING

Second generation selection (family plus within-family) of black spruce continued on the basis of 10-year measurements made in a 1988 series of family tests. Just over 200 selections have now been made. The remaining 155 needed to complete the F_2 breeding population will come from a 1990 test series which is scheduled for measurement in 1999.

As for our white, red, and Norway spruce programs, following is a summary of breeding progress to date (excluding spring 1997 breeding effort).

Species	Mating	Total Crosses Required	Crosses Completed
White Spruce	Pair Mate[1]	930	783 (84%)
White Spruce	Polycross	465	441 (95%)
Red Spruce	Pair Mate	497	451 (91%)
Red Spruce	Polycross	497	471 (95%)
Norway Spruce	Polycross	295	56 (19%)

[1] two crosses per clone

Flowering in the spring of 1997 was poor among red and white spruce clones at Debert, particularly among those that have yet to be crossed. To facilitate completion of the first generation red and white spruce breeding and to ensure continued Norway spruce flower production for 1998, over 500 grafts received a stem injection of $GA_{4/7}$ during spring 1997.

PROGENY TESTING

In 1996, a polycross progeny test series was established for each of white, red, and Norway spruce. In 1997, cooperators are outplanting a series of white and one of red spruce polycross tests. A Norway spruce trial designed to compare performance among ten seed sources was planted at 13 locations in 1997. In these, sources are planted in large, unreplicated contiguous blocks.

A back-log of 15 year data collected in 1996 from three 1978 test series, a white spruce stand test series, a white spruce seed orchard progeny test series, and a black spruce series comparing stand progeny from Nova Scotia, New Brunswick, and Quebec, were analysed. Ten-year (1995) heights in seven 1986 test series were taken and assessed. These series tested half-sib white, red, and Norway spruce progeny from a clonal orchard in Lawrencetown which is used as the polycross pollen source. Ten-year (1996) heights from a Cape Breton Highland black spruce outcrossing trial were also assessed.

Nine year heights taken in 1996 from a 1988 series of black spruce family tests provided roguing information for seedling seed orchards at Debert and East Mines. They were also the basis for the second generation selections mentioned above.

TREE IMPROVEMENT ON PRINCE EDWARD ISLAND

W.J. MacKinnon, W.M. Glen, and M.N. Myers

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Charlottetown, PE
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Keywords: tree improvement, seed orchard, progeny tests, provenance trials, gene conservation

SEED ORCHARD

The major objective of the PEI Forestry Division Tree Improvement Program is to reverse the impact that two centuries of forest exploitation has had on the resource. Only remnants of the original Acadian Forest cover-type can be found. Agriculture as well as ship building at the turn of the century depleted the Island of its very best genetic base. To reverse this trend, a tree improvement program was initiated for black spruce (*Picea mariana* (Mill.) B.S.P.), white spruce (*Picea glauca* (Moench) Voss), red spruce (*Picea rubens* Sarg.) eastern white pine (*Pinus strobus* L.), and eastern larch (*Larix laricina* (Du Roi) K. Koch). Research plantings of hardwood to develop establishment guidelines as well as gene conservation for yellow birch (*Betula alleghaniensis* Britton.), red oak (*Quercus ruba* L.) white ash (*Fraxinus americana* L.) black ash (*Fraxinus nigra* Marsh), and ironwood (*Ostrya virginiana* (Mill.)K. Koch) have been initiated.

The tree improvement program on PEI began in 1974. The development years included testing progeny from open pollinated plus tree selections, general stand collections, and species range-wide provenance tests. Species included were white spruce, red spruce, and yellow birch. In 1980, a black spruce seedling seed orchard was established using material from the New Brunswick Tree Improvement Council which has subsequently been found to be superior to Island sources. In the late 1980's, selections were made from primarily natural stands for the establishment of clonal seed orchards of white spruce, eastern larch, eastern white pine, and red spruce and later balsam fir (*Abies balsamea* (L.) Mill.) for the Christmas tree industry.

ORCHARD ESTABLISHMENT

First generation orchard establishment was completed in 1995 with the exception of red spruce. A second generation black spruce orchard has been established at the Upton Road Nursery. All black spruce reforestation stock on PEI has come from the first generation seedling seed orchard since 1988. A 30% roguing of the 1980 orchard has improved genetic gain until the second generation orchard comes online. White spruce improved stock was available in 1997 while eastern larch improved material has been available since 1995. At present, white pine and red spruce stock are grown from Nova Scotia sources. Plans to graft a hybrid larch orchard with twenty European larch (*Larix decidua* Mill.) and twenty Japanese larch (*Larix kaempferi* (Lamb.) Carrière) are underway for 1998.

ORCHARD MANAGEMENT

The Province's primary tree seed orchard area in Dover was established on abandoned farm land in the late 1980's. Soil type and a wide window of frost free days make this an excellent location. Orchard management includes fertilizing, mowing, irrigation, pest management, topping and fall herbicide treatments. The formerly wooded portions of the property are being used for provenance testing of non-native tree species and establishment of hardwood research plots.

PROGENY TRIALS

In the spring of 1997 there was a white spruce polycross test established as well as an open-pollinated eastern larch test (both used three sites). Fifteen-year diameter and height measurements of a black spruce progeny trial have been collected. These measurements will be compared to the ten year results to see if family ranking is constant.

PROVENANCE TESTING

The main area of research includes Norway spruce and *Larix* species. Several tests of each have been established and measurements have been made on both five and ten year tests. PEI established a Norway spruce provenance trial, in cooperation with the Nova Scotia Tree Improvement Working Group in 1997, containing 11 sources. A Corsican Pine (*Pinus maritima*) provenance trial (3 sites) as well as a white pine provenance trial (3 sites) will be established in 1998.

HARDWOOD RESEARCH/GENE POOL CONSERVATION

Five-year heights and survivals have been completed for yellow birch and red oak planting density trials. White ash five year measurements will begin in 1998. Survival and height have been encouraging to date.

Tree improvement efforts towards gene pool conservation for black ash and ironwood have been very slow. Earlier plantations show poor survival and growth. Additional research is required on germination techniques and establishment requirements. There were poor seed crops the past two years. Additional areas containing these rare species have been identified for future collection sites.

The Forestry Division is currently conducting research on *Taxus canandensis* (Ground Hemlock). Fruit collections were made and germination techniques will be developed. Mapping and plant indicators have been developed for PEI as well as clipping trials and rooted cutting research.

FRASER PAPERS INC. TREE IMPROVEMENT PROGRAM

Paul Roussel

Fraser Papers Inc.
27 Rice Street
Edmundston, NB
E3V 1S9

Keywords: Supplemental mass pollination, clonal seed orchard, Gibberellin $A_{4/7}$, paclobutrazol, polycross matings, progeny tests

This report summarizes 1996 and 1997 tree improvement activities at Fraser Papers Inc. Information on cone production and collection, test establishment, nursery production, and new developments is included.

SUPPLEMENTAL MASS POLLINATION

Due to insufficient quantities of male cones, half of the second generation black spruce (*Picea mariana* (Mill.) B.S.P.) clonal seed orchard (BSCSO) received a supplemental mass pollination early spring 1996. The pollen used came from 30 phenotypically superior trees chosen amongst 11 families in the Second Falls black spruce seedling seed orchard (BSSSO).

CONE PRODUCTION AND COLLECTION

Clonal Orchards

The first generation white spruce (*Picea glauca* (Moench)Voss) clonal seed orchard (WSCSO), covering 3.6 ha, contributed 41.36 kg of viable seed in 1996 (+/- 17 247 120 seed). At the same time, cones were collected from the 1991 second generation BSCSO which yielded 0.6446 kg of viable seed.

Nearly 25% of the WSCSO grafts (484) received Gibberellin $A_{4/7}$ ($GA_{4/7}$) injections in 1997 for cone induction. At the same time, a combined $GA_{4/7}$ and Paclobutrazol trial initiated by Ron Smith from CFS-Atlantic was undertaken in the BSCSO on 18 ramets of 10 clones for a total of 180 injected grafts.

Due to very low cone production, no cone collection is expected in the WSCSO in 1997. Small quantities of cones will be collected from the BSCSO. Total seed yield from the BSCSO in 1997 is expected to be lower than in 1996.

Natural Stands

On top of clonal seed orchard collections, red pine (*Pinus resinosa* Ait.) and Norway spruce (*Picea abies* [L.] Karst.) seed was collected from a natural stand and an old plantation, respectively, yielding close to 2 775 000 seed all together.

SEEDLING PRODUCTION

For the first time in 1997, seed from Fraser Papers Inc. second generation BSCSO was sowed at the nursery. All of the 1996 seed collected in the BSCSO was used. Seed from Fraser Papers BSSSO was also used to fulfill the 1997 black spruce seeding requirements (3 021 298).

For the first time in 1997, the total white spruce seedling production (4 975 822) came from first generation seed collected from Fraser Papers Inc. WSCSO. Other species grown at the nursery in 1997 were red pine (205 690) and Norway spruce (1 300 336) for a total of 9 503 146 seeded cavities reflecting a 10.5 per cent increase over 1996.

TESTING

As initiated in the mid-seventies, Fraser Papers Inc. continued to assist the New Brunswick Tree Improvement Council by performing polycross matings on second generation black spruce selections to obtain seed for progeny testing.

In 1996 and 1997, a total of 1.84 ha of tests was planted. This total includes one white spruce and two black spruce progeny tests. The total area covered with tree improvement related tests is now over 52 ha.

SPECIAL PROJECTS

A collaborative project with Dr. G.-É. Caron regarding the crossing of various Norway spruce provenances was initiated in 1996 to familiarize both parties with this foreign species. In 1997, with the guidance of both the Atlantic and Laurentian Centres of the Canadian Forest Service, Fraser Papers initiated its Norway spruce improvement program by grafting nearly 1000 scions from both CFS-Atlantic and CFS-Laurentian clone banks. These grafts, along with others to be grafted in early 1998, will be outplanted in 1998 at the Ste. Anne clonal orchard complex. Site preparation for this new orchard has been initiated.

J.D. IRVING, LIMITED - TREE IMPROVEMENT SUMMARY

Greg Adams

J.D. Irving, Limited
Sussex Tree Nursery
RR #4
Sussex, NB
E0E 1P0

Keywords: spruce species, jack pine, white pine, hardwood species, tree breeding, seed orchards, clonal propagation, somatic embryogenesis

STATUS OF BREEDING PROGRAMS AND ORCHARD PRODUCTION

J.D. Irving, Limited (JDI) participates in breeding and testing programs with the New Brunswick Tree Improvement Council (NBTIC) and the Nova Scotia Tree Improvement Working Group (NSTIWG) as well as operating independent testing programs. The company manages a total of 80 ha of clonal seed orchards including white spruce, black spruce (first and second generation), Norway spruce, red spruce, jack pine (first and second generation) and eastern larch. Breeding and progeny testing associated with first generation orchards of white spruce, black spruce and jack pine is completed and genetic roguing is in progress. Breeding and testing of red spruce and Norway spruce is still underway and work with eastern larch is not a priority at present. Second generation orchards of black spruce and jack pine were established from selections made in NBTIC open-pollinated family tests and the breeding and testing work for these orchards is nearly completed.

Annual reforestation stock production for the company is 15 million seedlings and seed orchards have been filling this requirement since the early 1990's for all species with the exceptions of Norway spruce and red spruce. Difficulty is still being experienced in obtaining good cone crops of Norway Spruce and flower induction is being used routinely. Vegetative propagation of controlled crosses of this species has also been started. A seed orchard of red spruce was not established until 1992 and cone production should begin in the next two years. Second generation orchard seed production for black spruce and jack pine increases each year and in 1996, sufficient jack pine seed was harvested to satisfy nursery stock production requirements in 1997.

In the last five years, JDI has been conducting operational trials on white pine management because of the high value of this species. Demand for reforestation stock has risen to a high enough level that a tree improvement program was initiated by the company in 1997. Plus tree selection is progressing and grafting for seed orchard and clone bank establishment will begin in 1998. Cone crops on plus trees will be assessed and open-pollinated family tests will be established if seed can be obtained from enough of the selections.

VEGETATIVE PROPAGATION AND CLONAL TESTING

Controlled crossing among tested second generation black spruce selections is conducted each spring using the most current field test information to produce crosses with high average breeding values. The resulting full-sib families are grown and potted as hedge stock for cutting production. Production of rooted cuttings is now at a level of one million per year and further expansion is planned. Norway spruce hedges have also been established. Controlled crossing was started in 1997 among the best tested first generation white spruce selections for hedging. The cuttings are being operationally planted on better quality planting sites across the company districts.

Clonal tests of 256 black spruce clones from 30 families were established at two field sites in 1996. The clones are being serially hedged on a four year cycle at Sussex Tree Nursery so that selected clones will be available for bulking up in 5 to 10 years based on performance in the field tests. A similar sized clonal testing effort is underway using clones produced by somatic embryogenesis. Somatic seedlings have been produced from close to 300 clones again originating from 30 families. These seedlings are being hedged for intermediate bulking up by rooted cuttings prior to field testing. Embryogenic tissue from all clones is being preserved in liquid nitrogen during the lengthy field testing process. Further expansion of this work to include Norway spruce and white spruce is planned.

PUBLICATIONS

Adams, G.W.; Kunze, H.A. 1996. Clonal variation in cone and seed production in black spruce and white spruce seed orchards and management implications. For. Chron. 72: 475-480.

Park, Y.S.; Adams, G.W.; Mullin, T.J. 1997. Incorporation of new information and technology in breeding and deployment strategies for black spruce in the Maritimes, Canada. *in* S. Puri, ed. Tree Improvement: Applied Research and Technology Transfer, Oxford and IBH Co. Publishers.

NEW BRUNSWICK TREE IMPROVEMENT COUNCIL UPDATE

K.J. Tosh

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Keywords: Breeding, second generation, seed orchard, black spruce, jack pine, white spruce, tamarack

The New Brunswick Tree Improvement Council (NBTIC) completed its 20th year of operation in 1996. Technical coordination and direction of NBTIC operations is now provided through the NB Department of Natural Resources and Energy (NBDNRE). Funding cuts at the Canadian Forest Service resulted in withdrawal from managing this program. The full-time data analyst is still funded by members, however the position is staffed out of the Kingsclear Forest Nursery. This important function is being conducted by Bryce McInnis who replaced Victor Steel following his resignation in late 1995. The program is focusing on completing breeding and testing of first generation white spruce (*Picea glauca* [Moench] Voss) and tamarack (*Larix laricina* [Mill.] Karst.) and selection and testing of second generation black spruce (*Picea mariana* [Mill.] B.S.P.) and jack pine (*Pinus banksiana* Lamb.). First generation orchards are providing enough seed for all reforestation and production in second generation orchards continues to increase.

SEED ORCHARDS AND SEED PRODUCTION

Since 1978, seed orchards have been established by the industrial members of NBTIC who operate reforestation programs on freehold land, as well as by the NBDNRE who is responsible for planting programs on Crown land. Over 130 ha of black spruce and jack pine seedling seed orchards were planted over a 10-year period ending in 1987. Clonal seed orchards, primarily of white spruce and tamarack, were also established over this time period, with over 60 ha planted. Second generation orchard establishment began in 1989, with three agencies participating. To date over 29 ha of second generation black spruce and jack pine orchard have been established.

As expected, after the record breaking cone crop in 1994, seed production was down in 1995. Seed production was up once again in 1996, however, many Council members had sufficient seed in storage and large collections were not made. The only exception to this was a large collection of white spruce made in a clonal seed orchard. The real good news in 1996 was the increased seed production in second generation orchards. Substantial quantities of seed are starting to be produced in these orchards and it is anticipated that within the next 4 years all of the black spruce and jack pine seed will originate from these second generation orchards.

BREEDING

The Council conducts a complimentary breeding program which began in 1987 with white spruce and tamarack. A polycross, consisting of a mix of 20 unrelated pollens, is used to estimate breeding values. Pair-mating, involving specific crosses, is conducted to produce material from which selections will be made for the next generation. Polycrossing of second generation black spruce and jack pine has made tremendous progress since the start of breeding. This is partly due to polycrossing *in situ* on the selections in the family tests as well as the considerable experience that Council members have gained over the 10 years of breeding work. Pair-mating of black spruce and jack pine commenced in 1994 and 1996, respectively, and will produce material for third cycle selections. Table 1 summarizes breeding progress for all species. Pair-mating of tamarack was discontinued due to reduced interest in planting this species.

Table 1. Summary of breeding progress.

	Polycross		Pair-mate	
Species	No. Completed	% completed	No. Completed	% completed
White spruce	362	87	467	90
Tamarack	209	78	60	-
Black spruce	213	53	89	18
Jack pine	243	60	104	22

The Council continues to follow the breeding strategy for black spruce that was adopted in 1993. Clones have been uniformly deployed to breeding groups and breeding is conducted in a positive assortative manner. A total of 6 sub-lines has been established for black spruce and 8 for jack pine. Breeding continues in the elite sub-line of black spruce and a clonal test from elite crosses was initiated in 1997 and will be planted in 1999.

SELECTION PROGRESS

Trees are selected in family tests for inclusion into the second-generation breeding population. Top performing families are identified based on 10-year height for black spruce and 7-year height for jack pine. Candidate trees are initially identified based on height growth, phenotypically graded in the family tests, and the final selection made from each family based on a combination of superior phenotypic and metric traits. The goal is to select 400 trees for these breeding populations. Selection work began in 1988 and is complete for jack pine with a total of 402 selections. The total number of black spruce selections to date is 347 or 87% of the total. Second-generation selection will be completed in 1997.

TESTING AND DATA ANALYSIS

Testing continues to be an important component of the NBTIC program. Over the past 20 years, 235 tests were planted on over 274 ha. Over the past 8 years, progeny tests have been established to assess the performance of white spruce and tamarack plus trees and second generation black spruce and jack pine selections. It is anticipated that progeny testing of white spruce and tamarack will be completed by 1999 while the establishment of white spruce selection plantations from pair-mate breeding will continue until 2000. Establishment of polycross tests of second generation black spruce and jack pine will be completed in the year 2000.

Realized gain tests of black spruce and jack pine have also been planted to quantify the actual gains of using improved seed. The test design used for both species was the same consisting of six seedlots planted in four replicates using 64-tree plots at five locations. Seedlots consisted of rogued and unrogued orchard and unimproved stand checklots. These tests were measured when 5 years old. The unrogued black spruce orchard seedlot was the same height as the average checklot, however, the rogued orchard seedlot was over 6% taller which can translate into a potential volume gain of 18% to 20%.

For jack pine, the unrogued seed orchard seedlot was 3% taller than the checklots, while the seedlot from the same orchard following a second roguing was over 4% taller. This has the potential for a 12 to 15% gain in volume. Stem straightness is an important quality trait for improvement in jack pine. Selection is made for this trait when seed orchards are rogued. The seedlot from the orchard twice rogued was 28% straighter than the checklots. Significant areas of jack pine plantations from seed orchards have been established since 1988 and trees in these areas are straighter with narrower crowns than those in unimproved plantations.

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TREE IMPROVEMENT PROGRESS BY NEW BRUNSWICK DEPARTMENT OF NATURAL RESOURCES AND ENERGY

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The tree improvement program in N.B. is celebrating over twenty years of operation. Our efforts continue to be focused on 4 major reforestation species, black spruce (*Picea mariana* (Mill.) B.S.P.), jack pine (*Pinus banksiana* Lamb.), white spruce (*Picea glauca* (Moench) Voss) and tamarack (*Larix laricina* (Du Roi) K. Koch.). Secondary species for tree improvement include balsam fir (*Abies balsamea* (L.) Mill.), and Norway spruce (*Picea abies* (L.) Karst).

All first generation selection and seed orchard establishment has been completed for the four major tree species. Second generation selections for black spruce and jack pine, cross-pollinations, and orchard establishment are well underway, or in some cases complete. The following report highlights some of our major accomplishments over the past twenty years:

TREE BREEDING/TESTING

The New Brunswick Dept.of Natural Resources and Energy (NBDNRE) is a member of the New Brunswick Tree Improvement Council (NBTIC) , a group of co-operators including NBDNRE, the federal government and eight large induatrial companies located in New Brunswick. All tree improvement work in the province is co-ordinated by the NBDNRE and all co-operators share in the workload. The 1995 and 1996 jack pine polycrosses done on second generation selections provided sufficient seedlots to grow and outplant the third and fourth series of jack pine progeny tests. The polycross seedlots totaled 131 families. All crosses on jack pine are done in the breeding garden. Black spruce crosses, however, are still being carried out in family tests, as well as in the breeding garden. Table 1 gives a brief summary of the ten years of our breeding effort.

In 1995 and 1996, white spruce, black spruce, jack pine and tamarack progeny tests were outplanted. Polycross breeding on both white spruce and tamarack is over 90% complete. Pair-mate breeding continues with the white spruce and is now 74% complete. Sub-lining of the second generation black spruce and jack pine is well underway with a full-sib clonal test of the elite group begun in 1997. It will be ready for outplanting in 1999.

Table 1. Summary of ten years of tree breeding

Species	Tamarack	White spruce	Black spruce	Jack pine
Number of bags	1 928	3 378	451	2 941
No. Females bagged	43 854	110 146	22 596	18 753
Number of crosses	444	941	321	734
Mean no. female/bag	21	29	34	5
Mean full seed/cone	5.0	10.9	8.9	17.2

SEED ORCHARDS

The best individuals selected from the best families in NBTIC family tests are being identified for second-generation material. To date, we are 87% complete for black spruce selections and 100% complete for jack pine. By the fall of 1997, all 2nd generation black spruce selections will be identified. A total of 11 ha of second generation black spruce orchard has been established and should be completely filled by 1998. The jack pine second generation orchard consists of 6 ha of the total of 7.5 ha to be planted. It is anticipated that the orchards will be fully stocked in 2-3 years.

Roguing has started in first generation clonal orchards of larch and white spruce based on five-year progeny test results. The bottom 4 and 18 families were removed, respectively; a conservative roguing for now.

CONE COLLECTION IN SEED ORCHARDS

The second generation clonal orchards have started to produce seed (Table 2). In 1995, jack pine was the only 1st generation species we collected cones from as we had an ample seed supply for the three other species. Second generation orchards are coming on line, enabling us to harvest cones in 1995 and 1996. We also collected from some of the top performing clones in our white spruce orchard (based on 5 year progeny test results).

Table 2. Cone collection and seed yield from orchards in 1995 and 1996

		Quantity of cones (l)		Amount of seed (kg)	
Species	Seed orchard	1995	1996	1995	1996
Jack pine	Otter Brook	3 938	-	45.8	-
Jack pine	2nd gen KCL	26	136	0.09	0.6
Black spruce	2nd gen KCL	22	192	0.02	0.45
White spruce	Queensbury	-	915	-	14.5

MINI ORCHARD PROJECT

In co-operation with the Canadian Forest Service and with funding under the Canada/NB CO-OPERATION Agreement, a miniaturized seed orchard project was initiated in 1993. The NBDNRE selected jack pine as the species to use for this study. The objective of the project is to develop a prototype mini orchard and to examine various seed orchard management techniques.

A total of 25 second generation jack pine clones were selected, grafted, and grown in 1993. Growth of the grafts was accelerated during the winter of 1994. The grafts were out-planted at the Kingsclear Nursery in 25 ramet clonal row plots. In conjunction with this project a research trial was conducted in the spring of 1994 on other older grafts to investigate the low seed set often obtained from jack pine controlled crosses. The three factors that were investigated were: 1) timing of pollen application, 2) amount of pollen applied per pollination bag, and 3) number of pollen applications.

Results indicated that: 1) timing of pollen application made no significant difference (am vs. pm), 2) three puffs of pollen applied weresufficient, especially if receptivity was maximum, and 3) one application was as effective as 2 or 3, if receptivity was maximum.

STUDIES RELATED TO TREE IMPROVEMENT AT THE UNIVERSITY OF NEW BRUNSWICK

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In June 1995, our Faculty's long-standing research emphasis on tree-crown and reproductive development, pollen and seed production, seed germination, and seedling development suffered a setback with the retirement of Graham R. Powell. Graham continues to support the Faculty's undergraduate teaching effort, however, his research program is winding down.

SEEDS AND SEEDLING DEVELOPMENT

Dormancy of seeds of *Bauhinia malabarica* Roxb. and *Acacia auriculiformis* A. Cunn. ex. Benth., both caused by impermeability of the seed coats to water, was overcome by treatment with sulphuric acid (30 min was best) and by nicking of individual seeds (Magsambol 1995; Welgas-Briz 1995). Treatments with hot or boiling water elicited much slower responses. For *B. malabarica*, studies of seed-coat morphology by scanning-electron microscopy and of rates of water uptake led to the proposition that the impermeability resided in the palisade layer of the seed coat (Magsambol 1995).

Seedlings of *A. auriculiformis* grown for their first 60 days under full light had significantly higher oven-dry weights than did seedlings grown under 70 or 45% of full light, though seedling heights did not differ (Welgas-Briz 1995). The seedlings typically produced, above the cotyledons, one pinnately compound leaf, then two bi-pinnately compound leaves, then one leaf with a basal phyllode and terminal bi-pinnately compound lamina, and then only phyllodes from leaf five onward. This changeover to phyllode production was more rapid than that in *Acacia mangium* Willd. Seedlings of *A. mangium* typically produced one pinnately compound leaf and then six or seven bi-pinnately compound leaves, the later ones with lengthening basal segments, and then through leaves eight to ten the basal segments broadened into phyllodes, but bi-pinnately compound segments persisted terminally. Phyllodes only, were formed thereafter (Mahdan 1995).

TREE PHYSIOLOGY

Genetic and environmental regulation of xylogenesis biochemistry continues to be a major focus of the UNB physiology research program (Savidge 1996). Chemical, immunological, and kinetic investigations into coniferyl alcohol oxidase (CAO), a new enzyme spatio-temporally associated with lignification in conifers, confirmed the novel nature of this cell-wall-bound enzyme and led to the conclusion that CAO is not a laccase and can best be regarded as a catechol oxidase (Udagama-Randeniya and Savidge 1995). Phenological investigations into uridine 5'-diphosphoglucose:coniferyl alcohol glucosyltransferase (CAGT), the enzyme catalyzing biosynthesis of *E*-coniferin (coniferin, the 4-*O*-β-D-glucopyranoside of *trans*-coniferyl alcohol), revealed CAGT to be active specifically in the cambium and only during active cambial growth, in agreement with coniferin itself being localized to the cambium and associated specifically with seasonal growth (Förster and Savidge 1995, 1996). Of all cambial metabolites so far investigated, coniferin is the only one to be qualitatively associated precisely with the period of cambial activity in temperate-zone conifers (Savidge 1996). Continuing investigation into CAGT should provide needed insight into the genetic control of seasonal cambial growth and dormancy.

In planta cambial growth of *Larix laricina* (Du Roi) K. Koch was simulated *in vitro* using explants from eight-year-old stem regions onto solid media containing varied concentrations of the auxin 1-naphthalene acetic acid (NAA). Subsequent microscopy revealed that NAA concentration was a factor determining bordered-pit numbers, diameter, and whether bordered pits were positioned in radial or tangential walls during differentiation of cambial derivatives into tracheids (Leitch 1995; Leitch and Savidge 1995; Savidge and Leitch 1995). *In vitro* research to determine the hormonal and nutriment requirements for cambial growth and xylogenesis in *Eucalyptus globulus* Labill. have been initiated (Leitch *et al.* 1996).

Using one- and twenty-year-old stem cuttings of *Fraxinus americana* L., woods induced to form *in vitro* in response to varied concentrations of exogenous auxin and gibberellic acid were investigated anatomically and chemically. Auxin promoted formation of a vessel-rich wood having a high guaiacyl:syringyl lignin ratio, whereas gibberellic acid promoted a fibre-rich wood having a high syringyl:guaiacyl lignin ratio (Zhong and Savidge 1995a, 1995b; Zhong 1996).

In addition to the evident role of auxin in determining wood-quality, as described above, evidence has been found for the existence of a direct correlation between cambial auxin content and growth rate by investigating three-month-old and 18-year-old members of three half-sib families of *Pinus banksiana* Lamb. of known growth capacity (slow, intermediate and fast). As reported at this conference, a method for screening seedlings rapidly and non-destructively for their cambial auxin content has been developed (Xu and Savidge 1997).

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FOREST GENETICS RESEARCH AT THE CANADIAN FOREST SERVICE - ATLANTIC FORESTRY CENTRE

R.F. Smith, J.M. Bonga, S.I. Cameron, K. Forbes, G. Gesner, M. Grant, R.D. Hallett, C.H.A. Little, I. MacEacheran, Y.S. Park, S. Pond, J. Sweeney, S. Whitney, and L.D. Yeates

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One of the outcomes of the reorganization of the Canadian Forest Service in 1995, was that research programs were partitioned into a series of ten National Networks. Research activities in the area of forest genetics and tree improvement now fall under three networks: 1) Tree Biotechnology and Advanced Genetics, 2) Biodiversity, and 3) Forest Health. The report below represents research and development efforts within the Tree Biotechnology and Advanced Genetics, and Forest Health Networks.

GENETIC STUDIES OF TREE POPULATIONS

by Y.S. Park

Nursery performance of white spruce progeny in a clonally replicated test has been evaluated. The test included a total of 300 clones derived by rooting of cuttings from progenies of a 20-parent disconnected diallel mating. The purpose of this experiment was to explore possibilities for implementing high-value clonal forestry and to examine potential genetic gains from clonal forestry. The nursery test was laid out using ten blocks of single tree plots. At age five, the mean height of the ten best clones was 54% taller than the average of all the clones in the test. As expected, the test exhibited a consistent within-clone uniformity while showing a large among-clone variability. The data on this 5-year nursery test will be correlated with the field test already in place at a regular intervals for long-term evaluation based on the same clones.

Diversity of managed tree populations in plantations can be an important factor for successful establishment and subsequent wood production. A study on genetic diversity of various seedlots of black spruce populations has been initiated to develop a relative diversity index, as well as to identify traits that best indicate genetic differences. The study included 16 seedlots: three open-pollinated plus tree collections from New Brunswick, four open-pollinated collections from Nova Scotia, three stand collections from New Brunswick, three full-sib controlled crossings among first generation selections, one seedlot from an unrogued seedling seed orchard, and two seedlots from two rogued seedling seed orchards. To date, detailed measurements on greenhouse and 3-year nursery experiments have been collected, including germination, survival, growth, phenology, and other morphological observations.

In collaboration with Dr. T.J. Mullin, a revision of POPSIM, a computer program for a stochastic tree population simulator (Mullin and Park 1995), has begun to include additional features of tree breeding components such as "multiple-population breeding" and optimization of parental contribution. Also, a computer program, called "DISCLONE" for analysis of clonally replicated disconnected diallel mating system, has been revised and compiled under Microsoft FORTRAN Power Station. The use and theoretical background of both programs were presented at the North American Quantitative Forest Genetics Group meeting in Orlando, FL, USA (Park and Mullin 1997, Mullin and Park 1997). Both programs are available for downloading from an internet FTP site at this centre (FTP server: **fcmr.forestry.ca**).

SOMATIC EMBRYOGENESIS IN JACK PINE, WHITE SPRUCE AND MATURE LARCH, AND STABILITY OF CRYOPRESERVED CLONES

by J.M. Bonga, S.I. Cameron, K. Forbes, M. Grant, I. MacEacheran, Y.S. Park, and S. Pond

Work on somatic embryogenesis (SE) of jack pine (*Pinus banksiana* Lamb) was initiated in 1995, and was given main emphasis in the past 3 years. The work on SE of white spruce (*Picea glauca* (Moench) Voss), which was initiated in 1991, continued. Also, the work to induce SE from mature European (*Larix decidua* Mill) and hybrid (*L.* x *eurolepis*) larches continued.

Jack pine is a commercially important species in eastern Canada, but is recalcitrant for SE induction. In the spring of 1995, immature cones from 20 open-pollinated families were collected at four weekly collection dates, i.e., July 4th, 11th, 17th, and 24th, and subjected to SE induction using two induction media. Of the 1083 cell lines produced, we obtained four embryogenic lines from the July 4th collection. The embryogenic cell lines were subsequently matured and produced plants (Park et al 1997). Thus, the induction frequency of SE was very low; however, this is the first such success in jack pine. The initial limited success in jack pine SE is considered a primary step for further detailed work.

Three major barriers to efficient jack pine SE culture still exist: 1) the inability to use stored and/or mature seed as a source of explant material, thereby removing the limitation of one two-week window during the year during which successful SE initiation can occur, 2) rapid ageing of SE tissue, requiring frequent cryopreservation to rejuvenate the callus, and 3) development of only a small number of acceptable quality embryos during maturation. Experimentation is currently focused on improving initiation protocols, using both immature and mature seedlots to investigate which combinations of different storage pretreatments and tissue culture media are able to stimulate early-stage SE tissue development.

A 2-year study of the effect of callus age on embryo production has been done. Samples of the same white spruce SE tissue line, either kept in continuous production for over 3 years or newly regrown from cryopreserved callus, were used as "old" and "new" variants, respectively, and their growth was compared in a series of experiments. It was confirmed that embryo yield decreases over time, and that cryopreservation, but not re-initiation from an existing embryo, can rejuvenate production in old SE callus. Production may also be stimulated by withdrawing either auxin, cytokinin, or both phytohormones from the proliferation medium, which may have operational benefits, but the effects differ depending on tissue age. Partial results were presented as a poster (Cameron and Grant 1997) at two meetings.

Genetic stability of cryopreserved white spruce embryogenic clone lines was studied by thawing a set of clones at two different dates, i.e., after 3 and 4 years of freezing, and by comparing developmental and morphological characters during the subsequent *in vitro* and *ex vitro* procedures. This work resulted in a MScF thesis at University of New Brunswick by D. Barrett under supervision of Dr. Y.S. Park. The results indicated that the clones were highly consistent with respect to *ex vitro* morphological characters. However, with respect to *in vitro* characters, clones were less consistent between the two thawing dates because inconsistent frequencies were found for morphological maturation categories. However, clones were consistent for eight germination categories examined. This indicates that tissue culture characteristics are influenced by the laboratory procedures but, once plants are produced, the growth and morphological traits are governed by genetics in a consistent manner.

The effects of glutamine-based dipeptides, glutamine and casein hydrolysate, as well as deletion of organic nitrogen, were investigated during white spruce somatic embryogenesis (Barrett *et al.* 1997). The results indicated that, without organic nitrogen, fresh weight increase was significantly lower than with organic nitrogen on both initiation and proliferation media. However, there were no differences in the total number of mature somatic embryos produced in cultures grown with various organic nitrogen combinations or without organic nitrogen.

Buds from 36-year-old *Larix decidua* and L. x *eurolepis* trees were used for culture immediately after collection in the field and after 3 months of storage in a freezer (-5 and -10°C). Storage in the freezer strongly stimulated the formation of somatic embryos. Subsequently it was found that the same stimulatory effect could be obtained by starving the explants (on agar with water; no nutrients) for 3 weeks.

REPRODUCTIVE BIOLOGY

by R.F. Smith, S. Whitney, and L.D. Yeates

Research trials focusing on reproductive development continued, primarily on two areas: 1) cone stimulation and 2) the molecular biology of cone development.

Although the induction of seed cones in many conifers has been successfully achieved through applications of gibberellins A_4 and A_7 (GA), pollen production remains more problematic. Work continued on trials to evaluate if a stem injection of Paclobutrazol (2RS,3RS)-1-(4-chloro-phenyl)-4,4-dimethyl-2-(IH-1,2,4-triazol-1-yl) (PAC) could be used as an adjunct treatment to increase the efficacy of GA in increasing flowering in black spruce. Results over 2 years indicate a dose-dependent, but non-linear increase in the production of cones of both sexes in response to stem injections of either GA or PAC. The optimum rate of GA for stimulating pollen production was 3.3 mg whereas the most seedcones were induced on trees receiving 11 mg. The sex ratio (number of seed cones/number of pollen cones) increased with the rate of GA applied. Injecting PAC also promoted cones of both sexes, equally, resulting in sex ratios comparable to that of the control trees. The use of PAC as an adjunct to GA treatments in black spruce seedling seed orchards appears effective, practical and safe. Both the mechanisms whereby PAC affects flowering in black spruce and the potential for increasing flowering in clonal seed orchards and in other conifer species remains to be determined.

Although considerable research has been directed at understanding the factors that control bud differentiation in conifers, efforts have been limited because, until recently, it has not been possible to either visualize or quantify the changes in gene expression that precede morphological differentiation. In 1995, a study was initiated in conjunction with Dr. Bob Rutledge and colleagues at CFS in Quebec on isolating and identifying expression patterns of flowering genes in black spruce. Our efforts focused on the latter component of the project and comprised primarily the use of the technique of *in situ* hybridization. Although preliminary, our findings indicated that the AGAMOUS-like gene, from which probes were synthesized in this study, exhibits a pattern of expression consistent with that of AGAMOUS. Work is ongoing to determine a course for expression of this gene with future studies to focus on testing additional genes that have been isolated and in comparing gene expression patterns between male and female strobili.

PHYSIOLOGY AND GENETIC ENGINEERING OF WOOD FORMATION

by C.H.A. Little

Research on the hormonal control of wood formation and the enhancement of wood quantity and quality using genetic engineering was continued in collaboration with personnel at 1) Swedish University of Agricultural Sciences, Umeå, Sweden, 2) Växjö University, Växjö, Sweden, and 3) University of New Brunswick, Fredericton.

A series of experiments was performed to investigate the interaction of ethylene and gibberellins (GAs) with indole-3-acetic acid (IAA) in the control of tracheid production in shoots of *Abies balsamea* and *Pinus sylvestris*. It was demonstrated that ethylene cannot mimic the promoting effect of IAA on cambial growth; however, when applied in a ring around the stem at unphysiologically high concentration in the form of Ethrel, ethylene does stimulate tracheid production, but indirectly, by locally increasing the IAA concentration in the cambial region (Eklund and Little 1995,1996). That GAs play a role in the control of cambial growth in conifer shoots, and act directly, rather than indirectly by raising the cambial region IAA level, is indicated by the findings that: 1) GAs 1, 3, 4, 9, 12 and 20 occur naturally in the shoot, 2) labelled GA4, GA9 and GA20 applied in a ring around the stem were absorbed into the cambial region, then translocated and metabolized, 3) provided an IAA source was present, ringing with GA4/7 promoted xylem and phloem production without elevating the IAA concentration, and 4) ringing with prohexadione, an inhibitor of GA biosynthesis, decreased cambial growth and the levels of GA1, GA3 and GA4 and increased the GA9 level, but did not alter the IAA level (Wang *et al.* 1995a, 1995b, 1996). The results also indicated that the GA9 to GA4 to GA1 pathway is a major route of GA biosynthesis in conifer shoots. IAA was observed to promote the formation of callus and ensuing differentiation of the vascular cambium that occurs in a bark-peeled portion of *Betula pubescens* stems, provided the girdled region is wrapped in transparent plastic to prevent dessication (Cui *et al.* 1995). Recent evidence implicating plant hormones in the regulation of radial and longitudinal growth in the stem of woody species was reviewed (Little and Pharis 1995).

Feulgen microspectrophotometry, flow cytometry and image analysis were used to measure the nuclear DNA content in ray cells obtained from the vascular cambium of *Fraxinus americana* shoots at intervals during the annual cycle of cambial activity and dormancy (Zhong *et al.* 1995). The results support the view that there is an annual oscillation in the nuclear genome size in shoot meristematic cells in tree species native to the northern temperate zone.

The relationship between nuclear genome size, measured cytophotometrically, and relative ribosomal RNA gene (rDNA) content, determined as the ratio of the hybridization signals from a 25S rRNA gene probe and a randomly labelled total genomic DNA probe, was investigated in cambial region cells of *Abies balsamea* shoots during the onset of dormancy and the transition between the dormancy stages of rest and quiescence (Lloyd *et al.* 1996). The data suggest that the increase in nuclear genome size associated with the rest-quiescence transition is caused by amplification of a fraction that is not rDNA but is recognized by our genomic probe.

The activities of two model heterologous promoters, the *Agrobacterium rhizogenes rolC* and the cauliflower mosaic virus (CaMV) *35S*, both fused to the *uidA* ß-glucuronidase (GUS) reporter gene, were observed to vary in very different, unpredictable ways during the annual cycle of growth and dormancy in stems of hybrid *Populus* (Nilsson *et al.* 1996). The spatial and temporal variation in *rolC* promoter activity reflected cellular and seasonal changes in sucrose content.

To investigate how the superior shoot growth of *Pinus contorta* compared with *Pinus sylvestris* is manifested, the patterns of current-year shoot, needle and terminal bud elongation, as well as mitotic activity in the apical meristem of the terminal bud, were compared in seedlings of three provenances per species during the third and fourth growing seasons after planting (Norgren *et al.* 1996). The greater final shoot, needle and bud lengths in *Pinus contorta* were attributable more to a faster rate than a longer duration of elongation. The longer final shoot length in *Pinus contorta* reflected more stem units rather than greater stem unit length.

SEED ORCHARD INSECT PEST MANAGEMENT RESEARCH

by J. Sweeney and G. Gesner

Most of our work has focused on the ecology and management of the major cone pest in white spruce seed orchards in Canada, the cone maggot, *Strobilomyia neanthracina* Michelsen. We have studied the population dynamics of the cone maggot at two seed orchards in New Brunswick since 1992, using cohort sampling for life table analysis and manipulative studies to estimate the impact of natural enemies such as parasites and predators. Results suggest that size of the cone crop and its year-to-year fluctuation is a big factor affecting cone maggot population dynamics. Light cone crops in 1995 and 1997 were heavily infested (>95%) and produced little, if any, filled seed; most maggot mortality was due to intraspecific competition. Heavier cone crops usually suffered less than 10% maggot infestation and intraspecific competition was a minor factor affecting maggot survival. The message for seed orchard managers is to concentrate on collecting large volumes of seeds in heavy cone crop years, and either ignore or abort light cone crops. Decisions to apply direct control measures will be more critical in moderate cone crop years, and when managers do not have a surplus of seeds in storage.

A greater proportion of cone maggots remained in extended diapause in light cone crop years, apparently opting to wait for a year when competition for food was less fierce, but we do not know how the maggots "predict" cone crop size. Results of an experiment in which we injected trees with gibberellic acid did not support the hypothesis that extended diapause in *S. neanthracina* was influenced by the perception of chemical cues by larvae feeding in the cones.

In collaboration with Dan Quiring (UNB) and graduate student, Laura Fidgen, we have looked at how certain host attributes, such as cone size, affect the foraging and survival of *S. neanthracina,* and its cousin on black spruce, *S. appalachensis.* Both oviposition and maggot survival tend to increase with cone size. Since maggots prefer to feed in larger cones that have more seeds, their impact on seed production is somewhat greater than if attack was independent of cone size. With support from Forest Renewal B.C., in collaboration with Robb Bennett (BC Min. of Forests), we also determined that the female *S. neanthracina* deposits a host-marking pheromone on cones after ovipositing, and that this pheromone deters oviposition by subsequent females. Manuscripts on both of these topics have been submitted to journals, and are currently in review.

We continued to field test entomopathogenic nematodes as a biological control for direct suppression of cone maggot populations in 1996 and 1997, with support from the Forest Renewal Program of B.C. Attempts to extend nematode efficacy and persistence through the application of bark or hay mulches had inconsistent results. Adequate suppression of cone maggots with nematodes would probably require 2-3 applications per season, and would not be as effective as applying a systemic insecticide. If use of systemics is restricted in the future, however, nematodes may become a viable part of an orchard pest management program.

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BIODIVERSITY RESEARCH AT CANADIAN FOREST SERVICE - ATLANTIC FORESTRY CENTRE

Tannis Beardmore, Bernard Daigle, Moira Campbell, Linda DeVerno, Kurt Johnsen, Judy Loo, John Major, Donnie McPhee, Alex Mosseler, Garry Scheer, and Dale Simpson

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With the closing of the Petawawa National Forestry Institute, researchers and facilities were transferred to the Atlantic Forestry Centre to join staff there as part of the new Biodiversity Network. Although the Biodiversity Project at Fredericton includes speciesand ecosystem diversity work, the group specializes in genetic aspects of biodiversity science including: population genetics, molecular genetics, physiological genetics, seed research, and germplasm storage.

RED SPRUCE ECOSYSTEM BIODIVERSITY PROJECT

by Linda DeVerno, Judy Loo, John Major, and Alex Mosseler

The Biodiversity Project at the Atlantic Forestry Centre, part of the Canadian Forest Service Biodiversity Network, has initiated a long-term study centered around the species red spruce. A workshop was held at CFS-Atlantic, October 22-24, 1996, in which scientists, foresters, and interested biologists from, government, university, and industry sectors of Ontario, Quebec, all Maritime provinces, and the USA were invited to discuss the status and issues surrounding red spruce. Red spruce is a shade tolerant, valuable timber species which is an important component of late successional forests. However, because of past forest practices, red spruce has been in decline over the majority of its range. In the United States, it has been estimated that there are now currently 1/5 the number of red spruce compared to pre-European colonization. This new project is a multi-faceted, multi-partner, collaborative research effort which intends to address a myriad of important forestry issues including the need to rigorously assess alternative silviculture, the impact, extent and role of hybridization, indicators of old growth forests, the sensitivity to climate change factors, and species and ecosystem restoration.

Red spruce and ecosystems containing red spruce represent a particularly useful "model" system for study. Genetic variation in red spruce appears low relative to other conifers. Red spruce also hybridizes with black spruce and clearcut logging appears to have increased the number of hybrids across the landscape; however, the extent of hybridization is hotly debated. In addition, red spruce is particularly interesting in regard to potential responses to climate change. In the United States, red spruce "decline" has been studied extensively and there are strong indications that red spruce responds negatively to winter climate variability. Such variability may increase dramatically in Canada with climate change over the next century. If monitored closely, red spruce, may act as a "bio-indicator" of climate change in Canada. Thus, by intensively studying red spruce, lessons and approaches learned regarding uneven-aged forest management, restoration, high-grading, species hybridization, and climate change, can be applied to other species and systems.

Newly initiated studies are progressing on several fronts. Individual-tree seed collections were made in Ontario, New Brunswick and Nova Scotia, mostly from "old-growth" stands. These will serve to assess the reproductive capacity of the species and also to serve as a "genetic benchmark" for future work in managed and disturbed ecosystems. In addition, the Project is taking advantage of older, pedigreed genetic plantations to study the physiology and molecular genetics of red spruce × black spruce hybrids. One paper currently in press, re-examines a previous hypothesis of physiological depression in F1 hybrids as a physiological barrier between species. Molecular markers are being developed to differentiate between red and black spruce and to identify hybrids. We also wish to establish how species-level biodiversity in managed red spruce stands compares to natural stands and what the impacts of various silvicultural regimes are on biodiversity, both temporally and spatially.

RED SPRUCE RESTORATION

by Alex Mosseler

Only remnant populations of red spruce remain in central Canada. Red spruce decline can be directly linked to human activities such as pollution and clearcutting. However, a growing interest in restoring this species comes from two sources: 1) timber management of conifers, using silvicultural alternatives to clearcutting (e.g. shelterwood and selection harvesting), and 2) habitat management for wildlife. It is anticipated that creation of red spruce deer yards may relieve adverse browsing pressure on hemlock regeneration. Such browsing pressure currently threatens hemlock across central and eastern Canada.

Red spruce restoration must be based on proper seed source selection for artificial regeneration. Unfortunately, there are few remaining viable populations of red spruce from which to collect seed adapted across much of its former range in central Canada. The few extant stands occur in parks and ecological reserves and are thus largely unavailable for operational seed collection. Furthermore, very little is known about the genetic and reproductive status of local remnants of red spruce. The CFS Atlantic Forestry Centre organized seed collections across much of the Canadian range during the good cone crop of 1996 to assess the reproductive status and health of the disjunct Ontario population which consists of small, isolated stands. In collaboration with the Ontario Ministry of Natural Resources, four sites were selected in 1997 for underplanting a range-wide sample of the red spruce gene pool aimed at: 1) assessing the genetic status of the Ontario gene pool both for molecular genetic diversity and for adaptive trait variation, 2) conservation of genetic resources, 3) assessing silvicultural protocols based on nurse crop testing, and 4) establishment of seed sources for eventual species restoration. These sites will be planted to red spruce in spring 1999. Following an analysis of provenances for growth performance, the range-wide red spruce tests established across eastern and central Canada by the CFS 40 years ago will also be rehabilitated to prepare them as seed sources for future restoration purposes.

Other partners in this red spruce restoration effort include companies holding Sustainable Forest Management

Licences in Ontario, the Eastern Ontario Model Forest, and the Forest Gene Conservation Association of Ontario. The strategic objectives of this restoration effort are to foster sustainable forest management practices by conserving the genetic diversity of one of Canada's major tree species by maintaining the wildlife habitat associated with red spruce dominated forests and by providing commercial wood supply based on naturally regenerating silvicultural systems.

GENETIC DIVERSITY OF BUR OAK

by Donnie McPhee and Judy Loo

Bur oak exists in New Brunswick as a few small isolated populations, near the species' northern limit. Historical accounts indicate that the New Brunswick range was once more extensive but the combined effects of harvesting, conversion for agriculture and cottage development throughout much of the species' habitat (river floodplain and lakefront) has greatly reduced the frequency of the species in this province. Threats to the remaining populations continue, prompting concern for gene conservation.

All six of the poulations in New Brunswick, meeting size and distributional requirements, have been sampled for genetic analysis. In addition, three isolated populations in New England, four populations on the fringe of the species' continuous range and six populations from within the continuous range have been sampled. Bud tissue is used for isozyme analysis to estimate levels of genetic diversity and gene flow among populations. In particular, these genetic analyses will be used to determine whether the New Brunswick populations differ from other isolated populations, fringe populations or populations within the continous range of the species, and if so, in what way. The results will be used to develop a gene conservation strategy for the New Brunswick populations.

SEED SOURCES FOR RESTORATION OF ACADIAN FOREST ON PRINCE EDWARD ISLAND

by Judy Loo

A study was completed to evaluate the genetic diversity of populations of sugar maple, red oak, white pine, and white spruce on Prince Edward Island (PEI) in comparison with populations from the mainland. For all but one of the species, four populations were sampled on PEI and three populations were sampled in each of the two Maritime mainland provinces.

Sugar maple was found to have the highest total genetic diversity among the four species and white pine had the lowest levels. Sugar maple also had the highest among population component of isozyme diversity, with the lowerst estimateed gene flow among populations. White spruce and white pine showed very little genetic structuring among regions and only a small proportion of teh total diversity was at teh population level. PEI populations of red oak had significantly less alleles per locus than the mainland populations. Alleles were detected in all mainland populations that were missing in the Island populations, but the Island populations did not have any alleles that were different from mainland populations. Two sugar maple alleles, on the other hand, were found only on the Island.

There is evidence that red oak populations on PEI are genetically isolated from mainland ones and that they have become genetically impoversihed, probably as a result of small population size. Thus restoration efforts should include material from coastal mainland populations. Sugar maple seed should be obtained on the island for planting on the island because of evidence of poplation differentiation and the possibility of specific adaptation.

PROTECTED AREAS AND GENE CONSERVATION STRATEGIES

by Judy Loo

For a short period of time, there was an ecological areas program within CFS funded by Green Plan. At the termination of Green Plan funding the protected areas mandate was transferred to the Biodiversity Network. The main CFS strategy for influencing protected areas was to work with the Model Forest program. Gap analysis projects were initiated in four of the model forests, primarily funded initially, by the Green Plan Ecological Reserves program. Each of these projects has either ended or changed direction at this point. Three of the projects have resulted in one or more new areas recommended for protection. In New Brunswick's Fundy Model Forest, the focus was on identifaction of small-scale plant community types, followed by an assessment of the degree to which the areas are protected or are threatened with land use which would lead to loss of biodiversity.

Approximately 60 sites were identified in the Fundy Model Forest to be in need of formalized protection. Most of these sites are small, but many include species which require conservation measures owing to their risk level and relative rarity in the province. Protection of the largest of these sites from resource extraction would significantly contribute to *in situ* gene conservation. The largest of the identifed sites, totalling more than 600 ha, is in the process of being protected through a land swap agreement. Another smaller site has been donated to the Nature Conservancy and securement of other areas is being pursued.

Recently, a new initiative was begun here to develop gene conservation strategies for tree species which are declining, or are perceived to be at risk. The first steps are to draw up a set of criteria by which tree species may be judged to require special conservation attention. The species are then rated according to the seriousness of the problem. The next step will be to develop conservation strategies for those species for which sufficient data are available and to determine how to obtain the information if it is not readily available.

GENETIC VARIATION IN RED PINE

by Linda DeVerno and Alex Mosseler

The RAPD technique was used in conjunction with high resolution agarose gel electrophoresis to detect genetic variation among individuals within and between seed sources in *Pinus resinosa*. A total of 57 primers that gave consistent, strongly amplified fragments were selected for further screening with DNA from four mutant trees and a rangewide sample of 21 normal trees. Only three of these primers generated amplification fragment patterns that were polymorphic. Restriction endonuclease digestion of RAPD reaction products (RAPD-RFLP analysis), using enzymes with four base-pair recognition sequences, was used to determine if fragments of identical electrophoretic mobility were the result of priming at either single or multiple genomic locations. Out of 64 primer/enzyme combinations tested, one primer/enzyme combination created reproducible polymorphic banding patterns in rangewide red pine DNA samples. Therefore, digestion of RAPD reaction products can be used as a method to increase the probability of detecting genetic variation between highly conserved genomes.

SEED RESEARCH

by Tannis Beardmore and Garry Scheer

Our work focuses on the study of tree seeds which are difficult to store. These 'hard to store' seeds are classified as recalcitrant. Many of Canada's native tree species, primarily hardwoods, produce seed which deteriorates very quickly in storage. Our main goal is to develop strategies and treatments for storing these tree seeds of a recalcitrant nature.

Low and Ultra Low Temperature Tolerance of Butternut Embryonic Axes

Butternut (*Juglans cinerea* L.) survival is being threatened in North America by the fungus *Sirococcus clavigignenti-Juglandacearum*. To date, control for this fungal disease does not exist and long-term seed storage is not a viable option for this species. Low (0°C, -5°C, -10°C, -15°C, -40°C) and ultra low (-196°C, cryopreservation) storage of butternut embryonic axes has been examined as a method of *ex situ* conservation. Embryonic axes with approximately 3 mm of cotyledonary tissue attached to the hypocotyl area germinated after exposure to 0°C, -5°C, -10°C, -15°C, -40°C and at -196° C (temperature reduced at a rate of -0.33°C/min from 0°C). Percent germination after exposure to 0°C and -5°C was 87 and 82%, respectively and after -10°C, and -15°C was 29, and 27%, respectively. Thirty-two percent of axes germinated after -40°C while 36% germinated after exposure to -196°C. Significant tree to tree variation was found in the embryonic axes tolerance to low temperature. This variation corresponded with the embryonic axes water content; the lower the embryonic axes water content, the greater the tolerance to -196°C. Reducing embryonic axes' water content by slow desiccation to 4.8 % or less resulted in an increased tolerance to -196°C. These results suggest that cryopreservation may be a viable means for *ex situ* conservation of butternut.

Silver and Red Maple Seed Development

In this project, silver maple (*Acer saccharinum*), which produces a recalcitrant seed and red maple (*Acer rubrum*) which produces an orthodox seed are used as a model system for studying biochemical processes that occur during seed development (e.g., the ability of the seed to tolerate desiccation), which are associated with the seed's ability to tolerate storage. *Acer rubrum* can be crossed to *Acer saccharinum* and these hybrid trees, taxonomically recognized as *Acer x freemanii*, produce seeds with a phenotype intermediate to that of the parentals. These three *Acer* species create an excellent experimental system for elucidating biochemical mechanisms that are involved in recalcitrant and orthodox seed behaviour. Results of this work have shown that desiccation tolerance of *Acer saccharinum* embryos can be induced and these embryos can then be stored in the dry state.

Long-Term Storage of Black Spruce, White Spruce, and Lodgepole Pine Seeds

This project initiated in 1994 is an on-going seed storage experiment which is examining the effect of seed moisture content (i.e., 3%, 5%, 15% and 20% moisture content for each species) and storage temperatures (i.e., +4°C, -20°C, -85°C, -195°C) on the germination of black spruce, white spruce, and lodgepole pine seeds. This experiment is on-going and will be completed in 2001.

NATIONAL FOREST GENETIC RESOURCES CENTRE

by Dale Simpson and Bernard Daigle

The Centre is comprised of four sections: National Tree Seed Centre, cryogenic facility, OECD seed certification, and genetics experiment database.

The mandate of the Seed Centre will focus *ex situ* gene conservation by aquiring and maintaining an inventory of species native to Canada. Collections of native species already in storage will be expanded and seed will be obtained from additional tree and shrub species. Samples will be obtained from throughout the natural ranges of the species in Canada. The Centre will continue to provide seed for research. Facilities for the Seed Centre consist of one walk-in cooler maintained at +4°C and two walk-in freezers set for -20°C, a cone drying room, and equipment for cleaning and testing the seed.

A cryogenic facility was established to provide support for research on alternative means for long-term storage of genetic material and to store somatic embryogenesis material. Facilities consist on two programmable and two stainless steel freezers.

Canada is a signatory member of the OECD Scheme for the Control of Forest Reproductive Material Moving in International Trade. The responsibility for implementing the scheme was directed to the Canadian Forest Service (CFS). Historically, all certification has been conducted in British Columbia. As a result of program review, management of the OECD Scheme was transferred to the Genetic Resources Centre while certification will continue to be conducted from the CFS lab in Victoria. The current scheme, which was implemented in 1974, will soon be replaced by a new scheme following its approval by OECD member countries.

A database of all genetics experiments established by the Petawawa National Forestry Institute was created over a ten-year period. This, as well as all experiment files, were also transferred with the Genetic Resources Centre. Work has begun on creating a similar database for genetic experiments planted in the Maritimes. Over time, databases can be developed for experiments established by other CFS laboratories.

PHYSIOLOGICAL GENETICS

by Kurt Johnsen, John Major and Moira Campbell

Results from intensive drought tolerance research conducted on four black spruce full-sib families at the Petawawa Research Forest have continued to be analyzed and written up. In addition to the photosynthetic responses reported previously, the families have been shown to differ in shoot water relations. Drought tolerant families consistently maintained higher turgor than intolerant families. Thus, it appears that stable families possess both a higher source of carbon from higher P_n and a higher sink for carbon via the influence of higher turgor on growth. It is unclear still if higher P_n and higher turgor are genetically independent or not. Across all three study years, genetic differences in carbon isotope discrimination, net photosynthesis, and water relations were remarkably consistent. Some of the measured traits were highly correlated with growth. For example, the relationship between mean family predawn turgor and mean family growth results in a 0.818 correlation coefficient. The genetic differences in the various traits were always small to moderate in magnitude. However, it is our contention that, due to compounding over time, these small differences in physiological function have contributed to large growth differences among the families.

In collaboration with Dr. Larry Flanagan (Carleton University) , samples were collected from 25 families (all crosses of a diallel without reciprocal crosses), measured for carbon isotope discrimination and subjected to quantitative genetic analyses (Dudly Huber, U. of Florida). Approximations of genetic correlations are -0.94 between height and discrimination and -0.82 between diameter and discrimination. Selfs deviate greatly from the strong growth-discrimination relationships indicating self pollination results in differential deleterious effects on photosynthetic properties and other mechanisms related to growth. Individual-tree heritability for carbon isotope discrimination was 0.66, higher than that calculated for height (0.45) or diameter (0.14), indicating carbon isotope discrimination in this population is under a high degree of genetic control.

In addition, experiments have been established with the main aim to assess within-stand variation to both drought and elevated CO_2. In cooperation with Dennis Joyce of the Ontario Ministry of Natural Resources, seed was collected from four stands in Ontario. Clones were serially propagated using rooted cuttings. Three clones from each of eight mother trees per stand were established in both a CO_2 and a drought interaction study. The studies will be three years in duration and will assess growth, phenological, and physiological traits.

Work conducted in the early 1970's indicated that seedlings resulting from the hybridization of black and red spruce exhibited negative heterosis in regard to both growth and photosynthesis. At that time, two field plantations were established with the same genetic material. Analysis of height growth to date indicates that in both plantations height growth decreases with the increased proportion of red spruce ancestry (based on morphological index of parents). A preliminary examination of gas exchange over a week in 1994 indicated no differences among progenies ranging in quartile increments from pure black spruce to pure red spruce. Gas exchange was examined more intensely in 1996 on the parent species as well as both putative F_1 and F_2 hybrids which again revealed no photosynthetic hybrid inferiority . These results all suggest negative heterosis appears to be of little importance as an isolating barrier between red and black spruce. Crossability and ecological barriers appear more important in maintaining the segregation of the species.

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Keywords: China, computer simulation, genetic engineering, group coancestry, *Picea glauca*, *Picea mariana*, *Pinus banksiana*, *Populus* spp., population-merit selection, Sweden, transgenic forest trees

Genesis has offered forestry consulting services for the past 7 years, specializing in aspects of forest renewal. This report summarizes the major contracts, completed or in-progress over the past 2 years, which are related to tree improvement and forest genetics.

GANSU FOREST TREE NURSERY PROJECT, CHINA

Technical services have been provided since 1992 to Roche ltée, Canadian Executing Agency for the Gansu Forest Tree Nursery Project, funded by the Canadian International Development Agency. In 1995, a 7-month overseas mission was completed as "Nursery Systems Specialist" to design and implement a program of technology transfer on all aspects of containerized and bareroot nursery production and to lead a program of applied research with the aim of adapting Canadian reforestation and tree improvement technology to local conditions (Mullin 1995a).

REGULATION OF GENETIC ENGINEERING FOR FOREST TREES

Canada is participating with the Organization of Economic Cooperation and Development (OECD) in efforts to harmonize regulatory control of products derived from biotechnology, including forest trees. An OECD committee adopted a plan to produce consensus documents on the biology of various tree species, as a first step in the regulatory process. Genesis was contracted by the Canadian Forest Service to draft consensus documents for white spruce (*Picea glauca*) and poplars (*Populus* spp.), as part of Canada's contribution to the OECD effort (Mullin 1997a, 1997b). While the release of transgenic materials in natural ecosystems must be done in an environmentally responsible manner, the issues surrounding the potential benefits and biosafety of this technology have not been well evaluated by Canadian stakeholders. The Canadian Forest Service thus contracted Genesis to prepare an overview document to facilitate a discussion within the forestry community, leading to improved direction of research and contributing to the harmonization of regulatory oversight of genetically engineered forest trees (Mullin and Bertrand 1997).

ANALYSIS OF STODDART BLACK SPRUCE FAMILY TEST DATA

Member agencies of the Northeast Seed Management Association established a black spruce (*Picea mariana*) seedling seed orchard for the Island Lake Tree Improvement Area and 2 associated family tests in Stoddart Township, Ontario in 1986. Field data collected from the 400 families after 5 and 9 growing seasons were analyzed and families ranked according to Best Linear Prediction (BLP) of breeding value, as a guide to orchard roguing. Estimated average gain in breeding value if the top 20% of the families are retained and mate as an ideal seed orchard population averaged 4.5% (Mullin 1996).

ANALYSIS OF LAKE NIPIGON WEST JACK PINE FAMILY TEST DATA

In 1987, members of the Ontario Tree Improvement Board established a jack pine (*Pinus banksiana*) seedling seed orchard at Kakabeka Falls, Ontario, and associated family tests at four locations in the Nipigon West Breeding Zone. The 400 families were ranked at 10 years according to BLP estimates of breeding value, as a guide to orchard roguing. If the top 20% of the families are retained and mate as an ideal population, volume gain from the roguing is estimated to average 8.7% (Mullin 1997c). Individual breeding values were calculated by BLP for over 32,000 trees growing in the family tests and seed orchard, as candidates for selection into the second-generation breeding population. Expected gain in volume from selecting the top 1.5% by the selection index was estimated as 18.6% (Mullin 1997d).

SIMULATION OF GENETIC CHANGE IN MANAGED POPULATIONS

The simulation techniques developed earlier in a computer program known as POPSIM were further developed and made available on the Internet (Mullin 1997e; Mullin and Park 1997; Mullin *et al.* 1995). A collaboration was formed with Professor Dag Lindgren (Swedish University of Agricultural Sciences, Umeå) to promote the application of simulation techniques to evaluate genetic change. During two visits to Sweden as an invited scientist, funded by the Jacob Wallenberg Foundation, the writer collaborated with graduate students and scientists at the Centre for Prediction of Genetic Change (Swedish University of Agricultural Sciences) and the Swedish Forest Research Institute (SkogForsk), and applied POPSIM in an evaluation of genetic diversity and potential for future gains from Sweden's tree improvement program (Mullin *et al.* 1996). This collaboration will continue under a two-year research grant, awarded to Genesis by the Swedish Tree Breeding Foundation (Föreningen Skogsträdsförädling).

COMPARING SELECTION METHODS AND THEIR IMPACT ON GAIN AND RELATEDNESS

When selecting breeding populations, tree breeders face the paradox of how to achieve gain while controlling relatedness so that genetic diversity is conserved. Selecting related individuals results in rapid loss of genetic diversity, and lost potential for future gain. The consequences of different selection approaches, in terms of both gain and relatedness, were examined in a series of simulation studies (Andersson *et al.* 1997a, 1997b; Lindgren *et al.* 1997b). The concept of "group coancestry" was incorporated in a new selection method that considers both gain and relatedness simultaneously (Lindgren and Mullin 1997a; Lindgren *et al.* 1997a; Mullin and Lindgren 1997). The new selection method, now known as "population-merit selection", was applied to the Lake Nipigon jack pine data described earlier and found to result in a more optimal balance of gain and relatedness in a real-life selection operation for advanced-generation breeding (Mullin 1997d).

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DETERMINATION OF WOOD QUALITY AND END-PRODUCT POTENTIAL FOR A GENETICALLY IMPROVED RESOURCE

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With the decreasing supply of softwood resource, poplar has become an important source of fibre supply in many eastern mills. Although great strides have been made in utilizing the poplar resource for various products there are still many problems to address and opportunities for value-added products. The development of fast-growing hybrid poplar clones, over nearly 30 years in Québec, has produced promising clones that are recommended for reforestation. While these clones have shown excellent growth performance and resistance to diseases and pests, there is, however, very limited knowledge on the wood quality and end-product potential of these clones. In an attempt to provide needed information and guidance to industry and governments, we initiated a multi-year project to address wood quality and end-product potential for balsam poplar and hybrid poplar clones recommended for reforestation in Québec.

In collaboration with Drs. N. Isabel, J. Beaulieu, and J. Bousquet, we also carried out a study on wood density of black spruce (*Picea mariana* (Mill.) B.S.P.) in Québec. The objectives of this study were to: 1) determine the general trend in growth and wood density profiles, 2) estimate the age of transition from juvenile to mature wood, 3) examine the phenotypic correlations among some intra-ring characteristics in juvenile and mature wood zones, 4) determine the age at which wood density and ring width can be predicted, and 5) evaluate the possibility of predicting wood density and growth from individual rings. Such a study is useful to both wood scientists and tree breeders. Wood density is highly correlated with wood mechanical and physical properties. Thus, the knowledge of density variation and its radial patterns are essential to efficient wood processing and end uses. For tree breeders, this study will provide valuable information on the variation in wood density and ring width.

In addition, we also carried out other research projects dealing with the impact of silviculture on log and wood characteristics, product quality, and value.

ESTABLISHING POTENTIAL END-USE OF HYBRID POPLAR CLONES

In collaboration with Dr. Gilles Vallée from the Québec Ministry of Natural Resources, les Industries Mégantic, Domtar, and University of Québec, we initiated a multi-year and multi-disciplinary project on end-use wood characteristics and utilization of hybrid poplar clones. The project is divided into two parts. The main objective of Part I of the study is to compare important wood characteristics of 21 three-year-old hybrid poplar clones growing on a fertile clay soil and on a poorly drained low quality site, for early selection of better performing clones. The objective of Part II is to evaluate key wood quality characteristics which determine end-use and product quality of 5 fast-growing hybrid poplar clones recommended for reforestation in southern Québec. These clones have reached rotation age (15 year-old).

Part I: Wood quality of 21 three-year-old hybrid poplar clones

This study revealed that site conditions affect the diameter and height growth of nearly all three-year-old hybrid poplar clones. The average DBH for the best quality site (St-Ours) was approximately 55 mm compared to 24 mm for the site in Windsor, Québec. The average fibre length in such young trees does not differ appreciably from site to site (< 2%). However, approximately $^{2}/_{3}$ of the clones recorded higher average fibre lengths on the most productive site.

Results also indicate that average wood density is lower on the best site for the overwhelming majority of the clones. On average, wood density for trees from St-Ours and Windsor is 351 kg/m^3 and 401 kg/m^3, respectively. Several clones did well on both sites. Among them are three *Populus interamericana* (*P. trichocarpa x P. deltoides*) clones from Belgium, that are recommended for reforestation in southern Québec. They were among the best 4 clones on each site.

It is difficult to determine if all wood characteristics of mature clones can be predicted at such an early age. However, as an example we noted that clone 3308, which ranked in the top 5 out of 21 clones on both sites for average fibre length, was first (see below) among 5 fifteen-year-old clones recommended for reforestation in southern Québec.

Part II: Wood characteristics and end uses of 5 fifteen-year-old clones recommended for Québec

Wood characteristics of approximately 45 fifteen-year-old trees from five clones recommended for reforestation in southern Québec and two reference clones were evaluated. Trees from this site were pruned and thinned at age 5. Three *Populus interamericana* clones (*P. trichocarpa x P. deltoides*) from Belgium had the best radial growth rate. Although preliminary mill trials showed that all poplars on this site can produce very good veneer, we believe that these 3 clones have the potential for producing above average veneer bolts because of their excellent growth rate and short rotation, which will maximize yield and practically eliminate any decay formation before harvesting. Pruning also helped produce veneer bolts with a very low incidence of knots in the lower parts of the stem. These clones can also be considered for lumber production, even if their wood density and bending properties are somewhat lower than those of the reference clones. Wood from these clones generally has shorter fibers which could limit their application in pulp and papermaking.

Clone 3308, a *Populus euramericana* (*P. deltoides x P. nigra*) from France, on the other hand, has the best average fibre length of all the recommended clones for southern Québec. It should thus have superior pulp and paper properties. A study by Dr. Jacques Valade and his associates from University of Québec, using the same material, concluded that this clone was the only selected clone for southern Québec that produced chemithermomechanical pulps having properties similar to aspen. Another clone (reference clone 3005), *P. euramericana* from France, also has excellent fibre length values (slightly superior to clone 3008). Clone 3008 may also produce high-quality logs for veneer production.

Wood properties of clone 131, a *Populus euramericana* from Québec, are among the lowest for most product applications. This clone has the lowest diameter growth, the lowest wood density and the shortest average fibre length. It is also at the lower end of the clones for bending properties. Its use in reforestation should be limited.

In conclusion, 4 of the 5 clones recommended for reforestation in southern Québec have shown good potential for producing quality fibre for the manufacture of composites and other end products (e.g., pulp and paper, lumber). It should, however, be kept in mind that volume growth comes at the expense of wood density and mechanical property. Nevertheless, large proportion of high quality clear wood will help industry produce high-quality and value-added products commanding top prices.

WOOD QUALITY AND END-USE POTENTIAL OF BALSAM POPLAR IN RELATION TO SITE, AGE, AND HEIGHT

In collaboration with the Québec Ministry of Natural Resources and the Société d'exploitation des ressources de la Neigette, we initiated a study on wood quality and end-product potential of balsam poplar because this species is almost completely underutilized in the Lower-Saint-Lawrence and little information is available on the effect of site and age on wood quality. Approximately 25 trees representing 5 diameter classes were selected from each of 3 typical sites where balsam poplar grows in the region. Discs were collected at several height levels from each tree for the determination of major wood characteristics (density, growth rate, age, stain, rot, ring shakes, etc.) that affect product quality and value. Additionally, a one-meter long bolt was collected from one tree per diameter class on each site, for the determination of bending properties.

The results indicate that balsam poplar grows almost twice as fast on the best type of site as on the worst site. Growth rate is extremely important in this species since trees are often severely affected by decay at a very young age. In fact, Zhang and Chauret (1996) found that balsam poplar should ideally be harvested at approximately 60 years of age to prevent severe occurrence of decay. The average DBH at this age will vary from site to site (20 cm to 50 cm). On the downside, both wood density and mechanical properties of the wood from trees grown on better sites are significantly lower. This study also revealed that wood density increases with position along stem height. It is unknown whether the mechanical properties of the wood from bolts located higher in the tree will be greater or not.

In conclusion, this study failed to identify any serious utilization problem in this species providing that trees are harvested at the recommended ages for each type of site. In fact, we found that the wood characteristics of this species seem to be adequate for the production of a number of products (e.g., pulp and paper, panel products, lumber). To take advantage of the variation in wood quality with height and to maximize the value of each tree, we recommend that each log (height levels) be sorted and transformed into products of the highest possible value. For example, large clear logs should be used for veneer, while smaller logs from tops or smaller trees could be converted into pulp and paper or panel products.

VARIATIONS AND CORRELATIONS OF WOOD DENSITY AND GROWTH IN BLACK SPRUCE

Part I: Transition age from juvenile wood to mature wood based on wood density

Two black spruce plantations from two different locations were sampled. At the end of the 1995 growing season, 1 032 trees from 86 provenances were sampled from a provenance test at Mont-Laurier, Québec. In addition, at the end of the 1996 growing season, 1 000 trees were sampled from a mature commercial plantation in Victorialle, Québec. From a constant compass direction, 6-mm increment cores were sampled from each tree at breast height. Each core was sawn into a 1.57-mm-thick (longitudinal) x 6-mm wide strip for X-ray densitometric analysis. This analysis provides various density and growth data on individual rings. These include earlywood width, latewood width, ring width, earlywood density, latewood density, and average wood density of the ring. Based on the data from individual rings, weighted averages were computed for all measured traits.

The intra-ring characteristics of all sampled trees in both plantations were studied. The radial trends were similar to those reported previously for *Picea* species. The ring density in juvenile wood is high near the pith, then decreases rapidly to a minimum in the transition zone, and finally shows a steady increase thereafter. Latewood density increases constantly to a maximum at 12 years of age, then decreases outwards.

Part II: Correlations in wood density and growth between juvenile wood and mature wood

Juvenile-mature correlations in black spruce were carried out based on increment core samples taken from the two plantations. For all measured characteristics, correlations between juvenile and mature wood are highly significant. Thus, selection for these wood characteristics appears feasible during the juvenile period. Twelve growth rings from the pith serve as a good predictor for the wood characteristics of both mature wood and the whole tree. In addition, individual growth rings from the juvenile-mature wood transition zone can be used to predict wood density of mature wood or of the whole tree. Moreover, ring density components are significantly correlated with their respective ring width components. Earlywood density and ring density are negatively correlated with ring width and earlywood width while ring density and latewood density are positively correlated with latewood width. These hold true in both juvenile wood and mature wood. However, the correlations are lower in mature wood. In fact, the correlations between these traits and ring density tend to decrease with increasing age.

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AMÉLIORATION DES ARBRES FORESTIERS À LA DIRECTION DE LA RECHERCHE FORESTIÈRE DU MINISTÈRE DES RESSOURCES NATURELLES

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AMÉLIORATION GÉNÉTIQUE DU PIN GRIS, DU PIN LODGEPOLE ET DU PIN SYLVESTRE

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Mots-clés : Test de descendances, test de provenances, éclaircie génétique, récolte dirigée.

L'éclaircie génétique des vergers à graines de semis de pin gris (*Pinus banksiana*) s'est poursuivie en 1995 et 1996. Le calcul du gain génétique pour 11 options de récolte de cônes (récoltes dirigées) dans sept vergers déjà éclaircis a été effectué. Des prescriptions d'éclaircie ont également été faites dans quatre tests de descendances de pin gris.

L'éclaircie génétique (sélection de provenances et sélection individuelle) a été faite en 1995 dans six tests de provenances de pin lodgepole (*P. contorta*). En 1995, un mémoire a été publié sur les résultats de 10 ans de 11 tests, de pin lodgepole établis en 1980 et 1981.

L'éclaircie génétique (sélection de provenances et sélection individuelle) a été faite en 1995 dans sept tests de provenances de pin sylvestre (*P. sylvestris*) et en 1996 dans deux tests de provenances et un verger à graines. En 1996, un mémoire a été publié sur les résultats de 10 ans de 12 tests de provenances de pin sylvestre d'Europe et d'Asie et de quelques sources issues de plantations du Québec. Ce mémoire comprend l'évaluation de la coloration automnale des aiguilles, pour les arbres de Noël.

En 1996, une note de recherche forestière a été publiée sur la performance (croissance et coloration des aiguilles) de 42 provenances d'épinette du Colorado (*Picea pungens*) et de deux provenances d'épinette d'Engelmann (*P. engelmannii*) en plantation sur un site au Québec.

RECHERCHE ET DÉVELOPPEMENT SUR LES SEMENCES ET LE POLLEN

par Stéphan Mercier

Mots-clés: Pollen, semence, pollinisation, verger sous abri, stratification, criblage.

Vergers à Graines Sous Abri

Ces vergers sont axés sur la production de graines améliorées d'épinette noire (*P. mariana*), d'épinette blanche (*P. glauca*) et de mélèze hybride (*Larix* sp). Les efforts sont mis principalement sur l'établissement d'une seconde génération de verger à graines, sur l'accélération de la croissance des greffes et sur les travaux de R-D concernant la pollinisation dirigée et de masse et l'induction florale du mélèze. Depuis cette année, nous travaillons à la mise en place d'un nouveau concept de verger de 2^{e} génération qui consiste à disposer les arbres à l'intérieur de brise-vent espacés de 60 à 80 m afin d'augmenter la température du site (accélération du développement des cônes mâles et femelles) et pour faciliter la gestion du vent lors des travaux de récolte massive de pollen et de pollinisation de masse. Par ailleurs, nous mettons au point un abri économique qui permet d'accueillir des arbres de 6 m de haut.

Production et Utilisation de Semences

Notre Direction, en collaboration avec le Centre des semences forestières de Berthier, a développé un système de stratification dit « en lasagne » qui permet d'accélérer, d'uniformiser et d'augmenter la germination des graines d'épinette blanche. Cette technique s'avère très supérieure par rapport à celles utilisées conventionnellement, dont la technique de *priming*. Par ailleurs, nous avons suivi l'effet du criblage des graines d'épinette blanche sur la qualité des plants produits en pépinière. Nous tentons de faire actuellement la démonstration que le criblage de ces graines ne réduit en rien la diversité génétique du matériel produit.

SÉLECTION D'ARBRES FEUILLUS POUR LEUR RÉSISTANCE AUX MALADIES

par Marie-Josée Mottet

Mots-clés : *Populus, Betula, Septoria musiva, Entoleuca mammata, Hypoxylon mammatum, Nectria galligena.*

Depuis 1986, la méthode employée pour évaluer la sensibilité des clones et semis de peuplier au chancre septorien (*Septoria musiva*) consiste à inoculer artificiellement le pathogène en pépinière. Plus de 200 clones et plusieurs milliers de semis de peuplier ont été sélectionnés pour leur résistance ou leur faible sensibilité. La sensibilité et la résistance des plants sélectionnés est suivie en plantation.

Les inoculations en serre et en pépinière nous ont permis de noter des différences de sensibilité à *Entoleuca mammata* (*Hypoxylon mammatum*) entre certains clones de peuplier. Quelque 135 semis sélectionnés pour leur résistance, ont été clonés et sont évalués sur différents sites. La plupart des semis résistants sont des hybrides avec *Populus alba*. Sur une centaine d'autres clones - principalement des peupliers faux-trembles - testés en 1993 dans la région de l'Abitibi, les résultats de 5 ans confirment la résistance de 30 clones d'hybrides de baumier. Sur 80 clones de la section Leuce, seulement six clones dont trois *P. tremuloides*, montrent une plus grande résistance.

Une méthode d'inoculation artificielle en serre et en pépinière a été utilisée sur différents clones et provenances de bouleau jaune afin d'étudier la variabilité génétique de la sensibilité de cette essence à *Nectria galligena*, champignon responsable du chancre. Un dispositif a été établi au champ pour un suivi à plus long terme. L'analyse des résultats des tests précoces a permis d'obtenir des clones et une provenance de bouleau jaune montrant jusqu'à maintenant, une meilleure résistance. Ce type de sélection pourra s'appliquer à d'autres maladies rencontrées en plantation.

AMÉLIORATION GÉNÉTIQUE DE L'ÉPINETTE BLANCHE

par Marie-Josée Mottet at André Rainville

La responsabilité de l'amélioration génétique de l'épinette blanche a été transférée du SCF (Service canadien des forêts) au MRN en 1996. Au programme de recherche initié par le SCF, qui a maintenant été repris par M André Rainville, le MRN a greffé un volet visant à tirer profit du matériel présent dans les vergers à graines clonaux de première génération en orientant les récoltes de cônes sur les meilleurs clones ; c'est Mme Marie-Josée Mottet qui en est responsable.

Quelque 3 000 greffes représentant 460 arbres sélectionnés dans des tests génétiques ont été repiquées en pépinière à la Station forestière de Duchesnay en 1996 pour culture intensive. Des observations sur la floraison et sur la densité du bois seront prises pour permettre de réduire cette population à 240 arbres ; ils serviront de géniteurs pour la prochaine génération.

Au printemps de 1996, deux plantations de sélection ont aussi été réalisées au Québec ; elles sont constituées de descendances issues de croisements dirigés réalisés entre les 100 premiers arbres sélectionnés par le SCF. En 1997, le MRN a fait la plantation de cinq tests de descendances issues de croisements dirigés polycross, réalisés à partir de la même population d'arbres sélectionnés.

Dans le cadre du second volet initié par le MRN en 1996, des tests de descendances seront réalisés à partir des 17 vergers à graines clonaux de première génération. Les graines issues de pollinisation libre, ont été récoltées en moyenne sur six ramets de chaque clone. En 1997, deux tests de descendances reliés à un verger ont été établis. Quatre autres tests ont été réalisés pour étudier les effets du type de pollinisation et du nombre de ramets sur le classement des clones. La production de plants pour 21 autres tests a été amorcée.

AMÉLIORATION GÉNÉTIQUE DES FEUILLUS À BOIS NOBLE

par André Rainville

Mots-clés : Amélioration génétique, croisements dirigés, feuillus nobles, sélection d'arbres, greffage.

Pour le chêne rouge (*Quercus rubra*) et le frêne d'Amérique (*Fraxinus americana*), le programme d'amélioration génétique est orienté vers une stratégie à long terme ayant pour base les tests de provenances-descendances. Les 5 tests de chêne rouge établis en 1993 devaient être complétés en 1995 et 1996, mais le gel des plants nous oblige maintenant à recommencer le travail de récolte. En 1997, deux vergers à graines clonaux constitués d'une centaine d'arbres-plus ont été plantés au Québec. Pour le frêne d'Amérique, un verger à graines a été planté en 1994. La constitution de tests de provenances-descendances est retardée depuis quatre ans en raison de la production erratique de samares de l'espèce.

Pour le bouleau jaune (*Betula alleghaniensis*), plus de 120 arbres-plus ont été établis dans 4 vergers à graines clonaux en 1996. Ces greffes serviront à faire des croisements dirigés interspécifiques. En 1996, deux tests de provenances-descendances ont été plantés en milieu forestier. Ces tests sont constitués de demi-fratries récoltées sur des arbres sélectionnés et sur des arbres-témoins ; en plus de valider l'efficacité de la sélection phénotypique, ces tests serviront à évaluer le comportement de l'espèce (qualité des tiges et croissance) lorsque plantée en milieu forestier.

Le programme d'amélioration du bouleau à papier (*B. papyrifera*) comporte une voie exploratoire basée sur les croisements inter-spécifiques, et une stratégie basée sur l'amélioration simultanée du bouleau à papier et de bouleaux d'espèces exotiques. Des greffes de bouleau à papier sélectionnés ont été plantées en 1996 et doivent servir pour effectuer les croisements interspécifiques à partir de 1998. Des bouleaux d'espèces exotiques seront greffés en 1997-98 dans cet objectif. Dans le second volet, la récolte de semences provenant de toute l'aire de distribution de l'espèce au Québec est prévue.

Finalement, 3 vergers à graines clonaux de noyer noir (*Juglans nigra*) ont été établis en 1996 et 1997 avec du matériel ayant démontré une bonne résistance au froid et une croissance intéressante au Québec. Les semences récoltées sur les ortets ont aussi permis d'établir 2 tests de descendances en 1997 (ensemencement direct sous paillis). Pour le noyer cendré (*J. cinerea*), trois plantations conservatoires constituées de provenances de tout le Québec ont été réalisées en 1996, hors de l'aire de distribution naturelle, dans le but de protéger l'espèce contre une maladie dévastatrice, le chancre du noyer cendré (*Sirrococcus clavigignenti-juglandacearum*).

AMÉLIORATION GÉNÉTIQUE DES MÉLÈZES (*LARIX* SP.) ET DE L'ÉPINETTE DE NORVÈGE (*PICEA ABIES* KARST.)

par Ante Stipanicic

Mots-clés : Éclaircie génétique, croisement dirigé, tests de descendances, tests de provenances.

Nous avons continué les éclaircies génétiques dans les tests de descendances ou de provenances de mélèze d'Europe (*L. decidua*), de mélèze du Japon (*L. kaempferi*), de mélèze hybride et de mélèze laricin (*L. laricina*) qui ont atteint l'âge de 15 ans. Le but est de transformer ces tests en sources de graines génétiquement améliorées. Nous avons profité de la bonne fructification de 1996 pour récolter les cônes dans un des tests éclaircis. La qualité génétique des arbres semenciers sera évaluée. La sélection des arbres était basée sur la hauteur et la flexuosité du tronc. Actuellement, 30 plantations d'une superficie totale de 40 ha ont été traitées.

Nous avons effectué 23 croisements entre des arbres d'élite de mélèze d'Europe, de mélèze du Japon et de mélèze laricin. Nous avons obtenu quelques hybrides triples (*decidua* X hybride *kaempferi* X *siberica* ou *decidua* X hybride *laricina*X *kaempferi*). En 1996, nous avons commencé une série de croisements dans notre parc à clones sous abri composé de 25 clones de mélèze du Japon et 25 clones de mélèze d'Europe sélectionnés. Les ramets sont cultivés dans des contenants de 50 l, et la première série de pollinisation nous a permis d'obtenir 10 croisements biparentaux et huit croisements issus de mélange de pollen (polycross).

Deux nouvelles plantations d'introduction sont composées de quelques provenances de mélèze d'Europe et d'hybride x *eurolepis*. Quatre nouveaux tests de descendances englobent 30 hybrides obtenus par nos croisements dirigés. Soixante descendances de mélèze de Sibérie font partie d'un autre test dans la forêt boréale. Un nouveau verger à graines de mélèze hybride, composé de 36 clones de mélèze d'Europe et de 190 de mélèze du Japon, est installé en partie sur trois sites. Parmi nos résultats, il faut mentionner l'accroissement remarquable de quelques hybrides dans un test de descendances âgé de 4 ans situé dans l'arboretum de Verchères : l'hybride x *eurolepis* « Lola 1 » d'Allemagne a atteint 4,19 m de hauteur moyenne et un de nos croisements, S10743, 3,99 m.

Pour l'épinette de Norvège, nous avons actuellement 14 dispositifs éclaircis (superficie totale de 11,6 ha), dans lesquels on peut récolter des graines améliorées. Les croisements dirigés et l'installation de nouveaux dispositifs expérimentaux sont faits en collaboration avec le Service canadien des forêts. En 1996, nous avons effectué huit croisements dans notre parc à clones de Duchesnay, en vue de compléter deux plans factoriels pour deux zones d'amélioration; 120 arbres sélectionnés dans 12 provenances recommandées seront utilisés pour obtenir des hybrides inter et intraprovenances. Une série de neuf tests de provenances-descendances pour la zone du Saint-Laurent a été mise en marche en février 1995. On veut délimiter avec plus de précision les zones d'amélioration de l'épinette de Norvège ainsi qu'évaluer plusieurs descendances de provenances québécoises et polonaises.

Deux tests de descendances en pépinière sont inclus dans une étude sur la biologie du charançon du pin blanc (*Pissodes strobi*) menée par l'équipe du Service canadien des forêts. Pour une autre étude dirigée par les chercheurs de Direction de la conservation des forêts du Ministère des Ressources naturelles du Québec, deux tests de provenances servent à évaluer l'impact des attaques de charançon sur différentes provenances d'épinette de Norvège.

SÉLECTION DE CLONES ET AMÉLIORATION GÉNÉTIQUE DU PEUPLIER

par Gilles Vallée

Mots-clés : *Populus* Michx., croisement, test clonal, test de descendances, test de provenances.

Durant les deux dernières années, l'intérêt de l'industrie forestière québécoise pour la plantation de peuplier hybride a continué de s'amplifier en même temps que la demande de bois de peuplier. Une nouvelle usine de panneaux à particules orientées s'est ajoutée aux cinq usines déjà en fonction et les usines de pâtes et papiers, de sciages et de déroulage consomment plus de bois de peuplier. L'un des problèmes rencontré est le manque de billes de qualité pour le déroulage et le sciage dans les peuplements naturels de peuplier faux-tremble (*Populus tremuloides* Michx.). La plantation de peuplier hybride peut pallier ce problème. La récolte d'arbres de 15 ans dans un test clonal de la région de Montréal a permis de faire un essai de déroulage en usine. Cet essai, fait à partir d'un échantillonnage des cinq meilleurs clones, a été très concluant de sorte que la compagnie qui a fait l'essai a réservé toutes les billes de déroulage du test.

En 1996, un plan de croisements a été mené en collaboration avec Panneaux Chambord inc. et la Direction régionale du Ministère, afin de développer une population d'hybrides pour le domaine écologique 8 de la région du Saguenay - Lac-Saint-Jean. Les croisements ont été faits en utilisant des espèces et hybrides autochtones (*P. deltoides* Marsh., *P. balsamifera* L., *P. tremuloides* Michx., *P. grandidentata* Michx., *P.* x *Jackii* Sarg., *P.* x Rollandii Rouleau, *P.* x *euramericana* Dode) et des espèces et hybrides de la collection du Ministère (*P. alba* L., *P.* x *canescens* Smith, *P. maximowiczii* Henry, *P. nigra* Dode, *P. tremula* L., *P. trichocarpa* Torr. & Gray, etc.). Quelque 741 croisements de la section Leuce ont été faits dont 140 ont donné 12 420 semis et 227 croisements des sections Aigeiros et Tacamahaca sur 1 215 réalisés ont donné 25 241 semis. Les plants ont été cultivés en 1996 et seront plantés en tests en 1997.

Onze tests clonaux et trois tests de descendances d'hybrides ont été établis en 1995 et 1996. Depuis 1969, 3 707 clones ont été évalués ; 575 ont été sélectionnés dans les peuplements naturels, 2 373 dans des plantations comparatives et des pépinières et 759 autres clones ont été introduits surtout d'Europe et d'Ontario. De plus, 93 tests clonaux, 28 plantations de collections de clones et 41 tests de provenances et descendances ont été mis en place. Quelque 6 260 croisements ont été faits dont 1 041 ont donné des semis. Ajoutons l'obtention de 257 lots de semences de pays étrangers et la récolte de 601 lots de semences du Québec sur 34 espèces ou hybrides.

AMÉLIORATION GÉNÉTIQUE DE L'ÉPINETTE NOIRE

par Michel Villeneuve

Mots-clés : Bouturage, embryogenèse somatique, gains réels, test précoce, variété multifamiliale, préconditionnement.

Depuis 1995, 15 nouveaux dispositifs ont été implantés sur 9 sites : 200 clones produits par bouturage (2 sites), 81 descendances biparentales (3 sites), 32 clones produits par embryogenèse somatique (2 sites), 32 croisements réalisés selon un plan factoriel (2 sites), 16 descendances produites par croisements d'arbres à cime étroite et à cime large (2 sites), et 4 plantations d'évaluation des gains réels.

Onze prescriptions d'éclaircies génétiques de vergers à graines ont été produites. Les gains en hauteur calculés varient de 2,3 à 8,0 %. L'intensité de l'éclaircie est souvent limitée par la capacité de production minimum à atteindre. On a calculé que les 100 clones d'élite qui serviront à établir un verger de 2^{e} génération donneront un gain de croissance en hauteur de 20 % à 10 ans.

Le testage précoce en pépinière s'est avéré très efficace. L'héritabilité familiale de la croissance en hauteur est élevée et stable (> 0,8). Après trois saisons de croissance, les familles sont supérieures de 12 à 16 % en hauteur par rapport aux six provenances témoins. Les meilleures familles ont une croissance jusqu'à 35 % supérieure. Il est possible d'identifier les familles les moins intéressantes dès la troisième saison de testage en pépinière.

Le suivi de 360 boutures pour chacune de 21 familles, depuis l'enracinement jusqu'au tri des plants avant livraison, a permis de déterminer que le nombre de pieds-mères et la productivité de ceux-ci (en boutures), variables entre les familles, détermine la diversité génétique effective du mélange. On doit viser à obtenir un nombre égal de boutures par famille à chaque nouveau bouturage, afin de préserver la diversité génétique anticipée dans la variété multifamiliale.

Afin d'évaluer l'importance du préconditionnement environnemental sur l'expression des gènes, des ramets de six clones ont été plantés sur cinq sites en 1994. Les mêmes croisements seront réalisés à chaque endroit. Ces combinaisons « croisement x site » seront testées dans un environnement commun.

Nous avons installé quatre plantations de comparaison de plants issus de variétés améliorées (3 lots) et de plants issus de semences tout venant (3 lots), afin d'évaluer les gains réels en croissance et en rendement (volume/ha) engendrés par le premier cycle d'amélioration génétique. Le dispositif utilisé est constitué de parcelles carrées de 196 arbres.

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FOREST GENETICS AND SOMATIC EMBRYOGENESIS

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GRADUATE STUDENTS AND POSTDOCTORAL FELLOWS

As a university research group, one of our main goals is to train graduate and postdoctoral research associates. We have witnessed, over the years, a large amount of high quality research work realized by these young scientists and their important contributions to various areas of forest genetics and evolutionary biology must be underlined. Dr. Nathalie Isabel completed her PhD in 1995 in molecular population genetics and its applications to somatic embryogenesis of spruce species. She is now a research scientist at the Canadian Forest Service and adjunct professor to Laval University. Dr. Sylvain Jeandroz, who was a postdoctoral fellow from the University of Besançon, returned to France in 1997 as associate professor at the University of Nancy after completing several studies on the molecular population and evolutionary genetics of ashes. Dr. Rodolphe Boivin also completed his postdoctoral studies in 1996 on the molecular genetics of somaclonal variation. Dr. Ahmed Koubaa also left us in 1997 for a position as research scientist at Forintek-BC, after completing postdoctoral studies on wood density in black spruce.

Among the new postdoctoral fellows, Dr. Daniel J. Perry joined us in 1996 from the University of Minnesota and is actively working on developing new codominant DNA markers for spruce species. Since 1997, Dr. Yvan L'Homme from McGill University has been pursuing work initiated by Drs. Isabel and Boivin on the molecular genetics of somaclonal variation. Dr. Zhou Yu Ping from Bejing University also joined us in 1997 to develop genetic maps in black spruce. Dr. Edwidge Cazaux from University of Montpellier has been working for the past year on spruce somatic embryo encapsulation while Dr. Marika Delalonde, from the same university, is currently involved in the characterization of endogenous growth regulators in the spruce somatic embryogenesis systems.

Several PhD students are expected to complete their degree in the following months. Mr. Martin Perron is pursuing his PhD studies on the molecular ecology of the black spruce - red spruce complex and he is expected to complete his work by the beginning of 1998. Mr. Jérome Laroche is also expected to complete his Ph.D. by the end of 1997 in the area of DNA sequence analysis and the study of plant and conifer mitochondrial genes. Mr. Stéphane Plante shall complete his PhD in 1998 on the biosystematics and conservation genetics of endangered plant species. Mr. Claude Bomal should also complete a PhD in 1998 on the dehydration of spruce somatic embryos while Mr. Abdelmalek El Meskaoui is expected to complete his PhD on the environmental control of spruce somatic embryogenesis. More recently, Mr. Driss Iraki initiated a PhD on the effect and biochemistry of carbohydrates during the different stages of somatic embryogenesis.

At the MSc level, Mr. Éric Forget, who was working on methods of mass selection for sap sugar content in maple, completed his degree in 1996 and is now working for the BC Ministry of Forests. Three new MSc students, Mrs. Sauphie Senneville, Marie Bouillé, and Mr. Ricardo Morin initiated several studies in 1997 related to the conservation genetics of endangered plant species and the population genetics of forest trees, in collaboration with scientists from the Canadian Forest Service (G. Daoust and J. Beaulieu).

MOLECULAR POPULATION AND CONSERVATION GENETICS

Over the past two years, much of the work in molecular population genetics has focused on estimating population genetics parameters from RAPD markers in black spruce (Isabel *et al.* 1995a) and white pine (Isabel, in prep.), and comparing these estimates with those derived from allozyme markers (supported by FCAR of Québec and in collaboration with J. Beaulieu from the Canadian Forest Service). The various estimates were quite congruent when derived from genotypic data but biases were observed when using dominant RAPD fingerprint data from diploid tissues. New codominant markers from polymorphic expressed gene sequences (PEGs) (Perry and Bousquet 1997) were also developed for spruce species and they are being applied to study the effects of different management regimes and natural disturbances on the diversity of black spruce (supported by the Network of Centers of Excellence on Sustainable Forest Management).

RAPD species-specific markers were used to estimate the incidence of natural hybridization and introgression between black spruce and red spruce (Perron *et al.* 1995; Perron and Bousquet 1997), and estimating levels of genetic diversity in red spruce (M. Perron, in prep.). These last studies, supported by the Québec Ministry of Natural Resources, have shown that natural hybridization between the two spruces is extensive in the area of sympatry in the St. Lawrence Valley while introgression has been detected in both zones of allopatry. Preliminary results also indicate that allopatric red spruce is genetically depauperated at the DNA level, as compared to allopatric black spruce. With the support of a France-Québec cooperation program, species-specific RFLP and RAPD markers have also been developed for the French ashes (Jeandroz *et al.* 1995, 1996) and they are currently being used to estimate the levels of natural interspecific hybridization and the population structure in collaboration with researchers at the University of Paris-Orsay (N. Frascaria-Lacoste *et al.*).

EVOLUTIONARY GENETICS

Studies conducted during the past two years in the area of molecular biosystematics and evolutionary genetics have been supported by grants from NSERC and FCAR of Québec and have encompassed a very large spectrum of subjects. They reflect the many collaborations we have had recently in that field of research. The phylogeny of the main groups of land plants has been estimated and compared between *rbc*L gene sequences and the newly isolated chloroplast gene *chl*B. Notably, the position of the main groups of gymnosperms was in agreement between the two gene phylogenies (Boivin *et al.* 1996). *Rbc*L gene sequences have also been used to estimate the phylogeny of over 100 angiosperm taxa; the results demonstrate that the nine families of nitrogen-fixing actinorhizal shrubs and trees have an unexpected large phylogenetic proximity in spite of being taxonomically unrelated (Roy and Bousquet 1997).

Our studies aimed at estimating the modes and tempos of evolution of mitochondrial introns and exons of angiosperms have also been completed, with a sampling of over 170 distinct DNA sequences distributed among 15 genes (Laroche *et al.* 1995, 1997). Notably, intron sequences have been shown to vary as much as synonymous sites of exon sequences, and mitochondrial *CoxI* genes of poplar, birch and other woody angiosperms were shown to evolve much slower than similar gene sequences in annual plants, paralleling such a contrast observed for the chloroplast gene rbcL from gymnosperms and angiosperms (Bousquet *et al.* 1992; Savard *et al.* 1994). Therefore, on the geological scale, woody taxa such as trees are evolving more slowly than annuals, and this is likely attributable to longer generation time, larger population sizes and slower speciation rate due to archaic reproductive isolation mechanisms.

At a much finer scale, the phylogeny and phylogeography of the genus *Fraxinus* was established using internal transcribed spacer sequences (ITS1 & ITS2) of nuclear ribosomal DNA for about 30 taxa (Jeandroz *et al.* 1997). This is the first complete phylogeny deduced from DNA sequences for a tree genus. Intraspecific variation was minimal and closely related hybridizing taxa showed a small divergence at the DNA level. Much higher diversity was observed among sections. The origin of the genus was determined to be in North America, with two latter events of intercontinental migration towards Asia. Biosystematic studies conducted with fungi and bacteria were aimed at describing chromosome length polymorphisms and determining the phylogenetic position of new species using 16S ribosomal DNA sequences (Dufresne *et al.* 1996; Shooner *et al.* 1996).

MOLECULAR TREE IMPROVEMENT AND QUANTITATIVE GENETICS

A collaborative project involving the development of marker-aided selection for mature wood density in eastern spruces was pursued and further supported by grants from NSERC and the Québec Ministry of Natural Resources, and active collaborations from the Canadian Forest Service (N. Isabel & J. Beaulieu), Forintek-Canada (S.Y. Zhang), the Québec Ministry of Natural Resources (M. Villeneuve), J.D. Irving (G. Adams), Fraser Papers Inc., and the Biotechnology Laboratory at UBC (J.E. Carlson). Over a five-year period, the goals of the project are to develop genetic markers for mature wood density in black spruce and white spruce, map these markers, and develop strategies for using these markers in tandem selection for growth and mature wood density. A similar study supported by the Québec Ministry of Natural Resources on marker-aided selection for sap sugar content in sugar maple and the development of first generation selections is also underway.

The studies conducted in collaboration with the Canadian Forest Service (J. Beaulieu) and P. Li (now at BC Research) on the development of multivariate approaches for the risk assessment of seed source movements in eastern white spruce have been completed (Li *et al.* 1997). Briefly, two large breeding zones have been delineated and validated for Québec. Latitude appeared as the main factor of population differentiation, and more geographic differentiation was observed for phenological traits than for growth characters. We have also completed our collaborative study supported by the Canadian Forest Service on the selection of superior white spruce seed sources for the eastern regions of Québec (Beaulieu *et al.* 1996). The publication of results from the provenance studies on Acacias and other tropical species has also been completed (Khasa *et al.* 1995a-e, now at University of Alberta). The early evaluation of intraspecific and interspecific crosses between black spruce and red spruce under various regimes of light conditions is underway, with the families completing their third year of growth (M. Perron). This project involves financial contributions and the active collaboration of the Québec Ministry of Natural Resources (M. Villeneuve).

SOMACLONAL VARIATION

Populations of white spruce raised *in vitro* following somatic embryogenesis typically show a low incidence of somaclonal variation. One of the few spontaneous changes observed, the *variegata* phenotype, was shown through ultrastructural studies to harbour extensively modified cells with immature chloroplasts (Isabel *et al.* 1995b). These mutants shared a single RAPD marker out of hundreds screened, but the sequence of the DNA fragment did not show any homology to known genes or intergenic regions. The presence of the fragment could be related to the relative abundance of nuclear and chloroplast genomes in the modified *variegata* phenotypes (Isabel *et al.* 1996).

SOMATIC EMBRYOGENESIS AND GENE TRANSFORMATION

With the financial support of the Québec Ministry of Natural Resources and the Québec Ministry of Trading, Industry, Science and Technology in partnership with three industrial seedling producers CPPFQ Enr., PAMPEV Inc., and BECHEDOR Inc. various research projects have continued to focus on white spruce and black spruce somatic embryogenesis.

Different components of the culture medium were studied to improve embryo production and quality. The results showed that glutamine could be used as the sole nitrogen source to support embryo maturation (Khlifi and Tremblay 1995). The beneficial effect of an increased sucrose concentration in the maturation medium was also shown to be caused by its complete and rapid hydrolysis under the enzymatic action of the cells (Tremblay and Tremblay 1995a). Furthermore, the experiments showed that sucrose, and later on glucose and fructose, were not utilized by the cells during maturation but seemed to act on maturation mainly through an increase in the osmotic potential of the medium. Other investigations conducted on the dessication of black spruce and white spruce somatic embryos have shown that they can survive dessiccation but survival was dependent on the relative humidity treatment (Bomal and Tremblay 1995a, b, 1996). An adequate control of the water loss was also shown to be necessary to subsequent embryo germination. When water loss was well controlled, desiccated embryos germinated in a comparable way to fresh embryos.

With the financial support of the Québec Ministry of Natural Resources, investigations were also conducted to understand the factors involved in the genetic transformation of white spruce. Using embryogenic suspension culture as study system, different factors such as the culture conditions of the cells prior to bombardment and the age of the suspension have been tested (unpublished). Transgenic tissues were obtained (Belles-Isles *et al.* 1995) and plants were regenerated. They are currently growing under greenhouse conditions for further testing.

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GÉNÉTIQUE ET AMÉLIORATION DES ARBRES AU SERVICE CANADIEN DES FORÊTS - QUÉBEC

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Mots-clés : *Picea glauca, Picea abies, Pinus strobus,* amélioration génétique, induction florale, culture *in vitro*, rouille vésiculeuse, charançon du pin blanc, marqueurs alloenzymatiques et RAPD, selection assistée

La présente période a été très fertile en changements. Nous sommes maintenant intégrés à des réseaux de recherche pan-canadiens plutôt qu'à des programmes régionaux. Nous avons de plus recentré nos efforts de recherche au niveau de la génétique forestière et transféré nos responsabilités en amélioration au ministère des Ressources naturelles du Québec. Notre consoeur, la D^re^ Ariane Plourde est devenue directrice du programme de biologie forestière au Centre de foresterie des Laurentides (CFL) et gestionnaire du réseau de biotechnologie des arbres et de génétique de pointe. Nous lui souhaitons un franc succès dans ses nouvelles fonctions et lui assurons notre support. Deux nouvelles chercheures font maintenant partie de notre groupe de recherche, soit la D^re^ Francine Bigras, spécialiste de la physiologie des arbres, et la D^re^ Nathalie Isabel, généticienne forestière spécialisée en biologie moléculaire. Le D^r^ Peng Li, qui était avec nous depuis deux ans à titre de chercheur post-doctoral, nous a quitté et poursuit maintenant sa carrière chez BCRI. La D^re^ Élisabeth Garin, spécialiste de la culture *in vitro*, est également avec nous depuis plus d'un an grâce à une bourse post-doctorale.

Toute une équipe de gens dévoués est venue appuyer nos efforts. Ainsi, en culture *in vitro*, nous avons eu le support de Julie Dubé, cadre technique, Fabrice Lantheaume (MSc, Université Laval) et Gervais Pelletier (MSc, UQUAM). L'équipe travaillant sur le marquage moléculaire a pu compter sur l'aide de Magella Gauthier, cadre technique, et Hugo Laplante (B. Sc. Université de Montréal). Tous nos progrès en génétique de pointe n'auraient pu être accomplis sans l'implication continue de René Pâquet, Serge Légaré, Roger Gagné et Yves Dubuc, cadres techniques, et de Chantal Ferland (MSc, Université Laval) et Elise Dubuc (agronome), assistés d'étudiants d'été.

Nous participons également à la formation d'une main-d'oeuvre hautement qualifiée en supervisant les travaux d'étudiants gradués. Ceux-ci sont Philippe Thériault, Sauphie Senneville, Ricardo Morin et Bruno Girard.

GÉNÉTIQUE ET AMÉLIORATION DE L'ÉPINETTE BLANCHE

par Jean Beaulieu

Le Service canadien des forêts conduisait depuis les années 1970 le programme d'amélioration génétique de l'épinette blanche (*Picea glauca* Moench Voss) au Québec. Toutefois, en 1995, le gouvernement du Canada décidait de revoir l'ensemble de ses programmes. Ainsi, à la suite de cette revue, le Service canadien des forêts recentrait son action et se retirait du champ de l'amélioration génétique pour concentrer ses efforts dans les recherches plus fondamentales portant sur la génétique des espèces forestières. Depuis, une entente a été conclue avec le ministère des Ressources naturelles du Québec et le transfert du matériel et des connaissances acquises est en cours. Afin de faciliter le transfert des responsabilités, un rapport d'information décrivant la stratégie d'amélioration suivie et le matériel constituant les populations d'amélioration a d'abord été produit. Ainsi, les nouveaux améliorateurs pourront poursuivre le travail initié en suivant une même ligne de pensée. Les croisements dirigés nécessaires à l'évaluation des géniteurs de la première génération ont été réalisés au cours des deux derniers printemps.

Des croisements dirigés ont été réalisés pour évaluer les aptitudes générale et spécifique à la combinaison des géniteurs. De plus, des variétés clonales et multifamiliales ont aussi été développées pour déterminer la valeur de l'approche clonale pour la production de matériel amélioré. Les semences issues de croisements dirigés avec mélange de pollen (polymixe) devant servir à l'évaluation de l'aptitude générale à la combinaison des géniteurs ont été mises en terre et les semis ont été produits. Un test en champ et un test avec espacements classiques ont été installés en 1996. Cinq autres tests en champ ont été installés au printemps 1997 par le ministère des Ressources naturelles du Québec. Les semences de descendances bi-parentales générées pour évaluer l'aptitude spécifique à la combinaison des géniteurs et de matériel pour la sélection de la seconde génération ont été mise en terre au cours de l'hiver 1997. Les semis seront cultivés en récipients pendant deux ans avant d'être utilisés pour établir quatre tests dans autant de régions écologiques différentes. Quatre tests en champ ont été installés en 1996 en vue de comparer les valeurs familiales obtenues à l'aide des semis et de variétés multifamiliales. La durée de vie prévue de ces tests est de huit à 10 ans. Les résultats permettront d'identifier les croisements à faire en priorité pour approvisionner le Centre de bouturage de Saint-Modeste. Des ramets de quelque 700 clones issus de familles non-apparentées ont aussi été produits au cours de la période 95-97 en partie grâce à la collaboration établie par le Centre de bouturage de Saint-Modeste. Cinq tests ont été établis au printemps 1997 dans le but d'évaluer les variances additive et non-additive des caractères de vigueur et d'identifier les familles fournissant les clones les plus performants.

À la suite de l'analyse des données des tests génécologiques établis au cours des années 1970 et 1980, des recommandations ont été faites pour la création de nouveaux vergers à graines plus performants. Ces vergers sont actuellement en phase de développement et aménagés par le ministère des Ressources naturelles du Québec. De même, des zones de déplacement des semences ont été proposées (Li *et al.* 1997).

Une étude d'impact de la pollution génique sur les complexes géniques adaptés a été initiée. Des semences issues de pollinisation libre dans deux peuplements naturels et dans un essai de provenances comprenant des individus représentant ces deux populations naturelles ont été récoltées. Des croisements de type polycross réalisés sur des arbres des mêmes provenances ont aussi été réalisés. Les semences ont été mises en terre et un dispositif expérimental sera établi dans chacun des sites des populations naturelles. Un suivi à long terme sera assuré pour détecter le cas échéant des différences en terme d'adaptation des divers matériels.

Les semences de familles issues de deux plans de croisement diallèle réalisés pour l'estimation des paramètres génétiques de caractères de croissance ont été mises en terre à l'hiver 1997. Les semis seront cultivés pendant deux ans avant d'être transférés dans quatre sites différents. De même, les croisements dirigés nécessaires à la recherche de marqueurs génétiques associés à la densité du bois mature chez l'épinette blanche ont été réalisés et les graines ont été ensemencées en 1996 et en 1997. De plus, une partie des semis est soumise à une croissance accélérée pour pouvoir réaliser une F_2 le plus rapidement possible. Des croisements dirigés ont également été réalisés suivant un plan diallèle dans le cadre du programme de recherche de marqueurs associés à la capacité embryogène chez l'épinette blanche.

GÉNÉTIQUE DES POPULATIONS ET RECHERCHE DE MARQUEURS

par Nathalie Isabel, Jean Beaulieu et Marie Deslauriers

Ce secteur d'activités de recherche est en pleine expansion au CFL puisqu'en plus de faire de la diversité génétique nous avons débuté un programme axé sur le développement de marqueurs associés à des caractères d'intérêt économique tel que la densité du bois mature et la capacité embryogène. Initialement, un projet de cartographie génomique et de sélection assistée par marqueurs pour la densité du bois mature avait été amorcé chez l'épinette blanche en collaboration avec les Drs Jean Bousquet (U. Laval) et John Carlson (UBC). Depuis deux ans, ce projet s'est élargi et inclut maintenant l'épinette noire grâce à une subvention CRSNG-stratégique (obtenue par les Drs J. Bousquet, J. Beaulieu et N. Isabel) dont la mission est l'amélioration des caractères de qualité du bois chez l'épinette blanche et l'épinette noire par la mise en place de systèmes de sélection assistée par marqueurs. Ce projet se fait en collaboration avec les Drs Tony Zhang, Ahmed Koubaa (Forintek Canada Corp.), J. Carlson (UBC), MM. Michel Villeneuve (MRNQ-Québec) et Greg Adams (J.D. Irving Ltd).

Un autre projet semblable a également été initié chez l'épinette blanche mais cette fois en vue de disséquer au niveau génétique la capacité embryogène. Ce projet se fait en collaboration avec les Drs Jean Bousquet (U. Laval) et Yill Sung Park (SCF-Region de l'Atlantique). Une partie des travaux s'effectue dans le nouveau laboratoire de culture *in vitro* du CFL qui s'est agrandi depuis l'arrivée de l'équipe des Drs Bob Ruthledge et Armand Séguin de l'Institut forestier national de Petawawa en juin 1996. Les principales espèces étudiées dans ce laboratoire sont l'épinette blanche et le pin blanc. En ce qui concerne l'épinette blanche, la majorité des travaux porte sur l'induction et fait partie intégrante du projet sur la recherche de marqueurs associés à la capacité embryogène. Les travaux sur le pin blanc visent quant à eux l'optimisation de l'étape de la maturation. Ce travail est effectué par la D Dre Élisabeth Garin (Univ. Compiègne) en collaboration avec la Dre Kristina Klimaszewska (SCF-BCRI).

Plusieurs projets portant sur la diversité génétique sont en cours. Ainsi, nous visons à estimer les niveaux de diversité génétique existant dans les populations nordiques de noyer cendré avant que le chancre du noyer qui fait des ravages au sud de la frontière n'attaque sérieusement nos populations. Ce travail est réalisé par Ricardo Morin, étudiant à la maîtrise. De plus, des recherches au niveau de la culture des tissus et de la cryoconservation devraient être entreprises sous peu. Sauphie Senneville, étudiante à la maîtrise, réalise quant à elle une étude sur la génétique des populations d'if du Canada. Les aiguilles de cette essence renferme des taxanes utiles à la lutte contre certains cancers. Le but visé est de déterminer le niveau de diversité génétique chez cette essence avant que des récoltes viennent l'altérer. Ces deux étudiants sont co-dirigés par M. Gaétan Daoust et le Dr Jean Bousquet. Une étude du comportement au séchage du bois d'épinette blanche produit en plantation a été entreprise par Bruno Girard, étudiant à la maîtrise, co-dirigé par le Dr Yves Fortin. L'étude est réalisée grâce à la collaboration de la compagnie Avenor inc. qui a effectué une éclaircie dans un de nos essais de provenances et mis les grumes à notre disposition. L'étude portant sur le pin blanc et initiée par Philippe Thériault en collaboration avec le Dr J. Bousquet (U. Laval) est maintenant complétée (Isabel et coll. 1997). Elle visait la comparaison des alloenzymes et des marqueurs RAPDs dans des populations provenant de la Vallée du St-Laurent et de l'Outaouais qui démontraient des niveaux de diversité différents au niveau alloenzymatique (Beaulieu et Simon 1994). Une étude de la structure génétique des populations d'épinette blanche à partir de matériel récolté dans un essai de provenances a également