Proceedings of the twenty-second meeting of the Canadian Tree Improvement Association: Part 1

Comptes rendus de la vingt et deuxième conférence de l'Association canadienne pour l'amélioration des arbres: 1er partie

Edmonton, Alberta
August 14-18, 1989
du 14 au 18 août 1989

Minutes and members' reports

Procès-verbaux et rapports

Catalogue No. Fo/8-1/1989-1E
ISBN 0-662-17391-0

PROCEEDINGS

OF THE

TWENTY-SECOND MEETING

OF THE

C A N A D I A N T R E E I M P R O V E M E N T

A S S O C I A T I O N

PART 1:

MINUTES AND MEMBERS' REPORTS

Held in

Edmonton, Alberta

August 14-18, 1989

Editor:

S. Magnussen & T.J.B. Boyle

Part 1. Minutes and Members' Reports

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

Part 2. Tree Improvement - Picking the Winners

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

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

Produced by
Forestry Canada
for the
Canadian Tree Improvement Association,
Ottawa, 1989

COMPTES RENDUS

DE LA

VINGT ET DEUXIÈME CONFÉRENCE

DE

L'ASSOCIATION CANADIENNE POUR L'AMÉLIORATION DES ARBRES

PARTIE 1:

PROCÈS-VERBAUX ET RAPPORTS DES MEMBRES

Tenue à

Edmonton (Alberta)

du 14 au 18 août 1989

Rédacteur:

S. Magnussen & T.J.B. Boyle

Partie 1. Procès-verbaux et rapports des membres

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

Partie II. Amélioration des arbres - choisir les meilleures

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

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Publié par
Forêts Canada
pour
l'Association canadienne pour
l'amélioration des arbres,
Ottawa, 1989

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With the compliments of the Association

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BUSINESS MEETING MINUTES

COMPTES RENUS DE LA REUNION D'AFFAIRES

C.T.I.A./A.C.A.A. 22ND BUSINESS MEETING - MINUTES

Dr. J. Klein chaired the 22nd annual Business Meeting of the CTIA/ACAA held in the Humanities Centre, University of Alberta, Edmonton, Alberta, on Thursday, August 17th, 1989.

MINUTES OF THE LAST MEETING

Motion: That the Minutes of the 21st Business Meeting be approved as published.
Moved by K. Morgenstern, seconded by B. Wang. Carried.

MEMBERSHIP

The Chairman asked for a minute of silence to remember Active Member D. Brophy, Chief Forester of Quebec & Ontario Paper Co. and Past-Chairman of the Ontario Tree Improvement Council.

A. The following were nominated as new Active Members:

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Dr. Peter de Groot	Forestry Canada
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Dr. Ariane Plourde	Forestry Canada
Dr. Albert Sproule	Alberta Forest Service
Dr. Michael Stoehr	University of Toronto

Motion: That the nominated new active members be elected.
Moved by J. Dojack, seconded by Yill Sung Park. Carried.

B. The following were recorded as Corresponding Members:

Dr. Pierre Charest
Dr. Dave DeYoe
François Dumoulin
Gordon Falk
Douglas Hunt
Spencer MacDougal
Harold Peacock
Dr. Ben Sutton

In addition, a number of deletions and address changes were noted.

CHAIRMAN'S REPORT

Jerry Klein outlined the accomplishments of the CTIA/ACAA over the past two years and suggested that the success of this meeting was due to the efforts of many individuals. He sincerely thanked the local planning committee and sub-committee members and the outgoing executive for their contributions.

FINANCIAL STATEMENT

The audited financial statement, as of May 4th, 1989, was prepared by past-Treasurer Kit yeatman and was tabled for membership information and acceptance by nominated Treasurer Steen Magnussen [see attachment #1].

The statement shows a credit balance of $25,048.78.

Motion: That the financial statement be accepted as presented. Moved by Francis Yeh, seconded by Madan Pandila. Carried.

Motion: That the incoming executive spend some money on advertising the next biennial meeting in appropriate forestry and other scientific journals to raise awareness of the CTIA/ACAA. Moved by Steen Magnussen, seconded by Al Gordon. Carried.

FINANCIAL CONTRIBUTIONS

The Fund Raising Sub-Committee Report was presented on behalf of Chairman Daryl D'Amico [see attachment #2]. The Fund Raising Committee and all CTIA/ACAA members sincerely thank the contributors for their generosity. It was noted that the sub-committee report should read "... the CTIA/ACAA depends on contributions to pay for additional meeting arrangements and hospitality." Forestry Canada covers the publishing of the meeting procedures.

EDITOR'S REPORT

Due to the sudden illness of the Editor while returning from overseas, the Editor's Report was not available for discussion.

BUSINESS ARISING FROM THE MINUTES

A. Education Committee - Chairman Francis Yeh noted that the main activity of this committee was to encourage and fund attendance by students at the biennial meetings. Francis suggested that some schools were better than others at acting promptly and thereby obtaining reduced fares. Discussion on student funding was, as usual, considerable, and stems from the fact that the CTIA/ACAA has no set policy on this activity. Nonetheless, encouraging students [both undergrad. and grad.] to attend and funding that attendance was recognized as extremely important and must continue.

Motion: That the Education Committee sponsor the attendance of up to two students from each Forestry Faculty at future biennial meetings and that level of funding be reasonable based on travel requirements.
Moved by Kit Yeatman, seconded by Alvin Yanchuk. Carried.

Motion: That the Education Committee propose, to the membertship at the 23rd biennial meeting, options for a CTIA/ACAA policy on student sponsorship at future meetings.
Moved by Sally John, seconded by Rod Savidge. Carried.

B. Tree Seed Working Group - Chairman Graham Powell commented on the success of the Monday Workshop as a forum for information transfer and discussion of research needs. He suggested that publication of workshop papers in abstract form are of little use and that some consideration should be given to publishing complete papers.

Motion: That the incoming executive of the CTIA/ACAA send suitable letters to federal, provincial and other appropriate research-management agencies, stressing the urgent need for research on management of tree crowns in seed orchards; the objective being to reduce escalating cost of crop protection and cone collection by maintaining, through pruning, reasonably sized crowns capable of sustaining cone-crop production.
Moved by Graham Powell, seconded by Steve Ross. Carried.

FUTURE MEETINGS

A. Location of the 1991 meeting. Gordon Murray confirmed that Forestry Canada of Petawawa would sponsor the meeting as approved in item #246 of the minutes of the 21st biennial meeting.

B. Location of the 1993 meeting.

Motion: That the 1993 CTIA/ACAA meeting be hosted by the New Brunswick Dept. of Natural Reosurces and Energy in Fredericton, New Brunswick.
Moved by Catherine Tosh, seconded by Graham Powell.
Carried.

C. Location of 1995 meeting. The British Columbia Ministry of Forests offered to host the meeting in either Victoria or Vernon.

ELECTION OF OFFICERS

The Nominating Committee Chairman Tim Mullin proposed the following slate of officers for election to the 1989/1991 CTIA/ACAA executive:

Chairman:	Gordon Murray, Forestry Canada
Vice-Chairman - Symposium	Tim Boyle, Forestry Canada
Vice-Chairman - Arrangements	Ron Evers, OMNR
Editor/Treasurer	Steen Magnussen, Forestry Canada
Executive Secretary	Jim Coles, OTIC

No additional nominations were forthcoming.

Motion: That the proposed slate of officers for the 1989/1991 CTIA/ACAA executive be selected.
Moved by Greg Crook, seconded by Greg Adams. Carried.

ADJOURNMENT

A. Motion: That the CTIA/ACAA members thank the 1987/1989 executive for their efforts over the past two years to ensure a successful symposium and for their hospitality.
Moved by K. Yeatman, seconded by K. Morgenstern. Carried.

B. Motion: That the 22nd business meeting of the CTIA/ACAA be adjourned.
Moved by Francis Yeh. Carried.

ATTACHMENT #1

CANADIAN TREE IMPROVEMENT ASSOCIATION

TREASURER'S REPORT

1987-89

The accounts of the CTIA/ACAA were duly audited for the calendar years 1986, 1987, and 1988 by Geo. Welch and Co. of Pembroke, Ontario by signature dated May 4, 1989. The balance at the end of 1988 stood at $20,314., which represented an excess of revenue over expenditure for years 1986 to 1988 of $8,178. A surplus of $8,604.69 was transferred from the operation of the 21st Meeting, together with the return of $1,000. cash advance, following audit and close-out of the accounts. The current cash balance (9th May, 1989) stands at $4,317.78 plus Bank of Montreal Guaranteed Investment Certificates totalling $14,280. The sum of $1,000. was advanced to the Chairman of the 22nd Meeting of CTIA, 27 January, 1989. No expenses against the CTIA/ACAA have been incurred in the intervening period beyond the auditor's fee.

A detailed cash flow from August 1987 to May 1989 is attached.

Respectfully submitted,

C.W. Yeatman
Treasurer
CTIA/ACAA

CTIA/ACAA

Cash Flow
August 1987 - May 1989

Balance, August 1987 $481.08

Credit

Year	Date	Item	Amount	
1987	Oct. 22	Return advance	1,000.00	
	Oct. 30	Bank interest	10.58	
1988	Apr. 29	21st Meeting surplus	8,604.69	
		Bank interest	11.69	
	June 13	G.I.C. principal	8,500.00	
		G.I.C. interest	680.00	
	Oct. 27	G.I.C. principal	1,000.00	
		G.I.C. interest	87.50	
	Oct. 31	Bank interest	146.60	
1989	Apr. 4	Bank interest	164.67	
	May 1	G.I.C. principal	4,000.00	
		G.I.C. interest	361.97	
		Total credit	24,567.70	$24,567.70
		Credit plus balance		$25,048.78

Debit

Year	Date	Item	Amount	
1987	Oct. 27	G.I.C.	1,000.50	
1988	Apr. 29	G.I.C.	4,000.50	
	June 13	G.I.C.	9,180.00	
	Oct. 27	G.I.C.	1,100.00	
1989	Jan. 27	22nd CTIA advance	1,000.00	
	May 1	G.I.C.	4,000.00	
	May 8	Audit	450.00	
		Total debit	20,731.00	$20,731.00
		Balance May 1989		4,317.78
		Total		$25,048.78

CANADIAN TREE IMPROVEMENT ASSOCIATION

Treasurer's Report

May 1989 - August 1989

All documents and accounts pertaining to the CTIA finances were hended over as per May 1989 to Steen Magnussen (PNFI). Since then the following transaction has been made:

Renewal of a Guaranteed Investment Certificate of $4,000 for another year (yield 11.75% p.a.). Expiration of a $9,180 GIC per June 11, 1989. Bought a $5,000 one-year GIC on July 25, 1989 (yield 10.75%). Balance on daily checking account: $9,349.26 as of July 26, 1989. Assets $10,100 in GIC's. (Maturation of GIC's: October 1989: $1,100, May 1990: $4,000, Juyly 1990: $5,000).

Steen Magnussen
July 26, 1989

ATTACHMENT #3

FUND RAISING SUB-COMMITTEE REPORT TO THE CANADIAN TREE IMPROVEMENT ASSOCIATION 22ND BIENNIAL MEETING AUGUST 13 - 18, 1989

INTRODUCTION

The Canadian Tree Improvement Association traditionally does not charge any membership dues and distributes all of the meeting proceedings free of charge to all interested individuals and organizations.

The collection of registration fees from meeting participants provides for the major meeting expenses, but the C.T.I.A. depends on contributions to pay for additional meeting arrangements and hospitality.

The Planning Committee for the 22nd Biennial Meeting, therefore formed a Fund Raising Sub-Committee with a goal to raise $5,000.00.

REPORT

The Fund Raising Sub-Committee sent 52 letters requesting support. Eighteen companies responded favorably and a total of $5,925.00 was raised as summarized below. Thank you letters were sent to all contributors.

SPECIAL SPONSORING MEMBERS

1.	Alberta Forestry, Lands & Wildlife	$1,000
2.	Forestry Canada (F.R.D.A.)	500
3.	University of Alberta Department of Forest Science	300
		$1,800

INDUSTRY SPONSORING MEMBERS

1.	Blue Ridge Lumber (1981) Ltd.	$ 500
2.	Canadian Forest Products Ltd., G.P.	500
3.	Proctor & Gamble Cellulose Ltd.	500
4.	Saskatchewan Parks, Recreation & Culture	500
5.	Weldwood of Canada Limited, Hinton	300
6.	Weyerhaeuser Canada Ltd. Prince Alberta	500
		$2,800

OTHER INDUSTRY SUPPORTING

1.	Alberta Department of Agriculture	$ 200
2.	Beaver Plastics Ltd.	100
3.	Canadian Forest Products Ltd., H.L.	200
4.	Canadian Forestry Equipment Ltd.	200
5.	Evergreen Forestry Services Ltd.	100
6.	K.D.S. Silviculture Contractors Inc.	75
7.	Noval Enterprises	200
8.	Spencer - Lemaire Industries Ltd.	200
9.	Sundance Forest Industries Ltd.	50
		$1,325
	TOTAL	**$5,925**

The Fund Raising Committee would like to take this opportunity to sincerely thank these Companies for their generous contributions in support of the C.T.I.A. 22nd Biennial Meeting.

Gratefully Submitted

Daryl D'Amico
Fund Raising Sub-Committee

The Newsbulletin has developed into a major means of information dissemination and exchange. In the latest issue (number 11), the editor listed its mandate and indicated how that mandate was being met by giving numbers of items of each class that were published in the two issues of 1988. The mandate and numbers of items were given as to:

produce executive notes and editorials and comments on these (5);
announce meetings (10);
report on meetings attended (6);
indicate recent published articles (78+);
comment on research papers read (4);
indicate recent appointments or positions available (0);
show activities of other associated organizations (8);
report on members' activities, projects, or problems (11);
request assistance with problems (2);
indicate equipment and technological developments (3).

I trust that this report constitutes a satisfactory resolution of the apparent deficiency in earlier reporting back to CTIA/ACAA. The TSWG is a viable, active, and useful adjunct to the work of the Association.

Respectfully submitted,

Graham R. Powell
Chairman 1987-89

GRP/sf

ATTACHMENT 4

ERRATUM: CTIA/ACAA Constitution and Bylaws (1987)

The chairman duties according to the 1979 version, had not been carried over to the 1987 version of our Constitution and Bylaws.

Article V section a should read:

Article V
OFFICERS
a. Chairman
The Chairman shall take office upon completion of the meeting which elected the new Executive. The Chairman shall have the power and responsibility: 1) to preside over the business meeting of the Association; 2) to ascertain the will of the Executive within its mandate; 3) to assume or delegate authority as required to carry out the functions of the Executive; and 4) to carry out instructions from the previous business meeting to the Chairman.

The Chairman shall be responsible for managing the financial accounts of the current meeting. Following the Meeting, and within the same calendar year, the Chairman shall provide the Treasurer with an audited, detailed statement of receipts, expenditures, and balance of the Meeting accounts. A surplus will be transferred to the CTIA account. A request for funds to cover a deficit must be made to the Treasurer.

Article V
OFFICIERS
a. Président
Le président entrera en fonction à la fin de la réunion durant laquelle le nouvel exécutif a été élu. Le président aura le pouvoir et la responsibilité: 1) de présider la réunion d'affaires de l'Association; 2) de s'informer de la volonté de l'exécutif durant son mandat; 3) d'assumer ou de déléguer son autorité sur demande afin d'exécuter les fonctions de l'exécutif; et 4) de donner suite aux instructions transmises au président lors de la réunion d'affaires précédente.

Le président sera responsable du budget de la réunion en cours. Suite à cette réunion, et au cours de la même année civile, le président donnera au trésorier une liste vérifiée et détaillée des reçus, des dépenses et de la balance des comptes pour la réunion. L'excédent sera ajouté au compte de l'A.C.A.A. Une demande de fonds devrait être adressée au trésorier en cas de manque de fonds.

ATTACHMENT 5

Report of the Tree Seed Working Group (TSWG)

At the 19th meeting of CTIA/ACAA, it was decided in three motions (1) that a Working Group on Seed Research be established, (2) that the Tree Seed Working Group should organize a workshop for the 20th meeting, and (3) that B.S.P. Wang be interim chairman and establish terms of reference and a mandate.

At the 20th meeting, it was reported that Y. Lamontagne had been elected chairman of the TSWG, and H. Schooley as editor of the Newsbulletin.

Associated with the 21st meeting, the TSWG elected G.R. Powell as its chairman.

In the view of the TSWG the mandate and terms of reference of the TSWG were already partially established by motions of the 17th meeting listed in the foregoing as 1 and 2. Following that meeting, the objective of the TSWG was developed, but it was not subsequently presented to a meeting of CTIA/ACAA.

The objective of the Tree Seed Working Group is to promote tree seed science and technology through:

1. seed research from bud initiation to seed utilization;
2. identification of seed problems relating to tree improvement and forest management;
3. exchange of information on seed related problems;
4. advising on implementation practices.

This objective (or mandate) is met by:

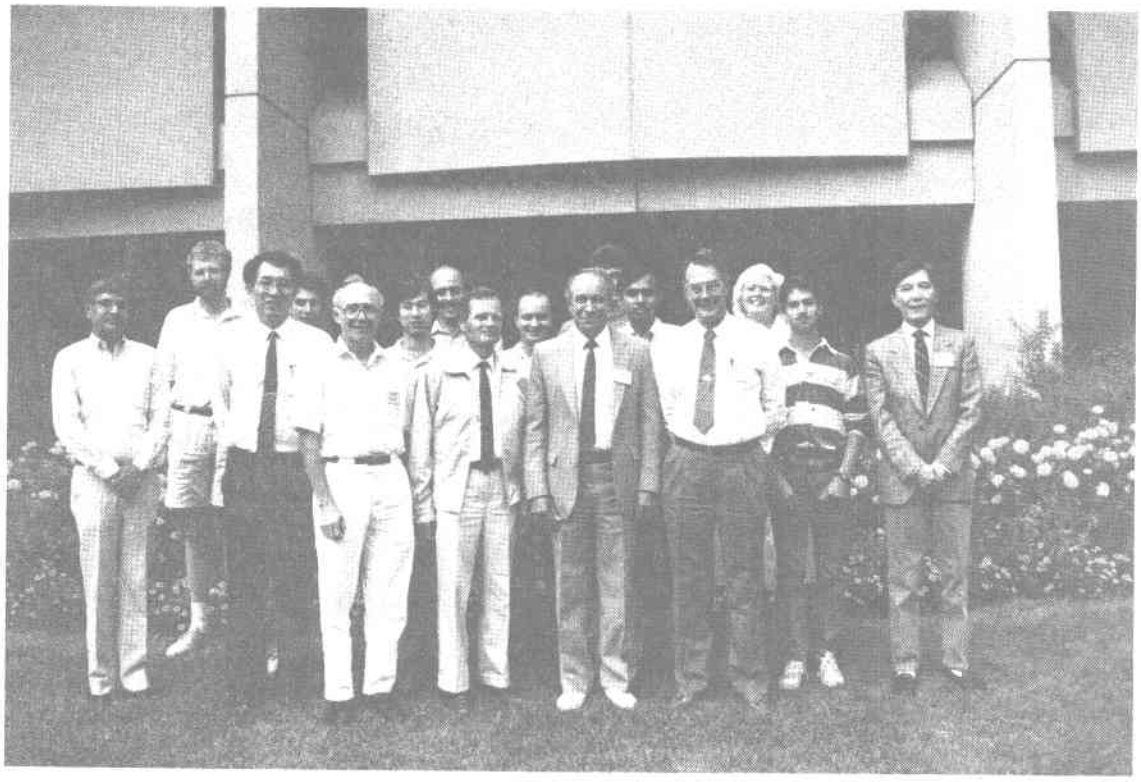
1. publishing a Newsbulletin twice a year;
2. conducting workshops, as appropriate, in conjunction with CTIA/ACAA biennial meetings;
3. acting as a means of disseminating information for the related Cone and Seed Insect Working Party, and liaising with that party;
4. having members promote tree seed science, research, and technology, whenever and wherever practicable, through their employment or interest in tree improvement, in production and use of seed, in protection of developing seed crops, in seed collection, in seed testing and handling, in stock production, in direct seeding, and in natural regenerations.

The affairs of the TSWG are overseen by a Chairman elected at the biennial business meeting, and by a Newsbulletin Editor, who maintains membership lists. Membership is open to any interested person, and is currently at a level of about 150. Members' interest in tree seed can be roughly categorized, through employment, to disciplines as follows:

tree improvement	37%;
seed-production management	35%;
seed utilization	24%;
seed collection, testing and handling	4%.

SYMPOSIUM AND FIELD TOURS - PHOTOS

SYMPOSIUM, ET TOURS DES LIEUX - PHOTOS

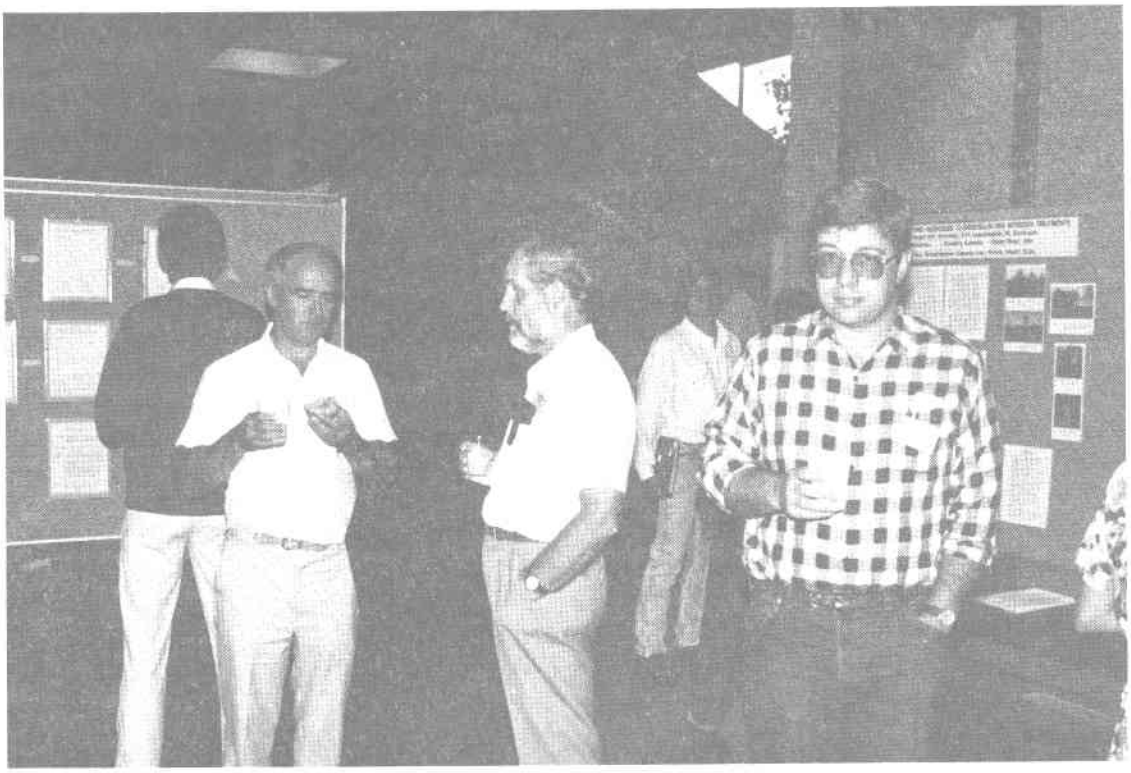


1988-89 Executive, Invited Speakers, and scholarship-winning students

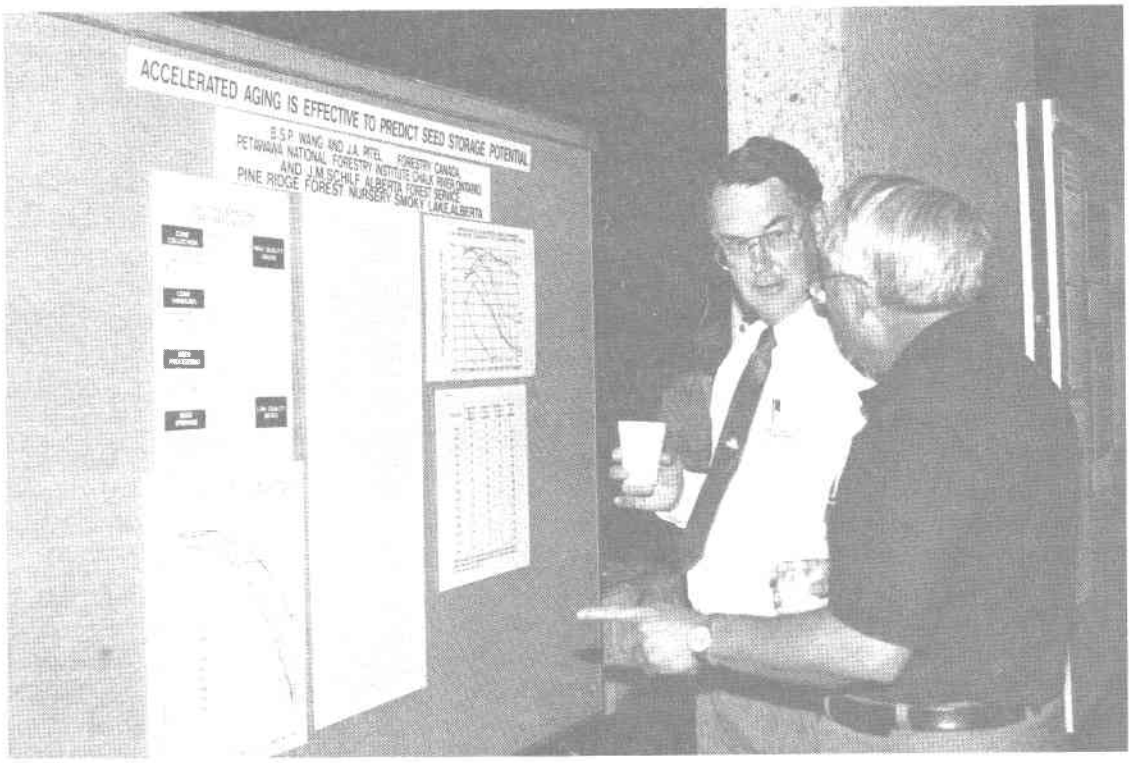
Third row: Steen Magnussen; Mathew Leitch

Second row: John King; Daniel Laplante; Xraming Wu; Filipos Aravanopoulos; Mathew Koshy; Annette van Niejehuis; Francis Yeh

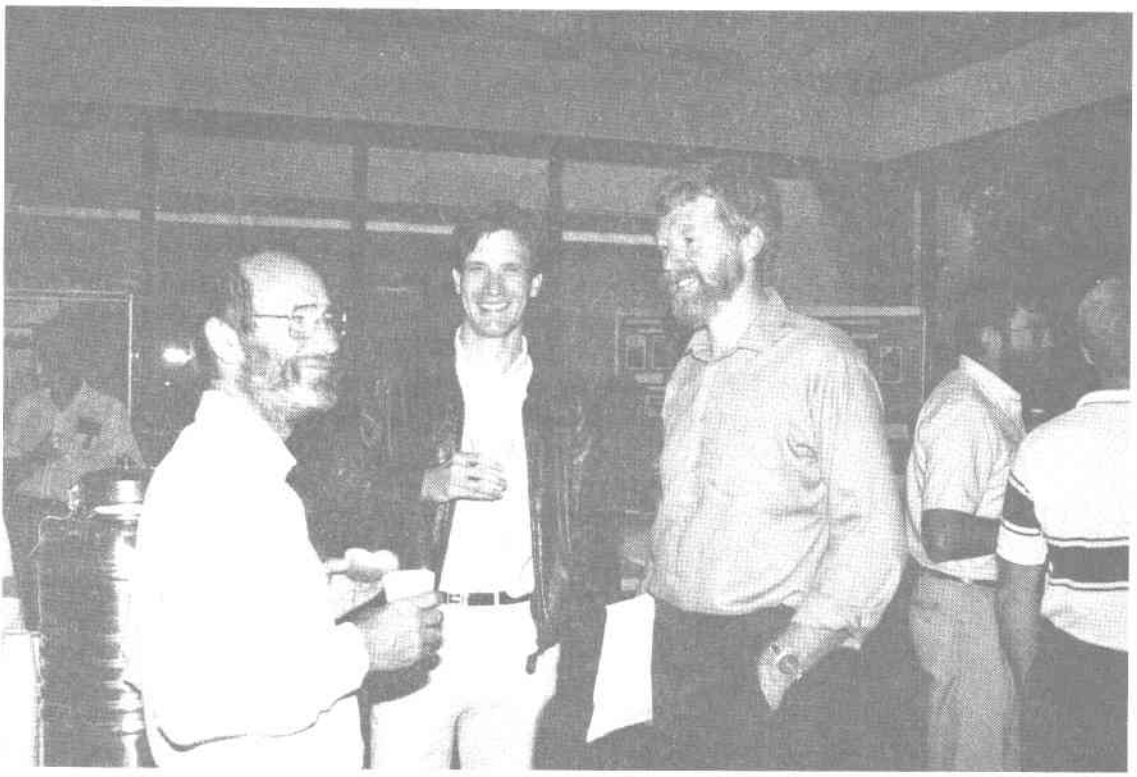
Front row: Narinder Dhir; Israel Jiang; Jerry Klein; Kris Morgenstern; Gilles Vallée; Kit Yeatman; Eric Girouard



"Let's try the donouts at Tim Horton's"
(from left to right: G. Murray, G. Powell and P. de Groot)



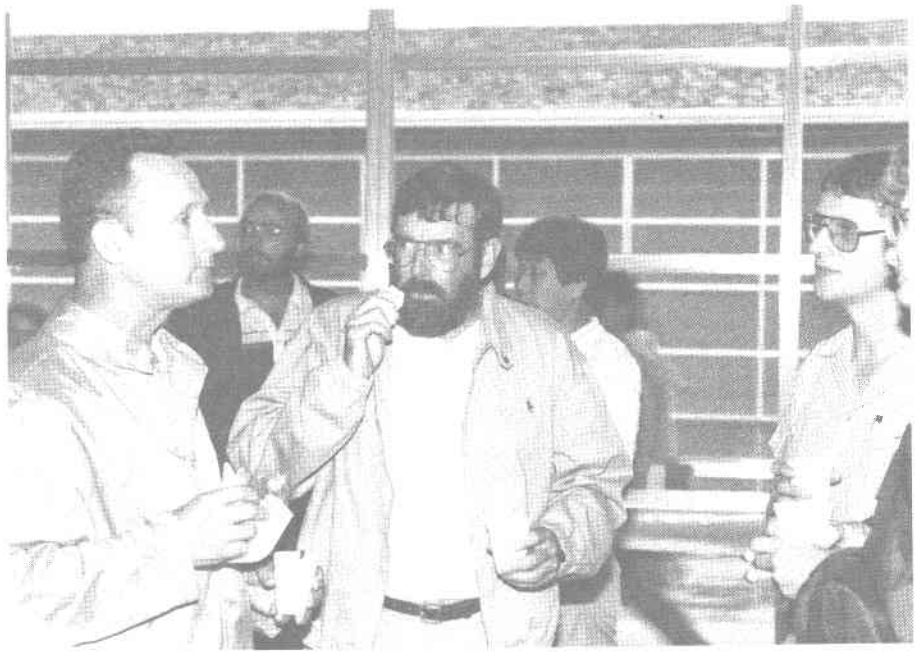
"Is that so?"
(from left to right: C.W. Yeatman and B.S.P. Wang)



"The friendly lot from Alberta and B.C.
(from left to right front: A. Sproule, A. Yanchuk, and J. King)

"Me excited? not at all, my pulse is only 172?
(F. Aravanopolous with admirees, K. Tosh, F. Wild, C. Nielsen, E. Chogala, R. Ford is not impressed)

"Wanna buy some hot seed?
(P. Nitschke wheeling and dealing with G. Adams, R. LeBlanc, and M. Leith (the lookout))



"You gotta be kidding"
(The incredulous J. Coles and C. Keith (front))

An overweight bus gets stuck ... "Who should we leave behind?"
(Front: N. Dhir, J. Klein; Back: C.W. Yeatman, A. van Niejenhuis, C. Harrison)

MEMBERS' REPORT

RAPPORTS DES MEMBRES

TREE IMPROVEMENT IN LABRADOR

C.M. Harrison

Department of Forestry and Agriculture
P.O. Box 2006, Herald Building
Corner Brook, NF
A2H 6J8

Keywords: exotics, pines, species trials, progeny tests, breeding, seed orchards, Labrador

Over 70% of the land area of the Province lies in the Labrador portion. Although much of this area is tundra, barren land, or scrub forest, there is enough productive forest land to give this region an economic potential. Labrador has been included in the tree improvement program from the start, and numerous plus trees (white spruce, black spruce, and tamarack) have been selected there. It is in the area of exotic introductions, though, that the greatest potential for increased production of forest products may lie.

THE FORESTS OF LABRADOR

The largest concentration of productive forests in Labrador is in the vicinity of Goose Bay, extending at least 50 km in every direction, and as much as 150 km northeastward along the shores of Lake Melville. Other areas are found in southeastern Labrador near the coast, and in the southwest corner near Wabush. The species composition is typical of the boreal forest zone. No pine is native to Labrador, except for a small stand of jack pine along the Quebec border near Wabush. Much area within and around the commercial forest surrounding Goose Bay is occupied by the spruce-lichen type. It is here, especially, that it is thought that pines would be productive.

PINE RESEARCH IN LABRADOR

The first known pine trials in Labrador commenced when jack pine seed were scattered over a small area west of Goose Bay in 1975. Those trees have grown at an average rate of about 30 cm a year since germination. Larger plantations of jack pine of Ontario and Quebec origins, and of lodgepole pine, have also shown good growth rates. The Quebec sources performing best so far. (Further experimentation with lodgepole pine, however, has been put on hold pending investigations regarding certain disease problems with the species.)

A climatic study was done in the summer of 1988 to determine what sources of jack pine seemed to be best suited for the Goose Bay area. The results seemed to favour Quebec sources, especially the Chibougamau-Lac-St.-Jean-Chicoutimi area. A visit was made to Quebec,

and arrangements were made to obtain seed for Quebec-wide provenance trials, progeny tests of Quebec plus trees, and larger quantities of seed from selected stands later on for production planting and direct seeding experiments.

A detailed strategy plan for pine research in Labrador has been submitted and approved. Experiments due to commence in 1989-90 include the Quebec trials mentioned above, a range-wide provenance trial, an experiment with Soviet sources of Scots pine, possible further experimentation with logdepole pine, pilot trials of other species, and production planting and direct seeding research. The last item will be accomplished by means of permanent sample plots. The questions to be addressed in this research are (1) whether results obtained in an extensive planted or seeded forest are necessarily the same as those obtained in small replicated trials; and (2) whether the sources that perform best when raised in the greenhouse and planted as seedlings are necessarily the same ones that perform best when scattered on the ground as seed and "left to fend for themselves".

OTHER ASPECTS OF TREE IMPROVEMENT IN LABRADOR

The pine research, described above, is meant to supplement, rather than replace, research on other genera. Improvement of native species will proceed as planned, and the exotics introduced by means of pilot trials will not necessarily all be pines, or even conifers.

TREE IMPROVEMENT BY FORESTRY CANADA IN THE NEWFOUNDLAND AND LABRADOR REGION, 1988-1989

A. Mosseler

Forestry Canada
Newfoundland and Labrador Region
P.O. Box 6028
St. John's, Newfoundland
A1C 5X8

Keywords: Provenance testing, seed production, biomass production

The position of forest geneticist vacated by Peter Hall in 1987 was filled in 1988. Much of 1988 was spent in becoming familiar with forestry issues affecting Newfoundland and with past and on-going research activities, developing research priorities and facilities, and formulating a research program which was defended at a peer review held in February, 1989. Current research activities emphasize problems with seed production and the continuing analyses of established provenance tests. However, with the establishment of laboratory facilities in organic and biochemistry, the research emphasis will shift to more "process oriented" studies.

A combination of factors including poor cone crops, spruce budworm infestations, squirrel predation, and a significant expansion of Newfoundland's artificial regeneration program over the past 10 years has led to seed shortages and the importation of untested seed sources from mainland Canada. To address the problem of future seed shortages and the seed supply, advantage was taken of the bumper cone crop of 1988 to launch several studies on seed production in the regional and range-wide black spruce and white spruce provenance tests. Cone collections were carried out in natural populations of black and white spruce to assess possibilities for early cone collections based on cumulative degree-days. A genetic study on the effects of the spruce cone maggot (Delia anthracina [Czerny]) was undertaken in a range-wide white spruce provenance test. Seed production is also being investigated in the spruce/lichen forest cover type of Labrador, as part of a larger study in cooperation with the provincial Department of Forestry, to identify factors responsible for the poor stocking and growth performance of black spruce on these sites, and to identify possibilities for stand conversion to pines.

Although the major emphasis of forest genetics research will continue to focus on the commercial conifer species, part of our new research effort will focus on biomass production in fast growing hardwood species like the native willows. Emerging wood conversion biotechnologies such as fermentation hold promise for the development of new wood-based chemical and energy related industries that may find a use for such highly productive species in the future. Stem cuttings of Salix

discolor Muhl. were collected from the different ecoregions of Newfoundland to test the effects of the island's ecoclimatic diversity on genetic variation, and to select clones for use in biomass production trials and for use as nurse crops for the establishment of conifers on the windswept barrenland sites of Newfoundland that were once occupied by commercial conifer forests.

Cooperation has been established with geneticists at the Memorial University of Newfoundland in the area of population genetics, and cooperative research studies in conifer genetics are being developed.

PUBLICATIONS

Mosseler, A., Zsuffa, L., Stoehr, M.U., and Kenney, W.A. 1988. Variation in biomass production, moisture content, and specific gravity in some North American willows (Salix L.). Can. J. For. Res. 18: 1535-1540.

Mosseler, A. and Zsuffa, L. 1989. Sex expression and sex ratios in intra- and interspecific families of Salix L. Silvae Genetica 38: 12-17.

Mosseler, A. and Papadopol, C.S. 1989. Seasonal isolation as a reproductive barrier among sympatric Salix species. Can. J. Bot. (In press).

Mosseler, A. 1989. Interspecific pollen-pistil incongruity in Salix L. Can. J. For. Res. (In press).

THE NB DEPARTMENT OF NATURAL RESOURCES TREE IMPROVEMENT PROGRAM

R.D. Bettle and K.J. Tosh

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

Keywords: Cone collection, cross pollinations, plus tree selections, seed orchards, second generation

Since the last members report the tree improvement program in NB has continued to grow and flourish. Tree improvement efforts are still concentrated on the four main 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 are Norway spruce (Picea abies [L.] Karst.), and the selection of balsam fir (Abies balsamea (L.) Karst.) for Christmas trees.

First generation selections and seed orchard establishment are completed for the four major tree species, and second generation selections and cross pollinations have started. The following report highlights our tree improvement activities for the last two years.

PLUS TREE SELECTION

All first generation selections are completed for black spruce (632), jack pine (539), white spruce (78) and tamarack (102). Second generation selections in black spruce and jack pine family tests were started in the winter of 1988. Scion was collected from these selections to establish second generation black spruce and jack pine clonal seed orchards and breeding garden's. Ramets from each clone will also be included in an accelerated growing and breeding program.

TREE BREEDING

In 1988 a total of 23 tamarack and 57 white spruce polycrosses were completed in an outdoor breeding garden. These crosses, together with polycross seedlots from NBTIC (New Brunswick Tree Improvement Council), provided a sufficient number of seedlots to grow and outplant the first series of progeny tests. This spring (1989), 10 tamarack and 75 white spruce clones were polycrossed and hopefully this winter we will grow the second series of progeny tests.

This spring we also attempted to polycross second generation black spruce and jack pine selections in family tests in the field. Although a very hectic operation we are hoping for good results. If field pollinations prove successful we plan to do most of our polycrosses in family tests, thus eliminating the necessity of waiting for grafted material to produce cones.

CONE COLLECTION IN SEED ORCHARDS

For many tree species in NB, 1988 was a bumper year for cone crops. Large cone collections were made in three seedling seed orchards. Two of the orchards, Bettsburg (total 32 ha) and Otter Brook (total 25 ha) are located in central NB, while the third orchard, Poliok (total 5 ha) is located near Fredericton. A summary of cone collection and seed yield is given in Table 1.

Table 1. Cone collection and seed yield in three seedling seed orchards in 1988.

SPECIES	LOCATION	YEAR OF PLANTING	NO. HECTARES	NO. LITRES COLLECTED	SEED YIELD (M)
Jack Pine	Otterbrook	1979	5	3042	7.7
		1981	3	544	1.5
		1982	8	3614	9.6
Black Spruce	Bettsberg	1980	6	1428	6.2
	Pokiok	1879	6	442	1.5

Up until now cones have been collected manually from the ground and from ladders; however, the trees are becoming too tall to collect from 14 foot ladders. Therefore, to address this concern, industry, government and two local NB firms designed and eventually built a cone harvester. This machine is designed to travel in cut overs and is only 6 feet wide, which allows movement between rows of trees in a seed orchard. A hydraulic lift is mounted on the harvester with a maximum height of 40 feet and has a 360^{o} rotation. The Department of Natural Resources has purchased the prototype and will use it operational this fall to collect cones.

TREE BREEDING AT FORESTRY CANADA - MARITIMES REGION 1987 AND 1988

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

Forestry Canada - Maritimes Region
P.O. Box 4000
Fredericton, New Brunswick
E3B 5P7

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

The objectives of the tree breeding work at Forestry Canada - Maritimes Region are to determine the amount of genetic improvement attainable within promising tree genera and to provide resource managers of the Region with the information and, in some cases, breeding materials required to obtain realistic levels of genetic improvement.

HYBRIDIZATION IN PICEA AND LARIX

Picea: In 1987, P. glauca (Moench) Voss (6 clones), P. engelmannii (Parry) Engelm. (1), P. rubens Sarg. (1), P. abies (L.) Karst. (1), P. mariana (Mill.) B.S.P. (10), and P. mariana x omorika (Pancic) Purekyne (3) were used as female parents for crosses with P. asperata Mast., P. glehnii (Fr. Schmidt) Mast., P. jezoensis (Sieb. et Zucc.) Carr., P. koraiensis Nakai, P. montigena Mast., and P. wilsonii Mast. The cross P. glauca x P. jezoensis, made in 1986, yield 5.6 full seeds per cone. Species crossability of P. engelmannii and P. glauca was as high or higher than intraspecific crosses of P. glauca.

Larix: Flowering in Larix in 1987 was two weeks earlier than normal and occurred over a 2-3 day period. We were caught with our pants down and consequently no controlled pollinations were attempted. In 1988, a partial 8-tree diallel (four each of L. leptolepis (Sieb. et Zucc.) Gord. and L. decidua Mill.) with reciprocal hybrids, as well as a series of crosses between these species and L. gmelini Kuz., were completed.

SPECIES AND PROVENANCE TRIALS

Except for the most recently established trials with Picea mariana and Larix laricina (Du Roi) K. Koch and the few trials established using large plots, most of the useful information on geographic variation has been extracted from the many species and provenance tests established under this study. During the report period 25-year data were obtained from a L. leptolepis trial which had been

planted in 49-tree square plots. Growth of trees of the best provenances was approximately 12 M^3/ha/yr. Data from a Picea rubens trial (age 23 years), a range-wide P. mariana trial (10 years), and a range-wide Betula alleghaniensis Britt. trial (16 years) were published.

POPULATION GENETICS

The study on population genetics includes experiments on population structure, inbreeding, progeny testing, and quantitative genetics. In 1987, selected clones of P. mariana were successfully crossed in three, 5-tree disconnected diallels to produce materials for a detailed study of clonal variation. In 1988, 14 cuttings were struck from each of 10 seedlings from each of the 30 full-sib families as well as from 6 open-pollinated "control" families. A second set of cuttings will be taken in early 1989 to produce 100 ramets/clone.

In 1988 selected clones of P. glauca were crossed in three, 5-tree complete diallels (without selfs). All crosses were successful. This material will be used for detailed studies of clonal variation in this species.

Population studies of tamarack received attention during the review period. Two tamarack plantations designed to elucidate effects of inbreeding in five sub-populations at Acadia Forest Experiment Station were measured.

COOPERATIVE TREE IMPROVEMENT

The New Brunswick Tree Improvement Council completed its 12th year of operation in 1988. Technical coordination and direction are provided by Forestry Canada - Maritimes Region. Seedling seed orchard establishment for black spruce and jack pine and clonal orchard planting for tamarack is complete. White spruce clonal orchard establishment will continue for several years.

Cone production from seed orchards is increasing dramatically. In 1988 the total collection of 23,000 litres of cones yielded about 65 million seed! For black spruce, it was a 15 fold increase over the previous year's production of 680 litres.

Breeding programs for white spruce and tamarack are progressing well with effort concentrating on polycrosses. It is anticipated that accelerated testing of polycross progenies will make it possible to rank the clones before conducting pair-matings to generate material for second generation selection.

The Council embarked upon a second generation program for black spruce and jack pine with the first selections made in 10-year-old family tests. Based on analysis of 10-year data, the best families were identified and the best tree selected within each. Jack pine were

selected for height growth, stem straightness, and quality branching while black spruce were selected for height growth, stem straightness, and crown form. Polycrosses will be initiated on these selections in 1989. Selection will continue for another seven years.

CONE AND SEED RESEARCH/SEED ORCHARD MANAGEMENT

There are currently over 250 ha of seed orchards in the Maritime Provinces. Numerous problems have arisen associated with both the establishment and management of these orchards. Forestry Canada - Maritimes Region staff from both Tree Improvement and Forest Insect and Disease Survey continue to provide assistance to orchard managers in the Region through technology transfer and by conducting operational, problem-oriented research trials.

Operational cone induction trials in black spruce seedling seed orchards were initiated in 1987 in conjunction with the New Brunswick Dept. Natural Resources and Fraser Inc. Banding ammonium nitrate along the tree rows approximately doubled cone production. This study is being continued to determine the optimum frequency of fertilizer applications.

Following discussions with representatives of industry, the New Brunswick Dept. Natural Resources, and the designer and manufacturer, the construction of a prototype cone harvester was completed and successfully field tested. The unit has a vertical reach of approximately 35 feet and is capable of working on rough terrain and within the narrow confines of seedling seed orchards.

TISSUE CULTURE OF CONIFERS

The objectives of this study are: 1) micropropagation of mature conifers, and 2) regeneration of haploid plants from female gametophytes of conifers.

Clonal propagation of selected, superior specimens is considered to be a viable alternative to breeding. However, clonal propagation of trees old enough to have demonstrated their superior characteristics, is difficult or impossible with traditionally employed methods such as rooting of cuttings.

The main obstacle in clonal propagation of conifers is maturation. In physiological terms, meristems on juvenile plants (embryos, young seedlings) behave differently from meristems on more mature plants. Whereas regeneration of plants from the former is simple, regeneration from the latter is very difficult. This is not just a matter of vigour, but of genuine physiological differences between the two. Maturation of meristems is reversed in the natural sexual process. To date we have only been partially successful in rejuvenating meristems from mature plants by tissue culture methods.

Our second objective is to regenerate plants from haploid tissue. Haploid tissues are of exceptional value in genetic experiments. Recessive genes that are not expressed in diploid tissues can be evaluated in haploid tissues. Furthermore, protoplasts from haploid tissues are ideal for fusion and genetic manipulation.

About four years ago we established haploid cultures from female gametophytes of Larix decidua. These cultures soon became embryogenic and have produced large numbers of haploid embryos continuously ever since. Initiation of such haploid embryogenic cultures is reproducible.

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TREE IMPROVEMENT AND RELATED STUDIES AT THE UNIVERSITY OF NEW BRUNSWICK 1987-1989

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Population structure, genetic parameters

The population structure of tamarack (Larix laricina (Du Roi) K. Koch) in New Brunswick is characterized by large within-population and small among-population variance (98.5% and 1.5% of total, respectively). The mean outcrossing rate was 0.904. In spite of its bladderless spherical pollen and reports on short-distance pollen flight, the population structure of tamarack is apparently similar to that of other eastern North American conifers (Ying 1988). In contrast, the small populations of black spruce (Picea mariana (Mill.) B.S.P.) on the Cape Breton Highlands have a much smaller outcrossing rate (range 0.648-0.849), which may explain their slow growth in provenance experiments (McCurdy 1988).

Full-sib families of Japanese larch (Larix leptolepis (Sieb. & Zucc.) Gord.) grown in the greenhouse under four nitrogen treatments and in the field, demonstrated the presence of both general and specific combining abilities (Ricard 1989).

White spruce (Picea glauca (Moench) Voss) family tests from open pollination, planted at four locations in New Brunswick, provided estimates of individual-tree heritibility for height of 0.089 and 0.091 at ages 6 and 11 years from seed. Genetic gain estimates ranged from 4.1 to 5.3%, depending upon desired spacing and family selection intensity in the seedling seed orchards (Steeves 1988). Gain estimates from a similar study in Nova Scotia were slightly lower (Veen 1989).

Tim Mullin, formerly manager of the tree breeding program in Nova Scotia, began his Ph.D. studies in September 1988 under Dr. Morgenstern. His research is based on a series of 5-year-old clonal field tests originating from a black spruce diallel cross. Utilization of clonal techniques in black spruce breeding strategies will be investigated.

Provenance

Provenance height in black spruce at ages 5 and 10 was well correlated in a series of New Brunswick experiments (Dulhanty 1988). A paper on the results of the range-wide black spruce study at age 15 years from seed was submitted for publication.

A new larch (Larix Mill.) species and provenance study including seedlots from Siberia and China was initiated in cooperation with other Maritime agencies. Seedlings are being raised by the Prince Edward Island Forestry Branch at Charlottetown for outplanting in 1990.

Cone production and crown development

Reproductive development of clones in seed orchards of jack pine (Pinus banksiana Lamb.), white spruce and black spruce was monitored and related to temperature sums. The amount of incoming wild pollen was also recorded. Results are helpful for planning controlled crosses and will indicate the extent of random mating in the orchard (MacTavish 1988).

Within-crown patterns in onset and duration of developmental stages of cones and shoots were investigated in 70 ramets of white spruce in a clonal seed orchard at Glencairn, Ontario (Phelps 1988). Shoot developmentprogressed acropetally, but that of pollen and seed cones progressed basipetally (except in the transition zone where trends for pollen cones varied). The direction and magnitude of temperature differences in shoots (monitored with inserted thermocouples) varied with position in the crown and time of day, and were related to developmental stages.

In crowns of tamarack, increasing acropetal trends occurred in time to bud burst; duration of short-shoot expansion; duration and rate of long-shoot elongation; time to terminal bud formation; and number, surface area, and weight of leaves per short and long shoot (Powell 1988b). These trends, when incorporated with patterns of leaf surface areas simulated by Remphrey and Powell (1988), provide information on photosynthetic capital and relative performance of trees with or without syllepsis. Trees with a propensity for syllepsis have growth advantages (McCurdy and Powell 1987; Morgenstern et al. 1988; Powell 1988a) that could be captured through selection and breeding.

Physiology and biotechnology

Following completion of extensive renovations and installation of major equipment, including a combined gas chromatograph-mass spectrometer (GC-MS), several research programs were initiated in late 1987. These include axenic culturing of Endocronartium harknessii (J.P. Moore) Y. Hiratsuka (western gall rust) to identify the molecules produced by this fungus causing localized acceleration of cambial growth, GC-MS investigations of endogenous auxin in 27 woody species indigenous to New Brunswick, correlating endogenous auxin levels with endogenous coniferin and sugar levels and with cambial growth in tamarack, investigating the relation between endogenous ethylene and growth of

different ages of Abies balsamea (L.) Mill. cambia, in vitro culturing of conifer cambia and of hardwood embryonic and leaf tissues from a number of species, investigating the regulation of lignin biosynthesis in conifers, and studying the regulatory effects of auxin and abscisic acid on cambial activity, tracheid production, tracheid diameter, tracheid wall thickness, and bordered-pit number in several conifer species.

Progress includes identification by GC-MS of endogenous indol-3-ylacetic acid (auxin) in developing xylem of 8 conifers and 19 angiosperms (R.A. Savidge, submitted), completion of a combined GC-MS and anatomical study on tamarack indicating seasonal relations between cambial levels of auxin, substrate molecules and growth, successful in vitro simulation of stem diameter growth and wood formation using small 'chips' of phloem-cambium-xylem excised from mature boles of tamarack, finding that the biochemistry of lignification is under cytokinin as well as auxin regulation (Savidge 1987, 1988a, 1989a), finding that abscisic acid interacts with auxin to influence cambial activity and tracheid dimensions, and that varied levels of the ethylene precursor 1-aminocyclopropane-1-carboxylic acid in different ages of cambia correlate with variations in cambial growth that occur in response to exogenous auxin (Savidge 1988c).

Some practical implications of these activities have been summarized (Savidge 1988b, 1989b), and several reviews of the regulation of cambial growth published (Little and Savidge 1987, 1988; Savidge 1988c).

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POLLEN MONITORING AND SEED RELATED STUDIES AT THE UNIVERSITY OF MONCTON, 1987-1989

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Keywords: Piazza mariana, Picea glauca, Larix laricina, pollen monitoring, cone storage, seed germination, cone and seed production

This report summarizes pollen monitoring and seed related studies at the University of Moncton for the past two years. Pollen monitoring studies, undertaken in collaboration with Fraser Inc. in 1987, were continued in 1988 and 1989 in two black spruce (Picea mariana (Mill.) B.S.P.) seedling seed orchards and expanded to a white spruce (Picea glauca (Moench) Voss) and a larch (Larix laricina (Du Roi) K. Koch) orchard in 1988. A study on white spruce seed germination in response to cone storage and seed prechilling that was initiated in Petawawa National Forestry Institute in 1984 was repeated in 1988.

POLLEN MONITORING STUDIES

Pollen monitoring was conducted in 1987 and 1988 for two black spruce seedling seed orchards located at Second Falls (S.F.) and Plaster Rock (P.R.), northwestern New Brunswick. The principal objectives of the study were: (i) to evaluate the level of within-orchard pollen and pollen-cone production and (ii) to estimate the level of pollen contamination from residual spruce stands in the vicinity of the two orchards. The 2.8 ha S.F. orchard was established in 1978. The 13.5 ha P.R. orchard was sequentially established in 1979, 1980, 1981, and 1984.

Pollen-cone production per tree in 1987 averaged 3.3 (in S.F.), 1.9, 1.9, 0.4, and 0.0 (in P.R.) for 10-, 9-, 8-, 7-, and 4-year-old trees, respectively. Production in 1988 averaged 39.5 (in S.F.), 37.6, 20.2, 10.6, and 0.0 (in P.R.) for 11-, 10-, 9-, 8-, and 5-year-old trees, respectively. Contamination level in 1987, during seed-cone receptivity, was established at 32.4 and 64.7% in the S.F. and P.R. orchards, respectively. In 1988, owing to 37-fold increase in pollen production (16.6 pollen grains trapped per mm2) by mature trees in the vicinity of the S.F. orchard and to the roguing of about 40% of the orchard trees, contamination level increased to 83.3 %. In contrast, the contamination level in 1988 in the unrogued P.R. orchard was reduced to 60.5% even with an 11-fold increase in pollen production (19.2 pollen grains trapped per mm2) from contaminant sources.

Pollen monitoring in the Ste-Anne-de-Madawaska white spruce clonal orchard and the future larch clonal orchard began in 1988. Pollen monitoring for all four orchard sites was repeated in 1989. Finally, the black spruce seedling seed orchard of J.D. Irving, in the Black Brook District, northwestern New Brunswick, was monitored for pollen contamination in 1988.

WHITE SPRUCE SEED GERMINATION

In 1984, a study was initiated with Messrs. B.S.P. Wang and H.O. Schooley in Petawawa National Forestry Institute (see Caron 1986). The principal objective of the study was to quantify the advantages of cone storage and seed prechilling on seed germination for white spruce from cones collected at the time of seed dissemination from individual trees. Collected cones were stored for 2 and 6 weeks before seed extraction. Caron et al. (1988) reported that seed maturation was promoted by post-harvest cone storage prior to seed extraction. Average seed dormancy remained about the same from 2 to 6 weeks of cone storage; however, seeds from some trees became more dormant with storage whereas those from others became less dormant.

Most trees used in the 1984 study bore seed cones again in 1988. Cones were collected at the time of natural seed dissemination and stored for 2, 4, 6, 10, and 14 weeks before seed extraction. Germination tests have been completed.

BLACK SPRUCE SEED-CONE AND POLLEN-CONE PRODUCTION

The research project on development of branch patterns and seed production in young black spruce was completed in 1987 (Caron 1987a). Some of the findings from that study, that lead to the obtention of my Ph.D., were published (Caron 1988a; Caron and Powell 1988, 1989a, 1989b).

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Keywords: Picea mariana, P. glauca, Larix laricina, plus tree selection, seed orchard, family test, cone induction, pollen monitoring.

This report summarizes Fraser Inc.'s tree improvement program since it's inception in 1976. The program is focused on 3 main species, black spruce (Picea mariana (Mill.) B.S.P.), white spruce (Picea glauca (Moench) Voss) and tamarack (Larix laricina (Du Roi) K. Koch). Efforts have concentrated on plus tree selection and the establishment and maintenance of family tests, seedling seed orchards and a clonal seed orchard. Progeny testing is now starting. Other projects will be discussed. Cooperation with the New Brunswick Tree Improvement Council has been close throughout all phases of the programme.

PLUS TREE SELECTION

Field selection of plus trees for first generation seedling and clonal orchards was completed in February 1987. A total of 276 black spruce, 87 white spruce and 17 tamarack plus trees have been selected by Fraser Inc. The selection of parent trees for second generation black spruce clonal orchards is currently being made in open pollinated family tests. Selections will be shared among members of the New Brunswick Tree Improvement Council (NBTIC).

SEEDLING SEED ORCHARDS

Fraser Inc. has established 2 black spruce seedling seed orchards from 1978 to 1984 totalling 16.3 hectares. Families planted in the orchards came from Fraser's selections and other selections shared within NBTIC. Seed production started in 1986 and in 1988 26 million seeds were collected from 14.5 hectares. Initial rogueing of the 1978 and 1979 orchards has been completed, leaving approximately 36% of the original trees.

CLONAL SEED ORCHARDS

Establishment of a 4.0 ha white spruce clonal seed orchard began in 1987. Fifty clones are represented, 45 Fraser selections and the balance shared with the New Brunswick Department of Natural Resources and New Brunswick International Paper Forest Products Inc. Grafting for this orchard was done at the Acadia Forest Experiment Station from 1983

to 1987 and continued at the Fraser Tree Nursery following construction of a tree improvement greenhouse. Grafting for a black spruce clonal orchard started in 1989.

FIELD TEST ESTABLISHMENT

Field test establishment started in 1978. Since that time two "stand" tests of black spruce and jack pine, 21 open pollinated family tests of black spruce, white spruce and jack pine and 2 progeny tests of white spruce and tamarack covering a total of 45.1 hectares have been planted. The purpose of these various types of tests is, (1) to identify the reserve stands best suited for seed supply, (2) to supply the genetic information to rogue seedling orchards and provide selections for second generation clonal orchards and (3) to provide information to rogue clonal orchards.

OTHER PROJECTS

Projects in the areas of cone induction, topping and retrospective testing are being conducted in cooperation with NBTIC. Pollen monitoring in seed orchards is contracted to the Faculty of Forestry, University of Moncton.

The use of fertilizer to induce female cone production in black spruce seedling orchards was initiated in 1987. Final assessments will be done in 1991 but preliminary results are promising. Topping is being examined as a means of controlling height growth to reduce cone collection costs without adversely affecting cone production in black spruce orchards. Retrospective testing using an intensive growth regime is being conducted to assess the confidence with which the results of early testing can be used. This work is being conducted using some of the families established in the Ottawa Valley white spruce family tests. Pollen monitoring in the black spruce orchards was started in 1987 and in the white spruce orchard in 1988 to identify the levels of within orchard pollen production versus contamination from outside sources. This study will be discontinued in these orchards after the 1989 season.

J.D. IRVING LTD. - TREE IMPROVEMENT PROGRESS

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Keywords: Picea mariana, P. glauca, P. abies, Pinus banksiana, Larix laricina, clonal seed orchard, seedling seed orchard, family test, flower induction, accelerated growth, retrospective progeny tests.

This report summarizes tree improvement progress since 1987 by J.D. Irving Ltd. First generation clonal orchard establishment has continued and is nearing completion. Seedling seed orchard management continued, including roguing based on family test measurements. A significant proportion of nursery seedling production now originates from orchard seed. Establishment is beginning on second generation clonal orchards of black spruce and jack pine using best individuals selected from the best families in New Brunswick Tree Improvement Council family tests.

CLONAL SEED ORCHARD

Establishment of first generation clonal seed orchards is nearing completion. To date, a total of 60 hectares have been planted for black spruce (Picea mariana (Mill.) B.S.P.), white spruce (Picea glauca (Moench) Voss), Norway spruce (Picea abies (L.) Karst.), jack pine (Pinus banksiana Lamb.) and eastern larch (Larix laricina (Du Roi) K. Koch). In 1988, 10 kg of seed including all species was harvested. Significant proportions of the company's 14 million per annum seedling crop now originates from either the clonal orchard or seedling seed orchards. In 1989, 100 percent of jack pine, 50 percent of white spruce and 25 percent of black spruce was grown from orchard seed. It is anticipated that within two years, all annual seed requirements will be supplied from orchards. In 1989, grafting began for establishment of second generation orchards of black spruce and jack pine using selections from New Brunswick Tree Improvement Council (NBTIC) family tests.

Installation of a new cone and seed processing facility was completed in 1988. The equipment was purchased from BCC in Sweden. Seed storage and testing is being conducted at the Sussex Tree Nursery.

FIELD TESTING AND SEEDLING SEED ORCHARDS

The New Brunswick Tree Improvement Council celebrated the final establishment of the open pollinated family tests and seedling seed orchards of black spruce and jack pine in 1987. As an active member of the council, J.D. Irving Ltd. established three black spruce family tests, one jack pine family test and one jack pine seedling seed orchard in the final year. This completes the establishment of family tests, but marks the start of the control-pollinated progeny tests, the first of which were planted in 1989.

Black spruce and jack pine seedling orchards which were established over past years are in various stages of genetic roguing. The oldest jack pine orchard (1979) has been rogued three times and is nearly producing enough seed to fulfill company requirements. The oldest black spruce orchard (1980) will receive its first genetic roguing in 1989 and has been producing increasing seed crops with the assistance of supplemental mass pollination which has been carried out during the past two years.

The evaluation of family tests has become a major component of the tree improvement program. The best individuals from the best families will be selected from these tests for future generation production orchards. These second generation selections will provide greater genetic gains for the reforestation program. To date a total of 20 black spruce and 44 jack pine selections have been made from research tests established by J.D. Irving Ltd. over the past ten years. These selections coupled with others from the NBTIC program will form the genetic base for future generations in the breeding program.

ACCELERATED BREEDING PROGRAM

Accelerated growth and flower induction methods are now operational tools used to accelerate the breeding and testing program. In 1988, a breeding hall was constructed and it is currently being used for breeding white spruce, black spruce, Norway spruce and jack pine. Significant numbers of controlled pollinations were carried out in 1989 on grafts made in 1986.

Retrospective progeny tests are yielding results which may have impact on breeding strategies. Accelerated tests of jack pine in the greenhouse have given a correlation value of 0.767 for height growth with 10-year field results. This work is continuing for black spruce, jack pine and white spruce (in co-operation with NBTIC). Planning is underway for incorporating accelerated progeny testing along with traditional field tests into long-term breeding strategies.

VEGETATIVE PROPAGATION

Work on vegetative propagation has continued for the past two years. Experiments have focussed on developing procedures and determining the best environmental regime for an operational rooted cutting program. Approximately 60000 cuttings are being rooted each year with success rates varying from close to 70 percent to 90 percent depending on species.

Trials are being grown in the nursery in 1989 for field planting in 1990 to compare performance of half-sib families grown as seedlings versus rooted cutting for white spruce and black spruce.

COOPERATIVE TREE IMPROVEMENT IN NOVA SCOTIA 1987 - 1989

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Keywords: government-industry cooperation, selection, seed orchards, breeding

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

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

Selection

During the latter part of 1988, a major effort to complete black spruce selection was made. The provincial government and pulp companies located and collected seed from almost 400 black spruce selections. Another 10 selections were provided by the Department of Energy and Forestry of Prince Edward Island. This seed has been extracted and is being grown in the greenhouse for test and orchard establishment in 1990. Because cone crops were generally heavy for 1988, collections were excellent. This effort brings the total number of selections to almost 1,000 for this species, 75% of which are local selections.

Expansion of Orchards

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

Species	Location	Type*	Approximate area (ha)	Managing Agency
Black Spruce	East Mines	S	4.1	Scott
	Aldershot	S	4.8	Stora
	Debert	S	3.6	L & F
White Spruce	Debert	C	4.2	L & F
	East Mines	C	3.6	Scott
	Waterville	C	3.8	Stora
Ottawa Valley White Spruce	MacQuarrie Lk. Rd.	S	1.8	Stora
Red Spruce	Melvern Square	C	4.5	Bowater
	Waterville	C	5.1	Stora
	Lawrencetown	C	1.6	L & F
	Debert	C	2.2	L & F
White Pine	Debert	C	1.6	L & F
Norway Spruce	East Mines	C	3.1	Scott
	Debert	C	4.5	L & F
		Total	48.5	

* Type: C = clonal (grafted), S = seedling

Breeding

Breeding strategies have been developed for all major species involved in the cooperative program (Fowler, 1986). Breeding has begun for white and red spruce, with emphasis being put on completing polycrosses. The pollen mix used consists of a mixture of 20 clones for each species which are represented in a very early orchard located in the Annapolis Valley. These trees do not form part of the current production population. To date, a total of 107 white and 44 red spruce polycrosses have been completed, not considering further work done this year. Cone induction work with gibberellins will start next year to try to shorten the breeding cycle.

Miscellaneous

Since 1982, the working group had functioned without a formal agreement. Although progress had been good, all parties felt that a renewal of formal commitment to the cooperative breeding program was in order. This agreement has been achieved and agreed to by all members, reflecting the importance that all participants place in this work.

Tim Mullin resigned his position with the Department of Lands and Forests in August 1988 to actively pursue a Ph.D. in Forest Genetics at the University of New Brunswick. In February of 1989, Peter Nitschke was hired to replace Tim as the Manager of the Tree Breeding Centre and Chairman of the working group. Peter had spent six years with J.D. Irving's tree improvement program prior to accepting employment at Debert, Nova Scotia.

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AMÉLIORATION DES ARBRES FORESTIERS À LA DIRECTION DE LA RECHERCHE ET DU DÉVELOPPEMENT DU MINISTÈRE DE L'ÉNERGIE ET DES RESSOURCES DU QUÉBEC

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AMÉLIORATION DU PIN GRIS (PINUS BANKSIANA LAMB.), DU PIN DE MURRAY (P. CONTORTA DOUGL. VAR. LATIFOLIA ENGELM.), PAR R. BEAUDOIN

Mots-clés: Tests de descendances, tests de provenances, sélection d'arbres, greffage, croisements dirigés.

Le Service de l'amélioration des arbres a poursuivi l'établisement de tests de descendances sur P. banksiana et la réalisation de croisements dirigés sur P. banksiana et P. contorta var. latifolia.

Durant 1987 et 1988, un total de 4 tets de descendances sur P. banksiana ont été établis en rapport avec l'établissement des vergers à graines de semis. Les 2 tests qui accompagnent chaque verger comprennent 392 et 437 descendances d'arbres-plus de la région du Saguenay - Lac-Saint-Jean.

En 1988, un total de 33 croisements dirigés ont été effectués sur P. banksiana entre les clones d'arbres-plus d'une provenance recommandée (canton Briand). Le choix des clones est basé sur la performance, pour la croissance en hauteur à 10 ans après la plantation, des descendances de ces arbres-plus dans un test. La même année, 45 croisements dirigés ont été réalisés sur P. contorta var. latifolia entre les meilleures provenances d'un test de 125 provenances à l'arboretum de Lotbinière. Les meilleures provenances sont surtout de Colombie-Britannique et queuques-unes de l'alberta. Nous n'avons pas remarqué la présence de chancre scléroderrien (Gremmenialla abietina (Lagerb.) Morelet) dans la plantation, mais le nodulier du pin gris (Petrova ablicapitana Busck.) et le charançon du pin blanc (Pissodes strobi Peck.) causent des dommages importants aux arbres rendant la sélection plus difficile à faire.

En 1988, un total de 454 greffes de P. banksiana ont été réalisées à partir de greffons récoltés sur 23 arbres sélectionnés parmi les meilleures provenances dans un test de 64 provenances représentant l'aire de distribution de l'espèce. Ces greffes seront installées dans un parc à clones ou sous abri pour la réalisation de croisements dirigés.

SÉLECTION D'ARBRES ET ÉTABLISSEMENT DE VERGERS À GRAINES, PAR Y. LAMONTAGNE ET A. RAINVILLE

Mots-clés: Vergers à graines, sélection d'arbres, résineux, greffes, densité du bois.

Cette activité a pour objectif l'établissement et l'aménagement d'un réseau de vergers à graines pour les résineux qui fournira éventuellement toutes les semences améliorées génétiquement nécessaires pour le programme de reboisement du Ministère.

A cette fin, les travaux de sélection d'arbres se sont poursuivis depuis 1987 et près de 800 nouveaux candidats ont été identifiés, ce qui porte à plus de 20 000 le nombre total d'arbres-plus. De ces nouvelles sélections, 215 lots de cônes ont été cueillis et traités. Au Centre de greffage de Duchesnay, 35 918 greffes ont été réalisées.

Les travaux de détermination de la densité du bois se sont poursuivis sur 3 212 échantillons d'épinettes blanche, rouge, noire et de Norvège portant ainsi à 5 199, le nombre total d'arbres-plus dont la densité est connue.

Des travaux de préparation de terrain ont été effectués sur 374 ha tandis que des travaux d'entretien ont eu lieu sur 547 ha de vergers déjà établis. De plus, la plantation de 25 nouveaux vergers aux printemps de 1987 et de 1988 (comprenant 92 ha du type clonal et 407 ha du type de semis) porte à 54 le nombre total de vergers établis et à 877 ha, la superficie plantée.

AMÉLIORATION GÉNÉTIQUE DES FEUILLUS À BOIS NOBLE, PAR J. MACKAY

Mots-clés: Amélioration génétique, feuillus nobles, bois d'oeuvre

Depuis avril 1989, nous mettons sur pied un nouveau programme d'amélioration génétique des feuillus nobles dans le but de produire des arbres à haut potentiel pour la production de bois d'oeuvre de qualité. Le programme vise trois espèces de façon prioritaire, soit le frêne blanc (Fraxinus americana L.), le chêne rouge (Quercus rubra L.) et le bouleau jaune (Betula alleghaniensis Britton); ce sont parmi les espèces feuillues les plus reboisées au Québec. Pour chacune de ces espèces l'objectif est de produire des variétés multiclonales adaptées aux conditions de plantation des régions destinées au reboisement de feuillus. Le programme utilisera et/ou adaptera des méthodes de propagation végétative (bouturage, greffage) pour multiplier les génotypes supérieurs issus de sélections en forêt naturelle, sans les

tests génétiques ou de croisements contrôlés afin d'accélérer la disponibilisation du matériel amélioré. Le projet débutera par une phase de sélection d'arbres (arbre-plus) priorisant les caractères morphologiques qui affectent la qualité du fût pour la production de bois d'oeuvre et qui sont reconnus comme possédant un bon niveau d'héritabilité.

SÉLECTION DE CLONES ET AMÉLIORATION DU PEUPLIER (POPULUS L.), PAR G. VALLÉE ET M.-J. MOTTET

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

En résumé à ce jour, un total de 2 211 clones ont été sous observation au Service, dont 545 ont été sélectionnés dans les peuplements naturels au Québec et 928 dans des plantations comparatives; les 738 autres clones ont été introduits surtout d'Europe et d'Ontario. De plus 48 dispositifs de tests clonaux, 9 plantations de collections de clones, 25 dispositifs de tests de provenances et descendances ont été mis en place. Un total de 2 784 croisements ont été faits dont 355 ont donné des semis. Ajoutons l'obtention de pays étrangers de 257 lots de semences et de la récolte au Québec de 433 lots de semences représentant 27 espèces ou hybrides.

En 1988 quelque 600 croisements intra et interspécifiques ont été faits avec les espèces P. alba, P. balsamifera, P. x canescens, P. deltoides, P. euramericana, P. grandidenta, P. x interamericana, P. jackii, P. maximowiczii, P. nigra, P. tremula, P. tremuloides. Des croisements interspécifiques intéressants ont été obtenus comme P. tremuloides x P. alba dont les semis montrent une bonne vigueur. Dans la région du nord-ouest québécois (Abitibi-Témiscamingue) 115 arbres-plus de P. tremuloides ont été sélectionnés dans autant de cantons par le personnel de M.E.R. de la région. L'objectif est de consituer une population de base pour les reboisements en tremble de la région et pour l'amélioration génétique du tremble (P. tremuloides).

Des quartiers de pieds-mères pour la production de plançons sont en cours d'installation dans 3 pépinières du Ministère situées en Abitibi, Lac Saint-Jean et Gaspésie où des plantations de peupliers seront faites. Ces quatiers de pieds-mères sont faits avec des clones de P. x jackiisélectionnés à partir de tests clonaux établis dans les climax de la forêt boréale du Québec.

Les travaux de sélection de clones et semis de peupliers résistants à Septoria musiva Pk. se poursuivent depuis 1986. Les inoculations artificielles du champignon pathogène s'effectuent chaque été sur des rejets de souches en pépinière. Dès 1 071 clones testés avec un isolat de S. musiva en 1986, nous en avons retenu 462 clones. Ceux-ci ont été inoculés en 1987 et 1988 avec trois autres isolats provenant de

diverses régions du Québec et de l'Ontario. Dès 1 071 clones initiaux, 162 clones demeurent résistants ou peu sensibles après trois années d'inoculation. En 1987, 2 374 plants ont été inoculés avec un isolat, puis repris généralement avec 3 autres isolats en 1988. Ces plants avaient été sélectionnés à partir de 9 000 plants obtenus d'hybridations artificielles. Nous avons aussi testé pour la première fois en 1988, 291 nouveaux clones. Une partie de ces clones (87) ont été obtenus de l'Agence Internationale de l'Énergie.

AMÉLIORATION DES MÉLÈZES (LARIX SP.) ET DE L'ÉPINETTE DE NORVÈGE (PICEA ABIES KARST.), PAR A. STIPANICIC

Mots-clés: Tests de descendances, tests de provenances, croisements dirigés, vergers à graines

Les travaux se sont poursuivis tels que prévu dans le cadre de notre projet d'amélioration des mélèzes. L'accent a été mis sur le croisement dirigé interspécifique en vue de produire des hybrides à partir des arbres de mélèze d'Europe, du Japon eet de mélèze laricin, sélectionnés dans nos conditions écologiques. Ainsi, à l'automne 1987, nous avons obtenu 167 lots de graines issus de la pollinisation dirigée effectuée au printemps de la même année. En 1988. 184 croisements ont été réalisés dans nos plantations et 173 lots de graines ont été obtenus après l'extraction. Le nombre de semences par lot varie considérablement dû non seulement au nombre de cônes qui se sont développés après la pollinisation mais aussi au nombre très variable de graines par cône. Au printemps 1989 nous avons effectué 185 autres croisements. Cette année nous avons travaillé surtout avec les arbres sélectionnés de mélèze d'Europe et de mélèze du Japon dans le but d'obtenir l'hybride x eurolepis.

Les graines issues de la pollinisation dirigée seront utilisées le plus vite possible pour l'établissement des tests de descendances. Ainsi nous allons évaluer les performances des nouveaux hybrides et les croisements les plus intéressants pourront être répétés pour obtenir une quantité plus grande de graines. 101 lots ont déjà été semés au mois de février de cette année dans les serres. Nous prévoyons multiplier par bouturage les jeunes semis afin d'obtenir suffisamment de matériel pour installer les tests dans la pépinière et sur le terrain.

Il faut aussi noter l'établissement en 1988 de 2 tests clonaux avec au total 188 clones de mélèze d'Europe et de 2 tests de descendances avec respectivement 162 et 150 familles de mélèze d'Europe, de mélèze du Japon, de mélèze laricin ainsi que l'hybride x eurolepis. Un parc à clones regroupant 135 clones sélectionnés dans les plantations de mélèze à été installé dans notre arboretum de Villeroy. Au printemps 1989, trois autres tests de descendances de mélèze laricin ont été réalisés dans trois domaines écologiques différents de la région d'Abitibi-Témiscamingue. Ces tests, composés de 226 familles, serviront comme base pour l'aménagemenet d'un verger à graines installé dans la même région.

En ce qui concerne les travaux d'amélioration de l'épinette de Norvège, il faut noter les essais de croisements dirigés entre les arbres sélectionnés de cette espèce. En 1988 nous avons réalisé 51 croisements, mais seulement 34 ont réussi. La quantité de graines par cône ainsi que le taux de germination sont très variables. 22 de ces 34 familles ont été semées en vue d'un tests regroupant plusieurs descendances récoltées sur les arbres sélectionnés de provenances déjà recommandées dans nos plantations. Deux autres tests de descendances ont été installés dans deux pépinières dans le but d'évaluer déjà au niveau de la pépinière les performances des familles. Ces tests seront transférés plus tard sur le terrain forestier, où ils vont nous permettre d'établir la relation entre les caractéristiques observées sur les arbres à l'état jeune et l'étatadulte.

Nous collaborons étroitement avec l'équipe de généticiens de Forêts Canada (Québec) à la mise en marche d'une expérience regroupant 300 descendances ou provenances d'épinette de Norvège du Québec et d'Europe. L'expérience vise à préciser les limites de sxecteurs d'amélioration et aussi à obtenir le matériel nécessaire à la poursuite du programme d'amélioration génétique de cette espèce.

AMÉLIORATION DE L'ÉPINETTE NOIRE (PICEA MARIANA), PAR M. VILLENEUVE

Mots-clés: Picea mariana, descendances, croisements dirigés, densité du bois, variétès multifamiliales, bouturage.

Depuis 1987, dix-sept tests de descendances sur terrains forestiers et deux tests précoces en pépinières ont été installés. Ceci porte le total de dispositifs expérimentaux à 67 pour l'épinette noire. Un rapport interne (Villeneuve 1988) a été produit pour définir une nouvelle approche pour la conception des dispositifs, approche qui devrait en faciliter l'analyse statistique.

Une étude de densité du bois (200 arbres de 22 peuplements) s'est poursuivie avec l'établissement de 2 dispositifs en Abitibi, au printemps 1988. Ceux-ci permettront de comparer la densité du bois des arbres-mères avec celle de leurs descendants.

Des croisements dirigés ont été faits à la station de Valcartier de Forêts Canada (Québec). Les provenances dans lesquelles les parents furent choisis ont été sélectionnées selon leur performance à l'arboretum de Lac-St-Ignace. En 1988, les 205 sacs de pollinisation ont donné 6 411 cônes de 159 famillles différentes. En 1989, 147 sacs ont été installés et 128 croisements ont été effectués. Au dernier relevé, il y avait environ 24 fleurs par sac. Ces croisements, selon un plan factoriel incomplet, ont pour buts de parfaire notre technique de pollinisation dirigée, de profiter du gain de croissance par le choix des meilleures provenances pour la Gaspésie et d'amorcer le processus de création de variétés multifamiliales.

A cet effect, en janvier 1989, 183 lots de semences (issus de croisements dirigés ou d'arbres sélectionnés) et 11 lots témoins ont été ensemencés au centre d'amélioration de St-Modeste. Les semis y sont multipliés par bouturage. Une partie des boutures servira pour des tests de descendances précoces et à long terme; le reste ira au reboisement.

Finalement, la stratégie d'amélioration retenue pour l'épinette noire devrait être bientôt sur papier (Villeneuve 1989). Plusieurs personnes-ressources du Québec, de l'Ontario et du Nouveau-Brunswick ont été consultées à ce sujet. Le document révisé sera disponible cet automne.

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GÉNÉTIQUE FORESTIÈRE À FORÊTS CANADA - RÉGION DU QUÉBEC

A. Corriveau, J. Beaulieu, G. Daoust et A. Plourde

Mots clefs: Pinus strobus, Picea glauca, Picea abies, Picea mariana, Picea rubens, Abies balsamea, induction florale, qualité du bois, héritabilité, stabilité phénotypique.

Au cours de la période 1987-89 des études de la variabilité génétique des caractères inrinsèques du bois de l'épinette blanche et de l'épicea commun ont été conduites. Des essais d'induction florale ont été effectués avec succès chez ces mêmes espèces et nombre de croisements dirigés ont été réalisés. La productivité volumique et la stabilité phénotypique de l'épinette noire, de l'épinette rouge et de l'épicea commun ont été étudiées et une première subdivision du territoire guébécois en zones d'amélioration a été tracée. L'héritabilité des caractères de croissance et de forme du sapin baumier a été évalué et les gains génétiques escomptés d'une sélection sur indices ont été calculés. De plus, une réorientation des travaux de recherche conduits au sein du projet de génétique forestière a été amorcée de manière à faire plus de place aux éléments biochimique et biotechnologie et ainsi accélérer l'étude des populations et de résistance aux pathogènes.

GÉNÉTIQUE DES CARACTÈRES DU BOIS

Une étude génétique de la qualité du bois de l'épinette blanche (Picea glauca (Moench) Voss) a été entreprise en 1987. Pour ce faire, 800 arbres d'un test de 40 descendances âgées de 23 ans ont été échantillonnés. Les barrettes de sondage furent sectionnées selon le nombre d'anneaux de croissance depuis l'écorce, les six derniers anneaux étant associés au bois mature et les anneaux antérieures au bois juvénile. Les analyses effectuées démontrèrent que les caractères de croissance et de qualité du bois sont interreliés au niveau génétique aussi bien qu'au niveau phénotypique. De manière générale, un accroissement de la largeur des cernes se traduit par une diminution de la densité et une augmentation de la teneur en humidité du bois de l'épinette blanche. Ceci arrive aussi bien chez le bois juvénile que chez le bois mature. Les différences familiales ne sont responsables que d'une faible proportion de la variation totale de la densité du bois juvénile alors qu'elles représentent lus de 15 % de celle du bois mature. Les valeurs d'héritabilité calculées indiquent que le bois mature de l'épinette blanche est sous fort contrôle génétique, alors que celles du bois juvénile sont beaucoup plus assujetties aux conditions environnmentales. Les gains génétiques espérés d'une sélection combinée à 1 pourcent respectivement pour le teneur en humidité, la largeur des cernes et la densité du bois respectivement (Corriveau et collab. 1989a soumis au J. can. rech. for.). Ce travail complétait une série de travaux sur la variabilité phénotypique et génétique de l'épinette blanche en forêt naturelle (Corriveau et collab. 1987) et en plantation (Beaulieu et Corriveau 1985, Corriveau et collab. 19).

Une seconde étude, portant cette fois sur la variabilité de la densité du bois de l'épicea commun (Picea abies (L.) Karst), a été réalisée en 1988. Pour ce faire, vingt arbres de chacune de 22 populations originaires de Roumanie, Lettonie, Bielorussie et d'Allemagne furent échantillonnés. Des différences significatives furent observées entre les populations tant au niveau du bois juvénile et du bois mature qu'au niveau de la largeur de cernes et de la teneur en humidité. Cependant, la majeure partie de la variation de ces caractères étaient attribuables aux différences entre les arbres d'une même population. Une variation clinale, suivant un gradient de variation longitudinal de la densité du bois, a été observée. Les différences de longitude des lieux d'origine des populations expliquent quelque 40 pourcent de la variabilité d'interpopulation du bois juvénile et du bois mature. Les informations obtenues de cette étude suggèrent qu'un programme d'amélioration génétique de l'épicea commun visant l'augmentation de productivité en masse anhydre devrait d'abord s'appuyer sur une sélection des populations à productivité volumique supérieure puis, en second lieu, sur le choix à l'intérieur de ces mêmes populations d'individus produisant un bois de densité supérieure (Blouin 1989).

STABILITÉ PHÉNOTYPIQUE ET ZONES D'AMÉLIORATION

Une étude de la stabilité phénotypique et de croissance de l'épinette noire (Picea mariana (Mill.) B.S.P.) a été effectuée à partir d'un essai de 100 populations, 15 ans après l'établissement en 4 régions écologiques du Québec méridional. Les différences d'origine de l'épinette noire expliquent de 5 à près de 20 pourcent de la variation de droissance de l'espèce, selon le site d'expérimentation. Les provenances réagissent différemment selon le milieu de croissance. Certaines ont une excellente stabilité relative alors que d'autres sont très instables. Un choix éclairé des stocks de reboisement s'avère donc nécessaire. Quatre grandes régions de provenances supérieures ont été définies et le territoire québécois susceptible d'être reboisé en épinette noire a été subdivisé en cinq zones d'amélioration. La sélection des dix meilleures populations pour chacune des zones d'amélioration résulterait en un gain de croissance de quelque 12 pourcent par rapport à la moyenne des populations testées (Beaulieu et collab. 1989).

Quarante-quatre provenances d'épicea commun (Picea abies (L.) Karst) furent étudiés quant à leur adaptabilité et productivité volumique, 15 ans après la plantation. Un changement important de classement des provenances dans le temps et l'espace fut noté. La région de la Mer Baltique, incluant le Nord-est de la Pologne, la Latvie, la Lithuanie et la Bielorussie s'est révélée être une région des provenances des plus intéressantes pour le reboisement au Québec. Quelques provenances des Carpathes ont démontré une forte productivité et une bonne adaptabilité. Il est suggéré que le territoire Québécois propice à la plantation de l'épicea commun soit subdivisé en trois zones d'amélioration correspondant grossièrement à de vastes domaines écologiques. Des provenances supérieures furent recommandées pour chaque

zone d'amélioration (Corriveau et collab. 1988). A la suite des résultats encourageants, un programme stratégique de recherche sur le génétique et d'amélioration de l'espèce a été initié en collaboration avec le MER du Québec.

La productivité vollumique et l'interaction avec l'environnement de 15 provenances d'épinette rouge (Picea rubens Sarg.) ont été étudiées 25 ans après la plantation. L'interaction provenances x milieux observée a semblée être accentuée par l'origine méridionale de plusieurs sources mésadaptées aux conditions des sites d'expérimentation. Quelques provenances possédant une bonne stabilité phénotypique se sont avérées suffisamment plastiques pour être recommandées lors des reboisements sous couverts feuillus. Les provenances d'épinette rouge étudiées avaient toutefois une productivité inférieure aux autres épinettes indigènes ainsi qu'à l'épicea commun. Ceci, en partie du moins, a été attribuable à la trop grande sensibilité au froid et à la dessiccation hivernale de cette espèce lorsque plantée à découvert (Beaulieu et collab. 1989).

INDUCTION FLORALE ET POLLINISATION DIRIGÉE

Au printemps 1987 et 1988, une centaine de clones d'épinette blanche âgés de 7 et 8 ans furent soumis à des traitements d'induction florale sous enceinte plastique. Les ramets avaient été cultivés en pots depuis le greffage. Pour ce faire, le protocole d'induction développé par le Dr. S.D. Ross chez l'épinette d'Engelmann (Picea engelmanii) fut adapt. à l'épinette blanche. Il s'agissait de l'application successive d'un stress hydrique, provoqué par une taille sévère du système racinaire, de pulvérisations d'acide gibbérellique 4/7, suivi d'un stress thermique à température maximale de 35°C, et synchronisée à la phénologie de l'espèce. Les résultats obtenus furent très encourageants. Soixante-cinq et quatre-vingt-trois pourcent des clones traités produisirent des strobiles femelles en 1988 et 1989 respectivement par comparaison à 2 et 5 pourcent des clones témoins. Quatre-vingt-dix et 144 cônes furent produits par greffe productrice. La production du pollen mâle fut beaucoup plus faible. Après ces travaux d'induction florale, deux cent quatre-vingt croisements dirigés génétique de l'épinette blanche et son amélioration. En 1988, les mêmes traitements d'induction furent appliqués à des clones d'épicea commun mais avec beaucoup moins de succès. Quatorze pourcent des ramets traités produisirent un total de 27 cônes femelles seulement. Un nombre supérieur de clones produisirent des strobiles mâles. D'autres essais seront entrrpris afin de forcer l'épicea commun à la floraison (Corriveau, et collab. 1989b, 1989c).

ASPECTS BIOTECHNOLOGIQUES ET BIOCHIMIQUES

Suite aux directives énoncés dans le plan stratégique de la recherche de ForCan et aux recommandations émises par le comité de révision de programme et de projet, une réorientation de notre effort de recherche fut entreprise. Ainsi, plus de recherches fondamentales et long terme seront conduites. En avril 1989, deux nouvelles études ont

été initiées; l'une portant sur l'embryogénèse sromatique et la résistance pathogénique du pin blanc tandis que l'autre portera sur la génétique des populations de cette même espèce à l'aide de marqueurs biochimiques. Pour ce faire, une nouvelle chercheure a été embauchée et un agent forestier chargé de recherche entreprendra dès septembre prochain des études de doctorat.

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CANADIAN PACIFIC FOREST PRODUCTS LIMITED TREE IMPROVEMENT ACTIVITIES 1987-1989 HARRINGTON AND ST. MAURICE DIVISIONS, QUEBEC

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Keywords: Pinus banksiana, Picea glauca, P. mariana, Larix leptolepis, family tests, clonal seed orchard

In 1979, a tree improvement programme was initiated by Canadian Pacific Forest Products Ltd. in Quebec, following two years' involvement in the New Brunswick Tree Improvement Council through its subsidiary, NBIP Forest Products Ltd. The programme's objective in Quebec is to produce genetically superior seed for the Company's reforestation programme on its Upper St. Maurice freehold in central Quebec.

Selection (1980-84) and testing (1982 +) of plus trees are underway in the Gouin (B-3) boreal region (Rowe, J.S. Forest Regions of Canada. Can. For. Serv. Publ. 1300, 1972). The principal seed orchard complex is located at the Company's Harrington Forestry Centre in southwestern Quebec, and a small orchard is established at Batiscan, near Three-Rivers, Quebec.

Canadian Pacific Forest Products' tree improvement programme concentrates on black spruce (P. mariana [Mill.] B.S.P.) and jack pine (Pinus banksiana Lamb.), with some work being done on Japanese larch (Larix leptolepis [Sieb. and Zucc.] Endl.), European larch (L. decidua Mill.) and Norway spruce (Picea abies [L.] Karst). At Harrington, a clonal white spruce (Picea glauca [Moench] voss) seed orchard will produce seeds for NBIP Forest Products' tree planting programme in New Brunswick.

Jack Pine and Black Spruce Family Tests

In 1987, it was decided to measure the jack pine family tests after 7 and 10 growing seasons, with another possible measurement after 12 seasons. Due to the slower growth habit of black spruce, it was decided to measure the black spruce family tests after 10 and 15 growing seasons.

Traits to be measured are: total height, stem form, branch angle, node configuration, leader condition, as well as the presence of wounds and diseases.

Measurements began in 1988, with the evaluation of 6000 jack pine trees in the first set of family tests.

In order to establish the rate of nutrient uptake, foliar analyses were done for both species in each replication of the two family tests. Other site management work included the manual cleaning of the second black spruce family test to remove the excess cutover debris and organic matter (moss and peat), as well as brush which was impeding seedling growth.

In 1989, family test measurements will continue, with 4900 jack pine seedlings to be evaluated. Also, brush control will be carried out on all test sites by a manual herbicide application. Work will continue in controlling insects, notably the pitch nodule maker (Petrova albicapitana) which has infested the tests over the past few years.

Japanese Larch

In the Company's provenance test established at Batiscan, an inventory was done following 9 growing seasons. Traits measured were: total height, dbh, stem form, branch angle, shoot configuration, tree condition and a description of any damage. The analysis of these data will allow us to determine the most interesting families to be kept at the time of the next thinning.

Harrington Seed Orchard

In 1988 establishment of the 6 ha (2484 ramets) white spruce clonal orchard was completed. This terminated the establishment phase of the 48 ha orchard complex. Table 1 gives a breakdown of the various orchard components.

Table 1. Harrington Seed Orchard Information Summary

Species	Type[1]	Area[2] (ha)	Number of Families (F)/ Clones (C)	Planted	Clone Bank	Clone Bank Area (ha)
Black Spruce	S	16,6	440 F	1985/86	yes	2,3
Jack Pine	S	12,0	480 F	1984/85	yes	2,5
White Spruce	C	6,0	65 C	1987/88	no	-
Norway Spruce	C	1,6	120 C	1984 & 86	yes	0,2

1 S: Seedling seed orchard C: Clonal seed orchard
2 Area in production

In 1989, a small phenology study was done in the jack pine and black spruce clone banks, in order to gather flowering data for use in any future second generation development work. Also, a small grafting programme was done to increase the number of available ramets for some clones of jack pine, white spruce and black spruce.

PROGRESS IN ONTARIO'S TREE IMPROVEMENT PROGRAM

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Keywords: Black spruce, jack pine, white spruce, white pine, seed orchards

Tree improvement programs are approaching the completion of initial targets in seed source control, controlled collection areas, plus tree selection, establishment of first generation orchards and family tests. The species included in Ontario's tree improvement program are black spruce (Picea mariana (Mill.) B.S.P.), jack pine (Pinus banksiana Lamb.), white spruce (Picea glauca (Moench) Voss), white pine (Pinus strobus L.) Norway spruce (Picea abies (L.) Karst), red spruce (Picea rubens Sarg.), tamarack (Larix laricina (Du Roi) K. Koch, Japanese larch L. leptolepis (Sieb. & Zucc.) Endl., and European larch L. decidua (Mill.), black walnut (Juglans nigra L.), white ash (Fraxinus americana L.) and red oak (Quercus rubra L.). A tree improvement program also exists for poplar with major emphasis on identifying superior Populus deltoides for hybridization with exotics. The following outlines the progress by species within each administrative Region.

NORTHWESTERN REGION

Black Spruce

The Red Lake 3300 seed orchard and its two family tests were planted in 1989. This completes the establishment phase of this program with 12 seed orchards and 24 family tests. All orchards utilize an irrigation system that is regulated by a climate based model.

Jack Pine

Two seed orchards (Dryden and Fort Frances) and 6 tests were planted in 1989, cooperatively with Canadian Pacific Forest Products and Boise-Cascade. Seed has been sown for two more orchards and 6 family tests. An additional two orchards and 6 family tests are planned to reach a target of 6 orchards and 18 family tests.

White Spruce

Six clonal orchards have been planted but mortality has been severe. Regrafting and refills are underway.

NORTH CENTRAL REGION

The North Central Region implements the tree improvement program cooperatively with the Ontario Tree Improvement Council (OTIC).

Breeding Orchard

A breeding orchard for both the old and new program was established on the north side of the Thunder Bay Tree Nursery in 1988.

Black Spruce

a) Nipigon West Breeding Zone

This program is now established with two (2) 16 hectare seed orchards (Abitibi-1; Ministry-1) and four family tests (Abitibi-2, CPFP-1, Ministry-1).

b) 4400 Breeding Zone

Three hundred and fifty-eight (358) superior trees have been selected to date. Plus trees from the old 4400 program (Pearson seed orchard) have been pollinated using a wild mix of pollen. Seed from these polymix crosses will be incorporated into the 4400 program along with seed from identified superior provenances. Trees will be grown in 1990 for planting in tests and orchards for 1991.

c) Nipigon East Breeding Zone

The clones from the old orchards Longlac, Matawin and O'Connor will be tested using a polymix testing design.

Jack Pine

a) Nipigon West Breeding Zone

This program was completed in 1987 with one 14 hectare seed orchard (Canadian Pacific) and four family tests (2-Canadian Pacific, 1-Abitibi, 1-Ministry) established.

b) 4400 Breeding Zone

The collection of 40 trees and the identification of approximately 100 additional trees has been done. The selection and collection of the remaining trees will be completed in the winter of 1989, with planting scheduled for 1992.

c) Nipigon East Breeding Zone

Sixty-seven (67) plus trees have been selected and collected.

White Spruce

a) 4400 Breeding Zone

One hundred and thirty-six (136) plus trees have been selected and 51 of these have been planted in the Pearson Orchard.

b) 3400 Site Region

The O'Connor Seed Orchard has been re-designed to improve pollination.

A polymix test design will be used to test the clones in the O'Connor, Longlac and Matawin orchards.

NORTHERN REGION

The direction and planning of the program is the responsibility of the Ontario Ministry of Natural Resources, Northern Forest Development Group (NFDG). The Northern Region continues to play and active role in the Ontario Tree Improvement Council cooperative activities.

Black Spruce

Plus-tree selection by each of the 5 breeding zones has been completed. Five seed orchard complexes have been established, comprising a total of 130 hectares. Fifteen associated family tests have been planted to finish the establishment phase of the first generation of improvement.

Jack Pine

Selection of superior trees from natural stands for each of the four breeding zones has been completed for this species. Three of the five seed orchard complexes mentioned for black spruce also have jack pine portions adding a total of 59 hectares. As a result of the completion of these seed orchards, the establishment of first generation tree improvement for jack pine is complete.

Operational trials include establishment of fertilizer rates and formulations using the Diagnosis and Recommendation Integrated System (DRIS), erosion control, climatic profiling and pollen infiltration.

Breeding Hall

Trials at the breeding hall at Swastika nursery have focused on the use of heat and $GA_{4/7}$ for flower induction of potted grafts. Trials have also been done to develop an effective protocol for vegetatively propagating jack pine. Other studies have addressed different overwintering techniques for potted grafts, the use of plant growth enhancer, fertilizer rates and products, encouraging greater lateral branching of jack pine grafts, flower induction of archive trees and the persistence of plagiotropism in black spruce stecklings.

The Northern Clonal Forestry Centre (NCFC), a private enterprise near Kapuskasing uses the seed from controlled crosses in the breeding hall to grow donor trees for rooted cuttings. The NCFC cooperates with NFDG staff in the development and testing of clones, as well as, producing one million rooted cuttings annually.

Clonal Archives

Three clonal archives are located at Swastika Tree Nursery, the Bonner Tree Improvement Center near Kapuskasing and the Island Lake Tree Improvement Area near Chapleau.

NORTHEASTERN REGION

White Pine

The orchard for the 5200 east breeding zone is complete. The 5200 west orchard is about 1/3 complete and the location for the third orchard for breeding zone 4200 has not been finalized yet. Field grafting is the method used for establishing white pine orchards.

Black Spruce

A seedling seed orchard and three family tests for breeding zone 4200 were established in 1989. Plus tree collection was completed for breeding zone 3200 and the establishment of a seedling seed orchard and two family tests is scheduled for 1991.

White Spruce

A clonal seed orchard has been started for breeding zone 4200, with completion scheduled for 1992. Thirty (30) clones have been planted, 136 have been grafted with a target of 216.

NORTH SHORE TREE IMPROVEMENT COOPERATIVE

Jack Pine

The North Shore Tree Improvement Cooperative members are Domtar Forest Products in White River, Dubreuil Forest Products in Dubreuilville, E.B. Eddy Forest Products in Espanola, and the Ministry in the Northeastern Region. The members cooperate on the jack pine tree improvement program in Northeastern Region, which includes 7 seedling orchards and 19 tests.

EASTERN REGION

The Fast Growing Forests Group (FGF), Brockville, Ontario, has continued to make progress in the conifer tree improvement program for the Eastern Region, which was initiated in 1985.

White Pine

Plus tree selections total 325, 295 of which have been grafted. Fall grafting was used in 1988-89 with 76 percent survival. The operational and economic advantages make the lower survival rate acceptable. In addition, 35 trees were selected for utilization in a polycross. Branches were collected from each tree and pollen was forced, collected, and stored for use in subsequent years.

Two 8 hectare white pine clonal seed orchards will be established in the spring of 1990. In the interim, seed quality is controlled by limiting collection to 10 hectares of managed seed production areas.

Developmental trials in the breeding hall have established a treatment for induction of pollen cones on 3 year old grafts of white pine. Several additional experiments were completed in 1989 to establish female flower induction protocol.

Experiments directed at improving the feasibility of vegetative propagation through the use of rooted cuttings are continuing. Increased numbers of shoots can now be obtained through the application of BAP, however, improvements in the percentage rooting must be achieved before this method of stock production becomes operationally feasible.

Norway Spruce

Plus tree selections total 50. Expansion of the gene pool will continue through the acquisition of material in plantations in the 5200 and 6200 seed zone outside of Eastern Region. To initiate a clonal program, 200 superseedling selections have been made to date to provide donor material, based on nursery screening trials. One nursery screening and one clonal progeny trial was established in 1989.

Accelerated growth of grafts in the breeding hall, accomplished by forcing two growth cycles in one calendar year, was utilized on an operational basis in 1989. Developmental work to determine the most effective flower induction techniques continues with stem injections of $GA_{4/7}$ being emphasized.

Larch

A total of 47 tamarack plus tree selections have been made to date. Twenty-one (21) Japanese larch and 23 European larch selections from landrace trials, collections and small plantations have been made and grafted. An interim seed supply for serial propagation of exotic larch is obtained through individual tree collections from landrace trials and a hybrid larch seed orchard located in the Eastern Region.

Development work is being conducted in both the breeding hall and hybrid larch seed orchard to determine the most effective flower induction treatments for tamarack and the exotic larches.

Poplar

The first generation breeding scheme, initiated in 1984, for Populus deltoides was completed in 1989. A factorial breeding scheme utilizing a number of males and females (depending on the size of the region) was completed for each of 11 physiographic site regions in the Eastern Region.

Interspecific crosses have also been completed between P. deltoides and P. nigra and P. maximowiczii, for the production of new hybrid clones in the short term. New clones entering the program are first screened in a short term test at the nursery. Characteristics evaluated include rooting, growth, susceptibility to frost, resistance to Melampsora leaf rust and Marssonina leaf spot and resistance to Septoria musiva Peck.

ALGONQUIN REGION

In 1989 a seed forecasting register was compiled by each district to assist seed collection from selected stands.

White Pine

The establishment of three 8 hectare clonal seed orchards for the Petawawa source is nearly completed. The breeding orchard established in Pembroke District for this source now contains 302 clones. The combined production-breeding orchard for the Georgian Bay source has 73 clones.

White Spruce

The Upper Ottawa Valley white spruce clonal seed orchard, established under the joint auspices of the Ministry and Forestry Canada (PNFI), is to perpetuate the Douglas and Beachburg provenances which showed superior growth in many parts of Canada and the United States. The seed orchard contains 220 clones in 8 hectares. One thousand (1,000) cones were picked from the orchard to investigate seed yields.

Tamarack

Ramets in the production/breeding orchard in Minden district showed vigorous growth in the last two years. Many trees attained a height of 5 metres or more. A phenology study done in 1988 indicated that both male and female flowers were fully mature in the first week of May and many clones were well synchronized for cross pollination. One thousand (1,000) cones were collected to investigate seed yields.

Red Spruce

In co-operation with the Ontario Forest Research Institute, 116 plus trees were selected and grafted, which will be planted in a seed orchard in the Bracebridge district in 1990.

CENTRAL AND SOUTHWESTERN REGION

All the seed orchards within these two regions are joint enterprises. Seed is currently being collected from seed collection areas and seed production areas until the seed orchards are productive. To meet this objective a seed forecasting registrar was compiled by each district in the two regions to ensure the identity and continuity of these areas.

White Pine

For site region 6200, a total of 24 hectares of white pine clonal seed orchard in two locations are being established and are now 70 percent complete. The breeding orchard established for this site region in the Midhurst Nursery has 256 clones.

For site region 7200, an 8 hectare clonal seed orchard is being established in Niagara District, which is 70 per cent complete. The breeding orchard for 7200 site region in St. Williams Nursery contains 234 clones.

Seed from the blister rust resistant white pine clonal seed orchard at Orono has been showing superior growth in nursery beds. The identification of individual ramets, the total number of clones, and their relative positions in the seed orchard are unknown; precluding any selective breeding in the orchard and increasing the possibility of inbreeding. Some isozyme analyses and breeding are underway to estimate heritability levels of resistance to blister rust and to determine patterns of inheritance.

White Spruce and Norway Spruce

Outplanting of the Southern Ontario white spruce breeding orchard is complete. A number of clones were treated with $GA_{4/7}$ to investigate the effect of various concentrations on different clones. A Norway spruce breeding orchard consisting of 200 selections was established in the Orono Nursery.

Black Walnut

The small black walnut production/breeding orchard at the St. Williams Nursery in the Southwestern Region was completed. At present, this seed orchard contains 420 ramets from 203 clones.

White Ash and Red Oak

Seeds will be collected from superior stands of white ash and red oak to establish local seed production areas. A number of hardwood trial plantations (formerly Forestry Canada's) will be considered for seed collection areas or seed production areas.

W.R. BUNTING TREE IMPROVEMENT CENTRE, ORONO

Activities at the Centre are continuing in support of the breeding and clonal forestry programs in Southern Ontario. A pollen lab has been constructed and a white pine pollen bank has been initiated. Flower induction trials on potted grafts in the breeding hall have yielded good results with white pine and white spruce; work has begun with Norway spruce and tamarack.

Approximately 120,000 rooted cuttings of Norway spruce, tamarack and European larch are being produced annually for plantations and genetic tests. The addition of a black-out system has enhanced the production system for the larches. Preliminary results of development work in rooting BAP-induced shoots of white pine are encouraging. Cold storage facilities are being tested for mid-summer rooting of larches.

TREE IMPROVEMENT AND TECHNOLOGY TRANSFER UNIT

The former Tree Seed and Forest Genetics Unit has changed its name to the above, its location to Sault Ste. Marie, and some key personnel. Vic Wearn and Dr. Dennis Joyce have joined the Unit as the supervisor and quantitative forest geneticist, respectively. Jim Hood is the quantitative forest geneticist at the Ontario Forest Research Institute.

Completed projects include a plus tree registry and query program, a tree improvement equipment catalogue, publication of Operational Guidelines to Tree Improvement in Ontario, and a review of the delivery structure of tree improvement. Tree improvement was included in the forest renewal evidence package given during the province's Environmental Assessment Hearings on Forest Management. A genetic test workshop was held for measuring jack pine family tests at five years.

The Ontario Tree Seed Plant has modernized its facilities to reduce airborne dust and manual lifting, and improve ergonomics. Eight new, airtight kilns were installed, as well as a robot and overhead crane to lift and load the cones. Cones, with the exception of jack pine are now shipped in stacking racks. A liquid separator and a gravity separator were added to the seed cleaning line and the tree seed requisition process has been streamlined.

SPRUCE GENETICS AND GENECOLOGY

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Keywords: Picea, interspecific hybridization, crossability, variation, clonal propagation of hybrids

The objectives of these studies are: (1) to investigate genotype x environment interaction with regard to variation in efficiency, growth and nutrition as related to site regions and productivity systems; (2) to create long-term genetic banks for gene pool and population studies, breeding and assessment of genetic parameters to elucidate the breeding system and structure of the genus Picea; (3) to produce, test and select the best hybrids for propagation; (4) to develop genetic and physiological techniques for breeding juvenile trees; and (5) to utilize the arrays of spruce species and genotypes located in the Piceta for long-term monitoring of forest health as related to possible airborne pollution and/or climatic change.

HYBRIDIZATION

Spruce flowering increased in 1987 from a near hiatus in 1986. Breeding was carried out in two Districts, Sault Ste. Marie in the mid-north and Simcoe in the south. One hundred tree x pollen parents were made, with replication by 251 ramets. There were 28 interspecific crosses attempted involving 17 species.

The results from many of the interspecific crosses were negative. Some were confirmation crosses following previous crossing which had yielded one or more year's negative results. Picea orientalis was crossed with nine species, nearly all of which yielded cones with filled seed but none of which germinated. Only seed from controls or from open pollinated cones germinated.

P. breweriana as male parent failed to cross with P. omorika which it markedly resembles morphologically; P. mexicana; P. orientalis; P. rubens; P. sitchensis; P. smithiana; and the natural P. glauca x P. sitchensis hybrid x P. lutzii.

Summer drought in 1987 stimulated massive flowering in spruce in 1988 and provided excellent opportunity for breeding. Breeding was conducted in three Districts: Sault Ste. Marie, Algonquin and Simcoe. We carried out our 328 tree x pollen parent combinations with a total of 506 ramets. Apart from control intraspecific crosses, there were 88 interspecific crosses. The number of species that flowers Piceta

increased. This year 12 species were used as female parents, and 18 species as male parents, only six of which were species common to that of the female parents. Only a few pollens were shipped in and not actually collected on our own trees.

A total of 24 spruce species were used in interspecific crossing.

Initiation of flowering in such an array of species and genotypes is very extended (cf. Owens and Molder 1977), over a month from the earliest to the latest. Year by year weather differences shift the whole or parts of the calendar schedule continuously forward or backward.

There were a few crosses of interest in 1988. P. engelmannii was crossed with P. pungens (cf. Kossuth and Fechner 1973) but crossability was extremely low, only two seedlings out of a total of about 5000 seeds (usable embryo sites). Similarly, P. engelmannii was also crossed successfully with P. rubens. Crossability was low.

P. mexicana was crossed successfully for the third time (repeatability cross) with P. mariana (cf. Gordon 1986). Crossability was again extremely low. P. omorika crossed with P. schrenkiana for the first time after many attempts, but the two seedlings out of 2665 seed were both extreme miniatures.

In our 1988 crossing, and in agreement with the literature, we noted that P. koyamai and P. koraiensis crossed equally well with P. abies. These two species, one (P. koyamai) a Japanese montane species of extremely limited range and the other a Chinese and Korean species with a very widespread range, appear so much alike that some workers consider them simply conspecific. The progenies, however, of the several families involved in the crosses with pollen from a common superlative P. abies plus tree parent, were consistently different both in colour and in height growth depending on whether their female parents were P. koyamai or P. koraiensis.

Both P. koyamai and P. koraiensis were alike in that they failed to cross with P. rubens, P. sitchensis, P. orientalis and P. schrenkiana. All parents of both species also failed to cross with P. omorika although we have previously crossed P. omorika with P. koyamai (very low crossability).

In addition, P. koraiensis failed to cross with P. glauca while P. koyamai also failed to cross with P. engelmannii, P. breweriana, P. mariana and P. maximowiczii. Female conelets of P. koyamai following pollination with other pollens: P. glehnii, P. jezoensis, P. pungens and, unfortunately, P. koraiensis all aborted and are therefore not yet included in evaluation.

P. koyamai, surprisingly, also crossed equally well with P. asperata with which it is morphologically dissimilar, as it did with P. abies, and also with P. obovata, the Siberian Taiga variant of P. abies. This then gives rise to that since P. koyamai is so similar to P. koraiensis and breeds so readily with P. asperata, how is it that P.

koraiensis is protected from complete introgression with P. asperata on mainland China? Current collections provide little evidence of introgression between P. koraiensis and P. asperata.

Flower induction with $GA_{4/7}$ in 1987 was successful in producing female conelets on P. smithiana which developed well to ripening, but interspecific crosses with P. breweriana, P. chihuahuana and P. mexicana were all unsuccessful.

In 1988, female conelets were produced on P. smithiana, P. spinulosa and P. morrisonicola. Although cones and seed developed well, no viable seed was obtained with crosses between P. smithiana and P. schrenkiana and P. obovata as males; and between P. spinulosa and P. morrisonicola and P. rubens as male.

Crossing emphasis to develop fast growing hybrids for use in the boreal forest was maintained in 1987 and 1988. Selected individuals of P. omorika, known from previous crossing to generate heterotic hybrid progeny, were crossed extensively with P. mariana selections from Black Sturgeon, Thunder Bay, Geraldton and Cochrane. Some of these crosses were repeats of those lost to squirrel depredation in 1986. Many of these particular combinations have now been completed. Only a few more are required to complete the design.

Similarly, breeding was continued with mid and high latitude selections of P. sitchensis and an array of P. glauca from Pagwa, Lake Superior and Algonquin representing Ontario Site Regions 3W, 3E, 4E and 5E.

OUTPLANTING OF HYBRIDS

Second-generation breeding has resulted in progeny from tri-hybrid and hybrid backcrosses. These were outplanted in the Bracebridge District in 1987. They are from crosses of fast-growing P. omorika x P. rubens parent hybrids, originally made in 1970, which have now been outcrosses with good selections of P. mariana, and these same parent hybrids backcrossed to the parent species P. omorika and P. rubens. Early results based only on nursery performance indicate, as expected, that variation is considerable and some will prove to be rapid growers.

RED SPRUCE SEED AND BREEDING ORCHARDS

Red spruce is expected to be particularly useful in Site Region 5, parts of Algonquin Region and the southern tier of Northeastern Region Districts. A 20-source provenance experiment was evaluated in 1985, 25 years after establishment. Variation was sufficient to establish rankings of height and diameter. Utilizing this data along with other

characteristics, selections were made in 1987. Scions from 83 trees representing 5% of the 2000 plantation trees were taken and grafted at Orono Nursery. The remaining trees required for the orchard designs are being selected from wild plus-trees. Scions of many of these have been collected in 1987-1988.

ARNOLD ARBORETUM VERIFICATION PROJECT

An external request to confirm all the Picea specimens in the collections of the Arnold Arboretum of Harvard University was initiated as part of the Arboretum's N.S.F. Verification Project for all their collections (cf. Michener 1989).

As well as their own staff, 24 external specialists are dealing with all the genera in their collections. Large numbers of herbarium specimens, acquisition and propagation records, etc. have been examined. Several were climbed for sampling.

Many original trees hold their identity although slight mixups during early transplanting long ago have led to some errors. Others have occurred particularly during cone collections but also during scion collection and subsequent regrafting and propagation. They occasionally occur during transfer to and from other arboreta and scientific institutions. In general, error level is low.

A third trip was made to Alaska and the Yukon in 1987 examining spruce stands and collecting white spruce phenotypes. This was done in company with Dr. G.T. Harvey of the C.F.S. while he was sampling spruce budworm populations.

Other work of this unit entails studies of productivity and nutrient cycling dynamics in spruce forest ecosystems, spruce-fir stand dynamics in relation to budworm events, and measurements of biomass, specific gravity, productivity and nutrient uptake in genotype x environment interaction studies in our Piceta.

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NATIONAL TREE SEED CENTER 1987-89
PETAWAWA NATIONAL FORESTRY INSTITUTE

by

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Keywords: Seed germination requirements, seed maturation, seed storage, flower induction, seed production, cone and seed insects, and seed fungi.

INTRODUCTION

The National Tree Seed Centre continues to provide international, national, and regional leadership in research, development and services. B.S.P. Wang has devoted much time to the ASEAN Forest Tree Seed Centre and maintained an active personal research program. W.H. Fogal and H.O. Schooley have made significant progress in their new work on flower induction while ensuring that results of previous research activities on insect control and cone crop management are published.

RESEARCH AND DEVELOPMENT

Seed Quality

Seed Maturation: A study on the effects of cone storage and prechilling on the germination of apparently mature white spruce (Picea glauca [Moench] Voss) seeds was repeated (with more cone storage periods) to determine the minimum and maximum cone storage limits. This study was in cooperation with Prof. Guy Caron of the University of Moncton.

Seed Germination Requirements: Studies on the germination of black spruce (Picea mariana [Mill.] B.S.P) and red alder (Alnus rubra Bong.) from several provenances have been completed. Black spruce seed is known to be non-dormant but a two week prechilling treatment not only promoted the rate of germination, it also enabled the seeds to germinate well in colder temperatures (10-15°C).

Seed-borne Fungi: NSERC Visiting Scientist, Dr. R. K. Mittal, completed his study on seed-borne fungi of white spruce and eastern white pine (Pinus strobus L), and returned to India. Some of his research results have been published and others are being prepared for publication.

Seed Storage: In the last two years accelerated aging by exposing seeds to high temperature and high humidity has been evaluated for predicting seed storability of white and black spruce and lodgepole pine (Pinus contorta Doug.). Differences among seedlots can be detected. A new cooperative study was initiated in 1989 involving the Alberta Forest Service, the Ontario Ministry of Natural Resources, and forestry agencies of the Maritime Provinces.

Seed production

Cone Crops and Insect Damage: Surveys of white spruce cone crops from 1979 to 1986 provided data for constructing models that predict and manage cone crops, cone and seed insect damage, and seed yields. Work on spruces has been concluded and several reports are being prepared for publication. Future work will concentrate on insects in jack pine seed orchards. All experimental trials of systemic insecticides for control of insects on white spruce have been concluded.

Flower Induction: Trials with gibberellins ($GA_{4/7}$) and fertilizer (NH_4NO_3) were initiated in 1987 in jack pine seedling and clonal orchards established by PNFI and the Saskatchewan Division of Weyerhauser Canada respectively. Untreated trees in both orchards produce equivalent numbers of female flowers but male flower production is five-to nine-fold higher in the seedling orchard. Gibberellin sprays and fertilizer applications both enhance female flowering. The best combination was gibberellin spray with 400 kg N/ha. This provided a two-fold increase in the clonal orchard and a four-fold increase in the seedling orchard. Gibberellin spray alone increased males three-fold in both orchards. Application of fertilizer may depress gibberellin-induced male flowering.

An experiment on 6-year-old trees transplanted from the field to pots under polythene shelters indicated that high soil nitrogen levels increase female flowering, whereas nitrogen deficiency increases male flowering. A prolonged period of severe moisture deficit depresses male and female flowering. Seedlings grown under accelerated growth conditions produced cones in 16 months from seed. Accelerated trees will be used in 1989 to further assess the role of soil nitrogen and water on flowering responses to $GA_{4/7}$.

Pruning: Experiments started in 1987 to determine the effect of top pruning on flowering and seed production suggest that the sexuality of lower branches of jack pine trees is changed from male to female by severe top pruning.

SEED BANK AND SERVICES

Processing & Testing

The National Seed Bank has continued to develop and improve its services by expanding and upgrading the seed storage facilities. The Bank procured 125 seedlots of 42 different species during 1987-88, and provided 900 seed samples of 129 species to clients in Canada and 14 other countries. A total of 865 routine and in-house service tests were conducted for the Seed Bank inventory and other Institute projects. These tests were for germination, moisture content, and seed weight determinations. An international Referee Testing of lodgepole pine seedlots was conducted. The Centre's seed extraction plant processed approximately 1120 lots of seeds. As well, in cooperation with the Institute's Genetics Project staff, Ernie Gilchrist provided a 5-day tree climbing course to technicians of the Quebec Ministry of Energy and Natural Resources.

National Seed Statistics

A review conducted for FORSTATS recognizes the value of collecting national statistics on seed collection and utilization.

TECHNOLOGY TRANSFER

Petawawa National Forestry Institute is the Canadian Executing Agency for CIDA's ASEAN-Canada Forest Tree Seed Centre Project in Thailand. Ben Wang, one of the three-member management team for the Project, has spent much time planning, organizing, and preparing for the start-up of the second phase of the Project in late fall 1989. He is also designated as a seed technology specialist for periodic consultancy work for the Project. Hugh Schooley continued to act as editor of the Tree Seed Working Group News Bulletin. Ongoing cooperative research and technical consultations with university, industrial and provincial agencies serves as an excellent vehicle for two-way transfer of information for delivery of research findings and identification of problems.

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FOREST GENETICS, PETAWAWA NATIONAL FORESTRY INSTITUTE 1987-89

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Keywords: Provenance, progeny testing, population genetics, early selection, genetic modeling, climate change.

INTRODUCTION

After 35 years' involvement with the Tree Genetics and Breeding Project, Dr. C.W. Yeatman resigned as Project Leader in October 1988 and retired in September 1989. He will soon begin a two-year posting as Canadian Project Manager at the ASEAN-Canada Forest Tree Seed Centre in Muak lek, Thailand. Dr. T.J.B. Boyle took over as Project Leader.

In preparation for a peer review held in February 1989, the project was restructured and its objectives redefined to place greater emphasis on investigations of the physiological basis of genetic variation and modeling. Two new studies were initiated, on the genetics of climate change and silvicultural implications of genetic improvement. In support of these changes, improved facilities will be established incorporating controlled-environment rooms and a state-of-the-art greenhouse. Facilities for rooting of cuttings have also been added in the past year.

PROVENANCE/POPULATION STUDIES AND HYBRIDS

Analysis of spatial genotypic organization in an "upland" black spruce (Picea mariana [Mill.] B.S.P.) population indicated that, compared to a "lowland" population, the degree of clustering was less pronounced. However, in neither population was the deviation from a random distribution significant.

Mating systems in eight populations of black spruce included in the range-wide provenance test series were analyzed, and then compared with their field performance at age 15. A positive relationship between outcrossing rate and growth rate was found, indicating that provenance test data should not be interpreted as showing real genetic differences among populations without supporting evidence on the genetic origin of the seed samples.

A comprehensive review of all experiments involving larch (Larix Mill.) species and hybrids established by the project over 65 years was conducted, resulting in the production of an information report summarizing all available information, with recommendations on species and provenance selection.

A seed collection trip to Siberia in 1987 resulted in about 60 seedlots being brought back from four populations in Novosibirsk and Kemerovo Oblast. Samples have since been distributed to 11 cooperators across the country for testing and operational plantation establishment.

Three studies of growth patterns in jack pine provenance hybrids showed that performance of the hybrids is largely intermediate to that of the parent populations. Although some cases of heterosis were observed, its potential for breeding purposes is very limited. Hybrids were also intermediate in rank stability across sites. Large differences in rates of shoot elongation can be exploited in a breeding program without adverse effects on hardiness. A few exceptional hybrids are recommended for clonal propagation.

PROGENY TESTING

The contrasting performances of black spruce families originating from a 7-tree diallel mating design on a range of sites from moist to dry was investigated under controlled environment conditions, in cooperation with the University of Toronto. The ability of seedlings to tolerate chemically-induced drought stress was positively related to the 16-year performance of the same families on dry sites compared to moist sites. Nursery tests are currently being undertaken to investigate whether field test results can be easily duplicated. If successful, early selection of families, adapted to drought conditions expected to become more frequent if current predictions concerning climatic change are accurate, should be possible.

Analysis of a progeny test of Scots pine (Pinus silvestris L.) incorporating material collected in Siberia in 1985 indicated that the potential exists for selection of families combining both rapid growth rates and superior crown form.

JACK PINE BREEDING

Detailed research plans were written for pedigreed progenies of selected jack pine derived from the Spoor Lake Breeding Population. Nursery experiments were planted in 1987 for early evaluation and a field trial was established in 1988 for longer-term study. Dr. Magnussen prepared a plan to follow up and expand upon this work.

EARLY SELECTION

Effective selection for most traits related to the size of economically mature trees can be carried out when the progenies are still fairly young. New approaches have been developed for establishing how early selections can be efficiently done. Based on decision-making principles and probability theory applied to the growth process (considered as a mixed process of random and fixed effects), the new models allow the tree breeder to use juvenile growth information to predict the expected association between mature and current tree size. Practical examples and step-by-step instructions should make these models easy to apply to actual problems.

INTER-TREE COMPETITION

It is well known that trees compete for light and other resources and that this competition intensifies after canopy closure. Competition may, therefore, be a serious confounding factor in older field trials. Generally, competition tends to inflate treatment effects and reduce the error variance. The problem for the analyst is to identify and quantify the effect of competition on estimates of genetic parameters. Efforts in this direction indicate a very complex problem with no single solution. A biologically interpretable model of the competition process has helped to identify the key parameters and their spatial and temporal dynamics. Attempts to adjust for the bias caused by spatial autocorrelations by expansion of classical linear models with spatial interaction terms have been relatively unsuccessful.

GENETIC RESOURCES

A complete review of Norway spruce (Picea abies L. Karst) was undertaken to identify experiments established at PNFI that would provide useful information regarding the potential for Norway spruce in eastern Canada.

Results from experiments representing three generations of Norway spruce of central European origin indicated that mass selection is a very effective method in the genetic improvement of traits, including weevil tolerance and growth characters. A fourth generation of this material will be created to investigate the extent of reduction in genetic variation, as well as to investigate the mechanism of the relationship between height growth and weevil tolerance.

ELECTRONIC DATA COLLECTION

The project upgraded its EDC hardware from the outdated Datamyte and Husky Hunter to the PC1000 manufactured by DAP Technologies, Vanier, Quebec. The new MS-DOS machine with 640K memory, large display, and data transfer at 38.4K bps should provide the project with a more precise and efficient method of scientific data collection. The project

joined two EDC User's Groups including one associated with Region 10 of the USDA Forest Service, Broomall, Pennsylvania and the other sponsored by OMNR Eastern Region in Brockville, Ontario.

ASEAN FOREST TREE SEED CENTRE PROJECT

Interim-phase plans were formulated for the operation of the ACFTSC in collaboration with Mr. B.S.P. Wang and officials of the Asia Branch of CIDA. Dr. Yeatman conducted study tours in Thailand (Nov.-Dec. 1987) and in ASEAN (Malaysia, Indonesia, Philippines, Jan.-March 1988). PNFI was appointed the Canadian Executing Agency to manage the six-year second phase of the Project, April 1989 to March 1995. Dr. Boyle trained at PNFI two Seed Centre staff in the principles and application of isoenzyme analysis for genetic characterization. He subsequently assisted in establishing an analytical laboratory at the Seed Centre, Muak Lek, Thailand, and conducted a training course for ASEAN personnel in the rôle of isoenzyme analysis in management of genetic resources. Dr. Yeatman participated with the PNFI management team (Mr. Boyd Case, Supervisor, Mr. Ben Wang, Scientific Coordinator) in preparing the Inception Report for Phase II of the ACFTSC Project. Dr. Yeatman was appointed Canadian Project Manager at the Seed Centre, Muak Lek, Thailand, for two years following his retirement from Forestry Canada in September, 1989.

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MOLECULAR GENETICS AND TISSUE CULTURE OF FOREST TREE SPECIES AT THE PETAWAWA NATIONAL FORESTRY INSTITUTE (1988-1989)

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The molecular genetics and tissue culture group at PNFI uses molecular biology and tissue culture techniques to both the gene structure and expression of tree species and to integrate this work in traditional tree breeding.

Research at the Institute on somatic embryogenesis in conifers has progressed dramatically. Routine protocols have been established for initiation of embryogenic callus from immature seeds of two Larix species and their reciprocal hybrids, and from mature seeds of black, white, and red spruce. As well, the genotype effect on initiation frequency of embryogenic callus has been studied in 20 families of black spruce. A high frequency of maturation and germination of somatic embryos has been achieved in hybrid larch and black spruce, and somatic embryo-derived plants of these species have been established in soil and transferred to the nursery. Protoplast systems leading to the regeneration of plants have been developed for hybrid larch and are being used for genetic transformation experiments. Cryopreservation procedures for long-term storage of embryogenic calli and cell suspensions of hybrid larch and black spruce have been developed. Plants have been regenerated from thawed tissues and are now in a nursery. Somatic embryogenesis is the first step to applications in molecular genetics studies and toward the development of artificial seeds.

Genomic libraries have been constructed for black spruce, white spruce, jack pine, and hybrid larch. cDNA libraries of various stages of seed germination have been constructed for black spruce and jack pine; these libraries are currently being screened for actin and cab genes and they are used to isolate germination-specific genes. These tools will be used for gene expression, evolution, and evaluation in studies of individual trees.

A major effort is currently underway to genetically transform hybrid larch (Larix eurolepis) and hybrid poplars (Populus deltoides x nigra and Populus nigra x maximowiczii) with Agrobacterium or direct DNA transfer methods. Transient gene expression has been obtained in protoplasts of hybrid larch with the chloramphenicol acetyltransferase gene and the b-glucoronidase gene. Work is ongoing toward stable gene transfer. With poplar, expression of the b-glucoronidase gene has been observed in transformed tissues using various plant promoters and regeneration of transgenic plants is being attempted.

Population genetics studies have been completed and results recently published. In one study dealing with the population structure of tamarack, isozyme data indicated that populations were more differentiated than populations of other species of more continuously distributed conifers. There was a general east versus west pattern; populations in the Great Lakes basin were further differentiated. Isozyme studies with balsam poplar along a latitudinal transect in northwestern Ontario revealed little genetic differentiation among populations. Isozyme studies with white spruce populations near Beachburg, Ontario, indicated that there was no dramatic reorganization of genetic variation in the pooled selected sample used for breeding, as compared to the random populations.

There is collaboration with INRA (Institut de la Recherche Agronomique, Orleans, France) to share complementary expertise and to avoid duplication of work between the two Institutes.

In terms of staff, Dr. W. Cheliak has moved to the Forestry Canada headquarters in Ottawa where he is the coordinator of the Biotechnology program for our department. Dr. P.J. Charest is assuming the role of project leader for the group.

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ONTARIO TREE IMPROVEMENT COUNCIL - PROGRESS

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Keywords: Cooperative, tree improvement

The Ontario Tree Improvement Council [OTIC] is an industrial/ government cooperative responsible for implementing a number of tree improvement projects in Northern Ontario. The members, objectives and structure of OTIC are briefly described.

Operational black spruce (Picea mariana [Mill.] B.S.P.] and jack pine [Pinus banksiana Lamb.] tree improvement projects have been established in the four Northern Regions of the Province. The members have selected almost 3000 plus trees, established 134 hectares of seedling seed orchard and planted 23 family tests in various breeding zones. Funding for these projects has come partially from the Canada-Ontario Forest Resources Development Agreement and partially from member agencies. OTIC has recently employed a Tree Improvement Specialist and a Seed Orchard Manager to provide support to the cooperating members. Progress has been excellent and has every prospect of continuing.

OTIC MEMBERS, OBJECTIVE AND STRUCTURE

OTIC is an incorporated cooperative composed of Abitibi-Price Inc., Boise Cascade Canada Ltd., Canadian Pacific Forest Products Ltd., Malette Inc., Quebec and Ontario Paper Co. Ltd., and the Northwestern, North Central, Northeastern, and Northern Regions and the Forest Resources Group of the Ontario Ministry of Natural Resources [OMNR].

The objective of OTIC is to increase the supply of roundwood available to the forest industries of Ontario by fostering the cooperative approach to a tree improvement program which will shorten rotations, increase yields and improve wood quality. OTIC is meeting this objective by (1) ensuring that all seed used in the reforestation program is well adapted and source identified, and (2) providing genetically improved seed through a program of plus tree selection, testing and seed orchard establishment.

OTIC is structured into two levels of committees. The Board Of Directors, composed of a senior management representative from each of the ten agencies, is responsible for setting policy, providing guidance to the Director and approving a yearly budget. A Regional Working Group is in place for each tree improvement project and is composed of the tree improvement specialists from the industrial woodlands and District and Regional OMNR offices involved. The Working Groups plan the projects, distribute the tasks, approve a budget, and are responsible for the

implementationof each project. In addition to the Board of Directors and the Working Groups, a Technical Committee, composed of member representatives and scientific advisors, meet annually or when needed to review progress, solve minor problems and recommend approaches to long term opportunities.

PROGRESS OF PROJECTS

OTIC was formed in 1985, by which time the OMNR had established tree improvement programmes over much of the Province. OTIC projects were designed to complement those of OMNR's in areas or species where OMNR had no programme and where OTIC industrial members had responsibility for forest management.

The strategies for improvement of both black spruce and jack pine are those outlined in the OMNR document "Tree Improvement Master Plan For Ontario" [1987]. Plus trees are extensively selected (i.e., sampling the population with the best available trees); cones and scions are collected; seedling families produced; and family tests (32 replications of single tree plots) and seedling seed orchards (x blocks of single tree plots) established. Seed orchards will be rogued based on family test results. Breeding orchards are also established from grafted material.

During the first year of OTIC operation, the Canada Ontario Forest Resources Development Agreement came into being and provided OTIC with substantial funds to implement the proposed projects. These COFRDA funds have been a tremendous boon to the programme and have covered roughly 60 percent of the establishment costs. Industry and OMNR have funded the remaining 40 percent of the establishment costs and will be funding all management costs.

Northwestern Region

Boise Cascade Canada Ltd. of Fort Frances, Canadian Pacific Forest Products Ltd. of Dryden, the Fort Frances and Dryden Districts and the NW Region of OMNR are cooperating to improve jack pine in two breeding zones. Over 850 plus trees have been selected; OMNR Fort Frances Dist. has established a 12 ha. seedling seed orchard and Boise Cascade has established three family tests in the southern breeding zone; while Dryden Dist. and Canadian Pacific have jointly established a 12 ha. seed orchard and three family tests in a more northerly breeding zone. The OMNR Northern Region nursery provided 138,000 seedlings for these installations and will be establishing a breeding orchard containing three ramets of each plus tree. The seed orchards and family tests were planted in the spring of 1989 so no survival assessment is available but the orchard sites have irrigation so few problems are anticipated.

The OTIC industrial and government members contributing to both the Northwestern and North Central Regional projects have pooled resources to employ a full time Tree Improvement Specialist to provide coordination and support for their programmes.

North Central Region

Three projects, in various stages of development, are ongoing in this Region. In a large breeding zone to the west of Lake Nipigon, Abitibi-Price Inc. and Canadian Pacific F.P.Ltd., both of Thunder Bay, and the Regional and Thunder Bay Dist. offices of OMNR are cooperating to improve black spruce and jack pine. Over 950 plus trees have been selected; A.P.Inc. and Thunder Bay Dist. have each established a 16 ha. black spruce seedling seed orchard; C.P.F.P.Ltd. has established a 14 ha jack pine orchard; and 4 family tests of each species have been planted. Survival assessments have shown that all but one black spruce family test are doing well. Severe drought in 1988 combined with considerable deer browse has necessitated some replanting in the jack pine orchard along with fencing the entire orchard.

In a breeding zone to the west of Thunder Bay, Canadian Pacific F.P.Ltd. and the Regional and Atikoken and Thunder Bay Dist. offices of OMNR are cooperating to improve both black spruce and jack pine. Plus tree selection began in 1988 following an abundant spruce cone crop in the area. Over 350 black spruce were selected which will be established in tests and an orchard in the near future. Jack pine selection, orchard and test establishment will continue as funds become available.

Planning for a tree improvement project for both black spruce and jack pine in a large breeding zone to the east of Lake Nipigon has begun. In addition to the usual plus tree selection component, breeding zone has an abundance of black spruce selections [intensively selected between 10 & 30 years ago] available in breeding orchards which will be crossed to provide families for testing and seed orchard establishment. OMNR will proceed without industrial cooperation in this project.

Northern Region

Abitibi-Price Inc., Malette Inc., Quebec and Ontario Paper Co. and the OMNR Districts of Cochrane, Kirkland Lake, and Timmins are cooperating to improve black spruce and jack pine in two breeding zones. Over 1100 plus trees have been selected; a 16 ha. jack pine seed orchard, a 36 ha. Cochrane breeding zone black spruce orchard, and a 16 ha. Timmins breeding zone black spruce orchard have been established along with 9 family tests. Considerable replanting in the 36 ha. black spruce orchard was necessary due to the extremely droughty conditions following the 1988 plant. The three industrial agencies and OMNR have employed a full time Seed Orchard Manager to coordinate the management of these tests and orchards. Funding for the Manager and cost incurred in managing these orchards and tests is being shared among the participants based on their forecasted stock requirements.

SUMMARY

The Ontario Tree Improvement Council has made significant progress during the first four years of operation. There has been a superb committment to the programme by both provincial government and industrial members as witnessed by the successful establishment of several tree improvement projects and the full time employment of two additional staff to provide technical support. The focus of OTIC members will now change from establishment to management to ensure that abundant, genetically improved seed is available from the orchards.

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FOREST GENETICS RESEARCH AT THE UNIVERSITY OF TORONTO 1987 - 1989

B. Beatson, R.L. Gambles, B. Vanstone and L. Zsuffa

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Keywords: electrophoresis, tissue culture, cp-DNA, biomass, Salicaceae, Pinus

Research at the Forest Genetics Laboratory is coordinated by L. Zsuffa, Professor of Forest Genetics. The laboratory currently has a graduate student complement of one Masters student and five Ph.D. students. During the past two years, four Masters candidates defended their theses. Also contributing to studies are a research associate (R.L. Gambles), two research assistants (B. Beatson and B. Vanstone), a post-doctoral fellow (K.H. Kim), and a visiting scientist (Zhang Qiwen, China).

Research focuses on the genetic improvement, characterization and evolution of Salix, Populus and Pinus. Studies include starch gel electrophoresis; chloroplast DNA-sequencing; tissue culture including cell-suspension culture; disease resistance; biomass production of Salix; and wood quality of biomass produced by Salix. The studies being conducted by the Forest Genetics Laboratory at the University of Toronto are described in the following:

INDUCTION AND EVALUATION OF HAPLOID AND DIHAPLOID LINES IN WILLOW AND POPLAR SPECIES

M. Stoehr, L. Zsuffa

The goals of this project are to produce haploid lines of selected willow and poplar species through another culture and to develop and evaluate haploid and dihaploid clonal lines. Plantlets have been obtained in two consecutive years in one clone of Populus maximowiczii. The majority of these plants are haploid as determined by chromosome counts. Aneuploids and putative dihaploids were also observed. Clonal lines have been established by vegetative propagation of another-derived plantlets. In willow species, haploid calli have been obtained but shoot induction is as yet unsuccessful.

CLONAL VARIATION IN PLANT REGENERATION VIA CALLUS CULTURE AND CELL SUSPENSION CULTURE IN WILLOWS (Salix L.)

Zhang Qiwen, M.U. Stoehr, L. Zsuffa

This study was initiated to find solutions to difficulties encountered in regenerating Salix L. plants and to establish species, clones and procedures for the same. Calli of 3 species and 7 clones of willow were obtained from young shoots cultured in three media at four hormone levels. Adventitious shoots were obtained from calli of two clones in three media at two hormone levels. Cell suspension cultures from the calli of 4 clones were established.

ISOZYME CHARACTERIZATION OF POPULUS SPECIES AND HYBRIDS

B. Beatson, O.P. Rajora, E. Viquez, L. Zsuffa

This research involves the examination of marker allozyme genes, multilocus genetic structures, species relationships and identification and differentiation of poplar species, interspecific hybrids and their clonal varieties. Publications have been completed resulting from an earlier Ph.D. study (by O.P. Rajora) entitled "Studies into genetics and species relationships of Populus deltoides Marsh., P. nigra L. and P. maximowiczii Henry based on isozymes, pollen competition and leaf morphology", and on a study of P. deltoides "Evaluation and genetic enhancement of Populus deltoides Bartr. native to Ontario". A Master of Science study was completed on the use of isozymes in the identification of P. deltoides and P. nigra clones and their interspecific hybrids. Some studies have been completed in cooperation with the University of Alberta, where Dr. Rajora is now a post-doctoral fellow.

DYNAMICS OF ISOZYME ELECTROPHORETIC SPECTRA IN INTRASPECIFIC FAMILIES OF SALIX EXIGUA N. AND S. ERIOCEPHALA M. AND THEIR IMPLEMENTATION IN WILLOW BREEDING RESEARCH

F.A. Aravanopoulos, L. Zsuffa

The objectives of this research are: to study inheritance and linkage of isozymes in Salix exigua Nutt. and S. eriocephala Muhl.; to investigate tissue differentiation in these species by comparing isozymes of root tips and fresh leaves; and to compare allozyme heterozygosity with growth parameters and biomass production in S. exigua and S. eriocephala. Eighteen enzyme systems in S. exigua and 16 in S. eriocephala have shown repeatable patterns. In S. exigua, variation in parental genotypes exists in 10 enzyme systems and Mendelian inheritance is confirmed at 8 loci. In S. eriocephala, variation in parental genotypes exists in 7 enzyme systems and Mendelian inheritance has been verified at 5 loci.

PHYLOGENETIC RELATIONSHIPS OF WILLOW SPECIES BASED ON ALLOZYME VARIATION AND CHLOROPLAST DNA DIVERSITY

K.X. Chong, L. Zsuffa

This study investigates: genetic structure, similarity and diversity of congeneric Salix species based on allozyme variation and chloroplast DNA (cpDNA) diversity; phylogenetic relations and evolution of willows using isozymes and cpDNA markers; the identification of isozymes and cpDNA as genetic markers for species used. Four buffer systems which are suitable for 14 isozyme systems have been worked out. Isozyme data analysis is underway. A protocol for chloroplast DNA isolation and hybridization has been developed.

GENETIC CHARACTERIZATION OF SOME WHITE PINE SPECIES AND THEIR HYBRIDS BY ISOZYMES AND ITS POSSIBLE RELATIONSHIP TO BLISTER RUST RESISTANCE

E. Chagala, B. Vanstone, L. Zsuffa

The goals of this research are: to characterize selected white pine species and their hybrids; and to study the possible relationship between isozyme markers and blister rust resistance. Studies show variation in isozyme patterns with some alleles having species-characteristic frequencies. Hybrids can be identified using unique isozymes in needles. Linkage studies in the five selected white pine species were carried out using seeds. Analysis of the data is now under way. Also, the possibility of using bark as a tissue for electrophoresis was examined and found feasible.

PROVENANCE VARIATION IN PINUS STROBUS L. (EASTERN WHITE PINE)

H. Ibrahim, L. Zsuffa

This research was initiated in order to define genetic and environmental components of phenotypic variation associated with geographic sources; patterns of genetic variation; juvenile/mature correlations; and provenance-environment interaction. Thirteen growth and morphological characteristics of the provenances were measured and scored. Statistical analysis consisting of univariate, multivariate and non-parametric methods was used for these data. Results showed that eastern white pine is highly variable and displays well-defined patterns of variation. A M.Sc. thesis was completed.

THE EFFECT OF GENOTYPE, SEASON AND NUTRITIONAL STATUS OF ORTET ON SURVIVAL OF STEM CUTTINGS OF ERYTHRINA POEPPIGIANA (WALP.) O.F. COOK

M. Rodrick, L. Zsuffa (in cooperation with C.A.T.I.E. Costa Rica)

The goals of this study were to establish the effects of genetic variation, seasonal changes and nutritional status of the ortet on initial survival and rooting ability of E. poeppigiana cuttings. Significant differences in rooting ability existed between the ortets. Clonal variation in rooting ability was significant within sites but not between sites. Broad-sense heritabilities for this trait ranged from .66 to .76. Percent rooted cuttings was significantly higher for most ortets when cuttings were taken in the dry season compared to the wet season. A marked seasonal difference in rooting success was apparent which coincided with differences in phenology and nutrient status of the ortet.

GROWTH RESPONSE OF SOME NORTH AMERICAN WILLOW SPECIES AND THEIR CLONES TO FERTILIZATION

M. Simon, B. Vanstone, L. Zsuffa

This research was undertaken in order to find differences in growth response of some North American willow species to the same fertilizer treatment and to establish clonal variation within these species. A M.Sc. thesis, based on this work, was defended. Biomass production was greatly improved through fertilization on nutrient-poor soils. There was significant variation in nitrogen uptake efficiency and biomass production among species and clones. Municipal sludge with liming treatment produced the best results. Species and clones can be selected which use sludge more efficiently to produce a larger amount of biomass. Experiments continue on a field trial at Petawawa.

QUANTITATIVE GENETIC ASPECTS OF SOME CHEMICAL CHARACTERISTICS OF MINI-ROTATION WILLOW (SALIX) BIOMASS

W.A. Kenney, D.N. Roy, L. Zsuffa

The objective of this study is to determine the components of variation in biomass chemical characteristics attributable to species, families, and clones within Salix. Broad-sense heritabilities, genotype x environment interaction and phenotypic and genotypic correlations between the traits will be assessed. Data analysis is underway. A literature review has been completed and accepted for publication.

STUDY OF POLLEN MORPHOLOGY IN SALIX L.

K.H. Kim, L. Zsuffa

This study investigates: the taxonomy of Salix via pollen morphology and the usefulness of pollen morphology in studying phylogenetic relationships in subgenus Salix; the classification of species in subgenus Vetrix based on pollen morphology; and identifies and quantifies clonal variation within willow species. Pollen morphometric traits in Salix discolor, S. eriocephala, S. lucida and S. petiolaris demonstrated significant interspecific variation, variable degrees of intraspecific variation and an unequal distance between species.

SPECIES IDENTIFICATION AND INTER- AND INTRASPECIFIC VARIATION IN PINUS L. BASED ON POLLEN MORPHOLOGY AND POLLEN ISOZYMES

K.H. Kim, F.A. Aravanopoulos, L. Zsuffa

This study was undertaken in order to: a) identify subgenera between Haploxylon and Diploxylon with marker allozymes and to produce keys for the reliable identification of subgenera and species of Pinus based on pollen isozymes, and b) study the amount of variation in morphometric traits among and within the four most common North American species of Pinus in the subgenus Haploxylon. The results of a) indicate that CE, GOT, IDH, MDH, PGI and 6PGD isozyme patterns in extracts of pollen from Haploxylon and Diploxylon can be used to separate Haploxylon species from Diploxylon species. Preliminary pollen morphology measurements for b) were conducted.

THE RESPONSE OF WILLOW SPECIES, INTERSPECIFIC HYBRIDS AND CLONES TO DIFFERENT ISOLATES OF THE RUST MELAMPSORA EPITEA THUEM.

B. Beatson, L. Zsuffa

This study investigates genetic resistance to disease by establishing the degree of variability in willow species, family and clonal response to attack by the pathogen, Melampsora rust. Initial planning and preparation is underway and measurement of leaf bioassays should begin in the late summer of 1989. A M.Sc. thesis, based on this work, is in progress.

IMPROVEMENT OF NORTH AMERICAN SALIX FOR BIOMASS PRODUCTION BY HYBRIDIZATION AND CLONAL SELECTION

B. Beatson, D. Nixon, B. Vanstone, L. Zsuffa

The goal of this work is to improve North American Salix for biomass production by hybridization and clonal selection. Clonal screening trials have yielded information on genetic x environmental interaction in biomass production, growth habit, disease resistance and frost hardiness. Some clones exhibit superior growth. Breeding to produce additional inter- and intra-specific hybrids of the most promising families has been successful. Backcrossing to breed for specific desirable traits has been initiated. Hybridization of good North American clones with highly productive European clones of S. viminalis is underway.

IMPROVEMENT OF BIOMASS GROWTH AND PRODUCTION TECHNOLOGY IN SHORT ROTATION FORESTRY

R.L. Gambles and L. Zsuffa

This project was developed to cultivate, conduct and coordinate an international cooperative research programme aimed at the improvement of biomass growth and production technology in short rotation forestry. Ten cooperative research projects have been completed on poplar exchange, alder evaluation, willow breeding, joint evaluation of genetic data, cell culture, biotechnology development, nutrient relations, coppicing, production technology and economics. A new agreement has been initiated for the period 1989-1991: Improvement of Energy-Dedicated Biomass Production Systems. Eight cooperative research projects are being undertaken on production systems, ecophysiology, agricultural/herbaceous crops, pest/disease management feedstock qualities, ideotype tree, exchange of genetic material and joint testing of stock.

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TREE IMPROVEMENT PROGRAMS IN MANITOBA, 1987-1989

by

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Keywords: jack pine, black spruce, white spruce, family tests, pedigreed seed orchard, clonal orchard, co-operative

The first draft of the provincial tree improvement strategy (Dojack, unpublished draft 1988) was circulated for review in 1988. The final strategy will be completed this fall. Following the development of the strategy's first draft, the Manitoba Tree Improvement Co-operative was formed between the Manitoba Forestry Branch (M.F.B.), Abitibi-Price Inc. and Repap Manitoba Inc. In 1989, Memorandums of Understanding describing the co-operative's purpose, structure and member responsibilities were signed by M.F.B. and both companies.

JACK PINE

The first tree improvement program in Manitoba was initiated in 1967 by Forestry Canada. Plus trees were selected and family tests established in Eastern and Western Manitoba. Based on the 10-year measurements of the Eastern Breeding District family tests, the 5 best family members from the 40 top ranked families were crossed to establish a 6.0 hectare pedigreed seed orchard in 1988. The 15-year measurements are currently being analyzed by the University of Alberta. The results of the analysis will be used to conduct further crosses in 1990 to enable expanding the orchard to 10.0 hectares and starting the second generation program.

Mass selection orchards have been established for jack pine in the Northern (1986) and Interlake (1987) Regions of Manitoba. This "low" cost approach involved selecting 10 plus trees from 32 source stands per breeding zone. The mass selection orchard is planted at a 0.5m x 0.5m initial spacing with 50% of the trees removed every 3 to 5 years based on their performance on the orchard site.

BLACK SPRUCE

Southern Manitoba

One hundred plus trees were selected by ground crews and 390 selections completed using a helicopter in 1987. The seed was sown in large styroblock 20 (20.5 cu. in. capacity) containers and grown under high-pressure sodium lights to the following average dimensions: height 23.4 cm; caliper 3.0 mm; total oven dry weight 2.8 gm; shoot/root ratio 5.3:1. Although this stock was more expensive to produce ($625 per 1,000 to grow, label, sort and ship), the second year survival was over 95% even though the trees were planted during a very severe drought.

The open-pollinated family test was planted in 1988 on two sites each with 30 replications. Every replication contains a single tree from each of 400 families and 20 general collection sources. The families were divided into 10 breeding groups within each replication. However, due to the increased cost associated with sorting, mapping and having to plant 20 general sources the first generation selections will no longer be divided into breeding groups.

Lake Winnipeg East: Abitibi-Price/M.F.B. Co-operative

Ground crews selected 200 plus trees and an additional 250 aerial selections were also completed in 1988. Specific gravity measurements were taken for all ground selections and scions from all trees were grafted for a clone bank. The family test stock was grown as an overwintered crop to the same specifications as listed above. The family test was established this spring on 3 sites with 20 replications per site using single tree plots. Husky Hunter dataloggers were used, enabling all numbering or entry errors to be identified, corrected and final maps produced by the next day. A 9.7 hectare seedling seed orchard site has been prepared for planting in 1990.

Northern Region: Repap Manitoba/M.F.B. Co-operative

Ground crews selected 250 plus trees and aerial selection crews completed 200 plus trees in 1988-89. Specific gravity measurements were taken from discs for all ground selections and scions from all trees grafted for a clone bank. The family test stock is being grown as an overwintered crop for planting on 3 sites in 1990. A 9.0 hectare seedling seed orchard site is currently being prepared for planting in 1991.

WHITE SPRUCE

At present only one white spruce program has been started in Manitoba. Cones were collected from 380 plus trees using ground and helicopter selection crews in the Duck and Porcupine Mountains in 1987. The seed was sown in the Styro 20 containers and grown to the following average dimensions: height 18.9 cm; caliper 4.2 mm; total oven dry

weight 3.7 gm; shoot/root ratio 4.6:1. The stock was used to establish an open-pollinated family test on 4 sites with 15 replications per site, using single tree plots. Scion material will be collected from all of the ground and aerial selections this winter to enable the establishment of a 4.5 hectare clonal seed orchard in 1993.

SUMMARY

The establishment of the above programs represents the first phase of the provincial strategy which concentrated on the primary species in the most active breeding zones. The next phase, which includes the establishment of supportive research programs, will be initiated over the next 2-5 years depending on funding and co-operative agreements.

SHELTERBELT TREE IMPROVEMENT
PFRA SHELTERBELT CENTRE 1987-89

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Keywords: shelterbelt, windbreak, progeny test, seed orchard, provenance test.

The primary objective of the tree improvement programme at the PFRA Shelterbelt Centre is to develop genetically superior tree and shrub species for shelterbelt planting in the prairie provinces of western Canada. This programme has focused on Populus, Pinus sylvestris L., Pinus ponderosa var. scopulorum Laws., Larix sibirica Ledeb., and Fraxinus pennsylvanica Marsh. var. subintergerrima (Vahl.) Fern.

POPULUS

In 1982, seedlings from open-pollinated populations of Populus X 'Walker' as well as several full-sib families of P. X 'Walker' and P. X 'Northwest, P. X 'Walker' and P. eurамericana 'gelrica', and P. X 'Walker' and P. tristis were planted at the Shelterbelt Centre. A total of 128 superior clones were selected from these populations, rooted and planted in a replicated clonal test near Indian Head. The test will be evaluated and further selections made after five growing seasons. Other poplar studies include evaluation of propagation techniques and screening for resistance to poplar bud gall mite.

PINUS SYLVESTRIS

An interprovenance breeding programme (300 crosses) including 24 superior phenotypes was completed. One full-sib progeny test was established in 1989 and two more are scheduled for 1990. Half-sib progeny from 24 families is being propagated for planting at four sites in 1990. P. sylvestris seed collected from ten families in Central Siberia are being propagated for planting in a progeny test in 1991.

PINUS PONDEROSA

Third year assessment of a P. ponderosa var. scopulorum open-pollinated progeny test was completed in 1988. The test includes 62 families from 11 sources in Nebraska, South Dakota and Montana. Mean height in the planting was 17.9 cm and survival was 92%. There were no statistical significant differences among families.

LARIX SIBIRICA

Fourth year assessment of a L. sibirica provenance test was completed in 1988. Mean height in the planting was 171.9 cm and survival was 71%. Mean height of the best source, Ivanovskaya oblast (Lat. 57.00N Long. 42.30E), exceeded the plantation mean by 26%. In 1987 a second provenance test of 12 seed sources from seed orchards and native stands of L. sibirica in the Soviet Union was established. Once these trees are producing flowers, superior trees will be selected for use in a breeding programme. In preparation for the breeding programme, detailed studies on flower development, pollen management, and pollination techniques for L. sibirica have been conducted.

FRAXINUS PENNSYLVANICA

The F. pennsylvanica improvement programme initiated in 1985 continued with the establishment of a clone bank in 1988, as well as, provenance tests (30 sources) at eight locations in Manitoba, Saskatchewan and Alberta and two open-pollinated progeny tests in 1989. Other studies include evaluation of pollination techniques and assessing drought tolerance of various seed sources.

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JACK PINE, WHITE SPRUCE AND ASPEN IMPROVEMENT

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Keywords: jack pine, white spruce, aspen, $GA_{4/7}$, seed orchard, cross pollination

Active tree improvement programs for jack pine (Pinus banksiana Lamb.) and white spruce (Picea glauca (Moench) Voss) have been underway since 1979 and 1983 respectively, and are now supplying most of our Company's seed needs from established seed orchards or selected trees and stands. A small scale aspen improvement program is being started in 1989 in response to our mill's increased production of hardwood pulp. This report gives highlights of progress made up to the spring of 1989 in the pine and spruce programs, and an outline of the direction we are taking in aspen improvement.

JACK PINE PROGRAM

A 7 ha clonal orchard, based on 32 selections, is now in the production stage. The 1989 crop will be triple the size of the 1988 crop. All clones in the orchard are now involved in a cross pollination program. The first full-sib seeds resulting from this work will be grown in 1990, and outplanted in field tests in 1991.

Several techniques to promote flowering (cone production) in the orchard have been tested over the years. Stem injections of $GA_{4/7}$ are much more preferable than spray applications. They have resulted in the largest increase in flowering, have not caused any phytotoxic effects on the grafts, and are much more efficient operationally. A "high" dose of 28 mg $GA_{4/7}$ per tree, (approximately .5 mg/cm^2 at root collar, in 1 ml ethanol), injected into the stem has given the best result to date -- a 6 fold increase in female flower production and a 28 fold increase in male flower production. "Early" injections (on June 24th, 1988) worked well for male production, while "late" injections (July 24th) worked best for female production. Girdling in conjunction with $GA_{4/7}$ stem injections did not demonstrate a significant enough increase in flowering, over the use of stem injections alone, to warrant taking the risk of using this technique in the seed orchard itself. Reluctant and poor flowering clones are being injected with $GA_{4/7}$ in 1989 to boost flower production so the cross pollination program can be completed. These treatments will further explore the possibility of an "early" injection for males and a "late" injection for females.

Family tests of offspring from over 200 selected trees have been established over the years. Individual tree selections will be made based on ten-year measurements of the oldest of these in the fall of 1990. These second generation selections will then be bred to get the third generation.

Seven small plantations of seedlings resulting from different aspects of the program have been established operationally in our cutover areas. A system is currently being developed to use a Geographic Information System to map all such plantations, track them back to their origins, and document all other pertinent information about them.

WHITE SPRUCE PROGRAM

Establishment of an 8 ha clonal seed orchard on the basis of 40 select trees was completed in 1989. With the start of flower production in the orchard the first 6 tree diallel was put together, and cross pollinations started in 1989.

A base of over 200 plus trees has been selected. Family tests of over half of these trees have been established. Tests for the rest of the selections will be established after the next white spruce cone year, when we will be able to finish collecting the cones from these trees and start raising the seedlings needed for testing.

Flower induction treatments have been started in the orchard, a standard procedure for stratifying spruce seeds established, and wood relative density tests done on all selections.

ASPEN PROGRAM

A small scale aspen program is being started in 1989. A test of improved aspen material from the Institute of Paper Chemistry has been established. As well, 100 wood cores will be tested for relative density, 30-40 plus trees selected, and techniques for cloning those selections (through rooted suckers arising from excised root segments) will be refined.

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GENETICS AND TREE IMPROVEMENT PROGRAMME ALBERTA FOREST SERVICE, 1987-1989

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Keywords: Tree breeding, genetic improvement, provenance studies, species testing, seed orchards, white spruce, lodgepole pine

This report summarizes the progress of the Alberta Forest Service (A.F.S.) genetics and tree improvement programme for the period 1987-1989.

PROGRAMME DEVELOPMENT

A review of technical planning for various genetic improvement projects was started in view of a very rapid forest industry development in the province over the past few years. A major part of this exercise is revision of the existing breeding regions to accommodate new industry and to expand existing projects to meet 'new' requirements.

New genetic improvement projects were started on western larch and Douglas-fir. With the surge of recent pulp mill developments based on hardwood utilization, aspen and poplars have become very important species for forestry in Alberta. In view of this, a small aspen and poplars genetics project was started. It is currently being reviewed for a major expansion in the near future. Funding from Canada/Alberta Forest Resource Development Agreement provided a major source of funds for the provincial genetics and tree improvement programme during the report period.

GENETIC IMPROVEMENT

Assembly of Breeding Stock

Field selection of superior trees to provide base material for A.F.S. as well as A.F.S./Industry cooperative genetic improvement projects continued. As part of A.F.S. responsibility projects a total of 35 white spruce, 3 black spruce, 5 tamarack, 32 Douglas-fir and 13 western larch trees were selected. As part of A.F.S./Industry cooperative projects a total of 32 lodgepole pine superior trees were selected jointly with Canadian Forest Products and Proctor and Gamble Cellulose.

Superior tree selections are invariably evaluated for wood density and fibre length. Results of wood density analyses conducted so far are shown in the following table:

Species	Number of trees tested	Density		Range	
		Mean	S.E.	Min.	Max.
white spruce	225	0.3409	0.0018	0.2743	0.3940
lodgepole pine	60	0.4180	0.0043	0.3489	0.4870
Douglas-fir	32	0.4324	0.0057	0.3831	0.4739
Tamarack	9	0.4738	0.0044	0.4467	0.4907
Black spruce	19	0.3968	0.0067	0.3404	0.4556

Progeny Testing

As part of genetic improvement for breeding region "G", two open-pollinated half-sib family field trials were outplanted in spring 1988 using plug+2 transplant stock. The trials contained 71-73 families. Experimental design consisted of randomized complete block design with 6 replications and 6-tree row plots. A white spruce northern areas provenance and open-pollinated family test trial was outplanted at three sites in northern Alberta. Some of the seedlots in this trial were also included in the region "G" white spruce open-pollinated half-sib family field trials.

Site development was continued for half-sib family testing as part of genetic improvement for breeding region "B2". Two sites are being developed jointly with Proctor and Gamble Cellulose for this project. The test material will be outplanted in spring 1990.

Western gall rust assessment was carried out on eight half-sib family field trials of lodgepole pine for regions "B1" and "C". Trees with stem galls were removed from the plantations and burned. In the case of branch galls, infected branches were removed and burned. Sanitation measures were completed in May 1989, prior to spore dispersal.

Seed Orchards

Three new white spruce clonal seed orchards were outplanted. These orchards correspond to breeding regions "G", "E" and "H". Region "G" orchard is located at Huallen Seed Orchard Site near Grande Prairie. It is an A.F.S./industry cooperative seed orchard and is managed by Proctor and Gamble. Region "E" seed orchard is located at Pine Ridge. For region "H" orchard a new site was acquired and developed. It is located about 10 km away from Pine Ridge. Planting of additional grafts will continue over the next 2-3 years to complete these orchards.

With regard to lodgepole pine, a small clonal seed orchard for region "B1" project was outplanted in 1989 at Huallen Seed Orchard Site, as an adjunct to the larger seed orchard established there earlier. A monitoring programme for "B1" orchard was commenced. As part of it, 2 permanent sample trees, randomly selected from each of the 55 blocks in the orchard are assessed each year for height growth, crown size and cone production.

A Douglas-fir clonal seed orchard was established for region "F" genetic improvement project at "Genetics and Future Reforestation" site in the Jumpingpound demonstration forest near Calgary. Also established at the same location is a western larch grafted seed orchard. It is comprised of 226 grafts from 13 western larch trees selected from scattered trees and small stands of this species found in the Kananaskis Valley and Crowsnest area on southwestern Alberta. The seed orchard will provide small quantities of seed for special reforestation projects located in the montane forest region of southern Alberta.

Flowering and cone production monitoring of region "D" white spruce seedling seed orchard, established in 1982-83, continued. Approximately two percent of the trees flowered over the past two years. Both male and female flowers were observed. White pine weevil has become a pest of major concern in this seed orchard, with up to 20% of the tress having to be topped each year to control the insect.

GENETICS AND TREE IMPROVEMENT RESEARCH

Species Testing

Four Douglas-fir field trials were established on drought-prone sites in the montane forest region of southwestern Alberta. Douglas-fir is becoming increasingly important for reforestation in southwestern Alberta as it provides an opportunity to diversify reforestation in the montane forest ecoregion to safeguard against outbreaks of mountain pine beetle, which is a serious pest in this area.

A modest poplar programme was initiated to provide practical hands on experience in the propagation of stock and management of poplar plantations in preparation for starting a major new project on poplar hardwoods. In this regard three small plantings of trembling aspen seedlings from two seedlots were outplanted at PRFN, Whitecourt and Wandering River. A clonal trembling aspen planting of five clones from central and southern Alberta was outplanted at PRFN. In addition a small planting containing northwest poplar and Assiniboine poplar was established. Northwest poplar is a hybrid poplar which does well in northern Alberta. The Assiniboine poplar is a relatively new hybrid which is expected to do well in northern Alberta. Its growth and development will be monitored and compared to the performance of the Northwest poplar.

Four green ash field trials were outplanted in central Alberta. Seed for planting stock originated from phenotypically desirable trees growing in Smoky Lake and Edmonton. Early growth in nursery beds had been good and in 1988 forty-eight percent of the stock showed little or no winter damage. The hardy stock was lifted and established in the field trials.

Provenance Studies

The establishment of seven tamarack provenance trials in 1988-89 completes the outplanting phase of a series of Alberta range-wide field trials being established throughout central and northern Alberta.

As part of a series of black spruce provenance trials to be established throughout Alberta, three field trials were outplanted. Stock for an additional four field trials to be outplanted in 1990 is being grown in nursery beds at PRFN.

Outplanting of a green ash provenance trial containing 15 seed sources from Manitoba and Saskatchewan was completed. This trial was established at PRFN in cooperation with PFRA at Indian Head, Saskatchewan.

Nine year assessment of a pine species trial at PRFN, containing 3 seed sources of ponderosa pine, originating from B.C., 8 seed sources of red pine from northern Ontario and Minnesota, 3 lodgepole pine seed sources from west-central Alberta and 1 jack pine seed source from central Alberta was completed. Ponderosa pine was a failure. The performance of the red pine compared favorably with that of the lodgepole pine and jack pine. Mean heights of 67.1 cm, 75.3 cm and 102.6 cm for red pine, jack pine and lodgepole pine respectively were recorded. Red pine may have some potential for selective forestry use in Alberta if hardy strains can be developed. It is recognized as being more drought hardy than lodgepole pine and also holds some merit as an ornamental or amenity tree. In this regard stock production began for further testing. Three red pine seed sources that performed well at PRFN were seeded for outplanting in two field trials in 1990. The seed sources originate from northwestern Ontario and northern Minnesota.

Ten year assessment of a Scots pine seed source trial established at PRFN and containing 25 seedlots of U.S.S.R. origin and a local lodgepole pine seedlot was completed. Results indicate that Scots pine may be a promising exotic suitable for forestry in Alberta. A Scots pine seed source originating from approximately the same latitude as the local lodgepole pine outperformed the lodgepole pine by 35 percent in height and 50% in Dbh growth. Scots pine, after a blizzard in mid May, 1987, proved to be more hardy to late spring frost than the native pine. In addition to two Scots pine seed source trials established in 1987 with seedlots of Scandinavian origin, two plantings containing three bulk U.S.S.R. Scots pine, 3 "local" Scots pine and one lodgepole pine seedlot was established. A third trial is scheduled to be outplanted in 1990. Greenhouse production of three U.S.S.R. Scots pine provenance/open-pollinated family trials is in progress. Each trial consists of 31

single-tree U.S.S.R. Scots pine seedlots, 4 bulk U.S.S.R. Scots pine seedlots and one "local" lodgepole pine seedlot. Outplanting is planned for 1990. The seed for these U.S.S.R. Scots pine trials was obtained through the Petawawa National Forestry Institute.

Seed Production and Related Studies

In 1980 a field study was established to evaluate the flowering and seed production response of lodgepole pine and white spruce seedlings that received an "accelerated growth" (AG) seedling rearing treatment. The AG treatment consisted of a continuous photoperiod and heavier application of nutrients for eight months in the greenhouse. Conventionally grown seedlings of the same seedlots were outplanted in a plantation adjacent to the "AG" plantation. Ten year assessment of these two plantings was completed. An evaluation of early growth and development indicates that the "AG" treatment is effective in promoting flowering at an earlier age and in reducing the time required to attain levels of seed production in the lodgepole pine. Flowering began at three years age and male and female flowering was observed. However, significant cone production began only at eight years age. The same flowering trends were observed two years later in the conventionally grown lodgepole pine. At ten years age the flowering and growth in the two treatments was comparable. The "AG" lodgepole pine produced an average of 66 female strobili and 170 male strobili clusters. This compares to 59 female strobili and 153 male strobili clusters observed in the conventionally grown pine. Seed yield and seed quality compares favorably to that of mature lodgepole pine and lodgepole pine-jack pine hybrid stands in Alberta. Results from the white spruce plantings indicates that the "AG" treatment promotes significantly more vigorous growth and flowering at an earlier age than that observed in conventionally grown white spruce. Eight percent of the "AG" white spruce have produced flowers whereas conventionally grown spruce has not began to flower to date.

A second study was initiated in a lodgepole pine research seedling seed orchard to confirm that mass supplemental pollination increases seed yield. Cones will be collected and seed yield and quality will be assessed in the fall of 1989.

Plant Propagation and Seed Bank

During the report period stock production consisted of 49,538 seedlings, 2700 grafts, 5448 potted rootstock trees, 923 stecklings and 304 rooted suckers.

Douglas fir and western larch grafting programs were started in 1988. 800 Douglas fir and 313 western larch grafts were completed during the report period. Overall grafting success was very good for both species with Douglas fir averaging 96 percent and western larch averaging 95 percent.

A total of 183 seedlots were added to the genetics seed bank. It presently contains 2948 seedlots. Seed quality of the seed bank is monitored by annually testing a set of reference seedlots which consists of a stratified sample of about two percent of the seed bank entries. Since the start of reference seedlot monitoring in 1981, mean seed germination of the seedlots has declined slightly from original 80 percent to 78.6 percent in 1989.

An ultra low temperature seed storage study was initiated in 1988 to monitor performance of white spruce and lodgepole pine seed stored at -80°C. Thirteen seedlots were selected for the study and portions of each seedlot were placed into -80°C storage. After eighteen months in -80°C storage the seed germination percent of these seedlots did not differ from the seed germination percent of seedlots remaining in -18°C storage. This trial will continue for another 1-2 year period. After that, results will be reviewed to decide if storage regime for seed bank should be changed to -80°C instead of the present -18°C.

EARLY FLOWERING AND SEED PRODUCTION OF A LODGEPOLE PINE SEEDLING SEED ORCHARD IN CENTRAL ALBERTA

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ABSTRACT

Flowering and seed production of lodgepole pine were studied in a research seed orchard located at Pine Ridge Forest Nursery in Central Alberta. The seed orchard was established in 1980 with seedlings from three West-central Alberta provenances. Planting stock was grown using "accelerated growth (AG)" and "Control" rearing regimes.

Flowering in both stock types began at age 3 years. Percentage of flowering trees increased at a more rapid rate in the "AG" trees than in the "Control" trees. Flowering in the "AG" trees increased steadily from 6% at age 3 years to 99% at age 10 years. Male and female flower production started at the same time. Female strobili production averaged 0.1 strobili per tree at age 3 years and climbed to 66 strobili per tree at age 10 years. Initially male strobili cluster production lagged behind female strobili production. At age 8 years male strobilus production began to increase rapidly. At age 10 years the "AG" trees averaged 153 male strobili clusters per tree. The same general flowering trends were observed in the "Control" trees, however in earlier years, they lagged 2-3 years behind the "AG" trees. At age 10 years the differences in flowering between the "AG" and "Control" trees had almost disappeared. Flowering occurred on 100 percent of the "Control" trees, which produced an average of 59 female strobili and 170 male strobili clusters per tree. Preliminary analyses of flowering data indicates provenance differences are not large.

Average number of cones per tree increased slightly in two study years (1987 and 1988). Cone counts were consistent with flower counts indicating cone abortion is not a problem in this orchard. Number of filled seeds per cone, however, did vary widely. In 1987 number of seeds per cone averaged 10.1 (range 2.3 - 30.9) compared to 5.1 (range 0.5 - 16.8) in 1988. The decrease in seed yield in the 1988 cone crop was attributed largely to a freak blizzard which occurred on May 18, 1987. Temperatures dropped to -11°C. Germination quality of the seed was consistently good in both years (86.6% and 94.8% in 1987 and 1988 respectively.)

It was concluded from the study of flowering and seed production in the lodgepole pine seed orchard that the "accelerated growth" treatment was effective in promoting flowering at an earlier age and in reducing the time required to attain commercial levels of seed production in lodgepole pine seed orchards in Alberta. Cone production, suitable for commercial collections, in lodgepole pine seed orchards can be expected to begin at age 8 to 10 years of age.

FOREST GENETICS AND TREE IMPROVEMENT ACTIVITIES AT THE UNIVERSITY OF ALBERTA, 1987-89

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Keywords: Inheritance, mating system, population structure, species hybridization, systematics, isozyme, molecular genetics, mycorrhizae, quantitative genetics, tree improvement

MATING SYSTEM, POPULATION STRUCTURE, SPECIATION, AND SYSTEMATICS

Isozyme Genetics: Albert Sproule completed his Ph.D. on the mating system and population structure of Picea mariana (Mill.) B.S.P. Xie Chang-yi completed his Ph.D. on the population structure and mating system of Thuja orientalis L. Agnes Vanende is completing her Ph.D. studies of chemotaxonomy of the Populus balsamifera L. - P. trichocarpa Torr. & Gray complex. Hong Zhu, under joint supervision of Dancik and Ken Higginbotham, is completing his Ph.D. studies of several aspects, including genetic variation, of ectomycorrhizal fungi. PDF Om Rajora completed introgression studies of Picea glauca (Moench) Voss with P. engelmannii Parry and of Poplus species.

Molecular Genetics: John Barrett is continuing his Ph.D. studies on the organization and structure of light-harvesting chlorophyll a/b binding genes in the Pinus contorta Dougl. complex. Graydon Smith is continuing his M.Sc. studies of phylogenetic relationships in the P. contorta Dougl. complex using chloroplast DNA (cpDNA). Om Rajora is continuing studies on inheritance of cpDNA in control crosses of Poplus deltoides, P. nigra, P. maximowiczii and their hybrids; and on cpDNA variation in Poplus species. Research Associate Keith Egger completed systematics studies of Ectendomycorrhizae and is continuing studies on rDNA intergenic spacer length in P. tremuloides. Technologist Mary Aleksiuk, Dancik, and Yeh are continuing the study on cpDNA of mature needles in Picea. Comparative studies of Pinus contorta Dougl. and P. banksiana Lamb. cpDNA with Dave Wagner, University of Kentucky, continue.

Quantitative Genetics: Yeh and Vic Lieffers studied variance and covariance structure of Picea mariana (Mill) B.S.P. in drained and flooded environments.

Funds for these studies have been provided by NSERC operating, Forestry PDF, and Forestry Transition and Development Grants, and the CFS.

TREE IMPROVEMENT

Early Evaluation: Dancik, Yeh, R. Pharis (Calgary), and PDF Israel Jiang are continuing studies of very early (90-180 day) progeny performance of several conifers. Wu Xiaming is continuing his Ph.D. studies of physiological and seedling traits in Pinus contorta spp. latifolia under accelerated growth.

Breeding: Paul Jefferson completed his Ph.D on discriminant functions in tree breeding. Jiang and Yeh are continuing studies of genotype-environment interactions for advanced-generation selection.

Tree Improvement Specialist Sally John completed a study of pollen dynamics in a seed orchard complex. John, Yeh, and Dancik are developing collaborative projects with the Alberta Forest Service and Forest Industries in P. tremuloides genetic resource management, and geographic and genetic variation in wood characteristics.

Funds for these studies have been provided by NSERC Strategic grant, Alberta Forest Development Research Trust, and Alberta Forest Products Association and Alberta Forest Service under the NSERC Unversity-Industry Program.

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TREE IMPROVEMENT AT THE NORTHERN FORESTRY CENTRE 1985-1989

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The program for genetic improvement of jack pine for Manitoba and Saskatchewan, initiated in 1967, continues to be the focus of tree improvement work in Forestry Canada's Northwest Region. Measurement of jack pine family tests at 10 years and 15 years from planting, and analysis of measurements, have been a major activity during the past four years. Technical guidance has been provided to the jack pine seed orchard project for Manitoba, led by Mr. A. Nanka of the Manitoba District Office of Forestry Canada, and funded by the Canada-Manitoba Forest Renewal Agreement. A 10-minute video was produced on the breeding program and seed orchard in southeastern Manitoba. Collaboration has begun with Dr. Y. Hiratsuka of Northern Forestry Centre on western gall rust resistance in the breeding program populations. Other activities included consultation with the Manitoba Forestry Branch tree improvement program on breeding strategies, and developing regressions for wood density estimation in test plantations using Pilodyns.

FAMILY TEST MEASUREMENT AND ANALYSIS

Family test measurement for height, diameter and stem quality at 10 years from planting was completed for the last of the three breeding districts, and measurement of the same trees at 16 years from planting was completed for two breeding districts. In addition, Pilodyn determinations were taken for estimation of family mean wood density and rust galls were counted. Statistical analysis was performed using FORTRAN programs run on Northern Forestry Centre's VAX-8350. At 10 years, family heritability of height, diameter, and stem quality was about 0.5, and individual heritability was about 0.1. In the south-eastern Manitoba (eastern breeding district) family test, variance among families was about equally attributed to stands and families within stands, and reduction of plot error by cubic lattice analysis resulted in detection of significant families by plantations interaction (Klein 1989).

Preliminary analysis of 15-year eastern district results indicated that two of the 20 control-pollinated "first-cousin" progenies (Klein 1986) produced for the breeding district's seed orchard had non-superior mid-parent values at 15 years. These progenies were consequently excluded from the seed orchard. The 20 best eastern

district parent clones according to the analysis were paired assortatively and mated in both directions in the clone bank in 1989. More controlled breeding will be done on selected individuals in the family test plantations in the near future to produce seed orchard stock and progenies for advanced generation breeding.

JACK PINE SEED ORCHARDS IN MANITOBA

A program funded by the Canada-Manitoba Forest Renewal Agreement and administered by the Manitoba District Office in Winnipeg has established a seed orchard of control-pollinated progenies of selected family test trees for the eastern breeding district (planted 1988), and mass selection seed orchards for two areas in northern Manitoba (planted 1986 and 1987). That program is separate from, but linked with, the tree improvement research program in Edmonton. The Edmonton program provides technical advice to the Winnipeg program, through meetings and correspondence, as requested. Layout of the 18 control-pollinated progenies in the eastern district seed orchard was accomplished using the COOL program (Bell and Fletcher 1978), adapted to the Northern Forestry Centre system, and modified to provide row and column listings for each progeny in addition to the output options in the original program. It is intended to use some of the seedlings from the 1989 crosses for an expansion of the existing seed orchard.

WESTERN GALL RUST STUDY

A comprehensive study of the jack pine-western gall rust (Endocronartium harknessii) pathosystem has been initiated by Dr. Y. Hiratsuka of Northern Forestry Centre. Part of the motivation for the study is to incorporate resistance to this rust into improved populations. The main contribution of the tree improvement program to this study has been provision of seed and seedlings of known ancestry for inoculation trials. It is planned to produce full-sib progenies of resistant and susceptible trees for experiments on mode of inheritance of host reaction to rust attack.

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TREE BREEDING, PROVENANCE AND ASSOCIATED RESEARCH ACTIVITIES OF THE BRITISH COLUMBIA MINISTRY OF FORESTS 1987-1989

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Keywords: Douglas-fir, white spruce, Engelmann spruce, lodgepole pine, western hemlock, red cedar, Sitka spruce, yellow cedar, breeding, progeny testing, forest genetics, selection, inbreeding, rooted cuttings, provenance testing

GENETIC IMPROVEMENT OF COASTAL DOUGLAS-FIR

J.C. Heaman (1) and J. Woods (2)

Diallel Program

The diallel project still represents the core of the Douglas-fir (Pseudotsuga menziesii [Mirb.] Franco) breeding program but efforts are now devoted to progeny test evaluation and to planning reselection strategies. In this project 372 selected parents have been brought together in 62 six-tree disconnected modified diallels and these crosses are each tested across eleven sites and spread over eight annual planting series from 1975 to 1985. With completion of the crossing and plantation establishment phases, progress is reflected in the accumulating growth of pedigreed seedlings and planning how this information and material can be used most effectively. Measures are taken at 7 and 12 years and improved material is being selected for replacement orchards and for further breeding.

Breeding Strategies

The immediate objective is the preparation of the long term breeding strategy and planning reselection projects. Jack Woods has joined the Douglas-fir program specifically to develop the advanced generation breeding program and draft plans were recently presented for peer review. These plans are now being confirmed and first selections will be propagated in 1990. Most selections will be made in the diallel project but additional material will be needed from other tests. The second and subsequent breeding population will consist of from 450 to 500 clones.

Advanced Generation Breeding

A complimentary mating system is planned for advanced generations, with progeny from polymix crosses to be used for estimating parental breeding values, and a partial diallel (double-pair mating) for developing full-sib families for selection of breeding populations. Polycross progeny will be deployed to about four sites using single-tree plots. Full-sib progeny will be planted on two sites in family blocks. The population will be maintained in sublines to control coancestry through multiple generations.

Additional Sources of Material

Additional materials will eventually be needed and in addition to the older projects of provenance (Ying 1987) and wide interracial crosses (Orr Ewing et al. 1972), 160 open pollinated families from selected trees in coastal Washington and Oregon were planted across coastal B.C. in 1987-1988. The expansion of U.S. material follows encouraging findings in the established provenance program.

Orchard Selections

Selections for an interim replacement orchard based on 7 year height data from 200 parents were propagated in 1985-6. The main replacement orchard will be selected on 12 year performance and some screening for wood quality will be included. Propagation of these selections will also start in 1990.

Wood Quality

The decision has been made to include wood quality traits in the selection programs. Volume will still be emphasized but early wood relative density will be considered as a secondary trait. At present pin penetration using a pilodyne is being used to provide estimates of parental general combining ability. Volume growth and relative density are negatively correlated but individuals breaking this negative relationship can be found.

Support Research

A number of research projects in support of the breeding program are continuing. A study of the effects of low levels of inbreeding on seed production, nursery performance and growth, concluded the seed production phase (Woods and Heaman 1989). Nursery growth data are collected and two test-sites are established.

A farm-field early selection trial with 70 full-sib families, outplanted in 1986, continues to be monitored, and will allow comparison of this method of progeny testing against results from 11 older field sites containing the same families.

A study of girdling methods for cone induction of Douglas-fir concluded in 1988. Results indicate a single cut with a knife causes less stress to the girdled tree and is as effective as other methods that remove bark and phloem tissue. This study is described in a recent publication (Woods 1989).

Quantitative Geneticist

Dr. Alvin Yanchuk was appointed Technical Advisor, Quantitative Genetics in 1988 and adds technical expertise to the Douglas-fir project as well as to the other Ministry tree improvement programs.

GENETIC IMPROVEMENT OF INTERIOR DOUGLAS-FIR/WESTERN LARCH

Barry C. Jaquish (3)

Parent Tree Selection

Parent tree selection for both species continued through this reporting period. For Douglas-fir, in 1988, one hundred and fifty trees were selected from helicopters in the Mt. Robson breeding zone, and 55 trees were selected from the ground in the East Kootenay breeding zone. This brings the total number of parent tree selections in the program to over 1500. In the western larch (Larix occidentalis Nutt.) breeding program, which was initiated in 1987, a total of 59 parent trees have been selected, grafted and established in first-phase seed orchards. Wind-pollinated seed has been collected from all 59 trees.

Genetic Testing

In fall 1988, three-year (four years from seed) baseline height measurements were completed for five tests in the Shuswap Adams breeding zone. Not surprisingly, differences among sites and among families for mean height were large. Of the 210 families tested, the top 30 families all originated from the Shuswap Lake area.

In spring 1988, two hundred and forty wind-pollinated (W.P.) families were planted on five sites in the West Kootenay High Elevation breeding zone, and in 1989, two hundred W.P. families were planted on five sites in the Mica breeding zone.

To date, in the Douglas-fir program, over 1300 wind-pollinated families are in test across thirty-two sites.

GENETIC IMPROVEMENT OF WHITE AND ENGELMANN SPRUCE

Gyula K. Kiss (3)

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

Progeny Trials

Fifteen-year height and diameter at breast height data assessment has been completed for the Prince George and Prince Rupert Selection Unit progeny trials (Kiss 1985 and 1987). Data analyses have not yet been completed but a cursory review indicates high correlations between ten and fifteen years heights (r=.96) and fifteen-year height and diameter (r=.89).

A severe weevil damage of the fifteen year plantations provided an opportunity to investigate the heritability of weevil resistance. Weevil resistance appears to be highly heritable (h2i=.18; h2f=.77). A report is in preparation to be published soon. It appears that families selected for seed orchards and future breeding are more resistant to weevil attacks than those of the less vigorous families. This finding reaffirms the value of tree improvement.

Three-year height measurements of the 850 open pollinated progeny trials (Kiss 1985) have been completed in 1988. Data analyses are in progress.

Controlled Crossing Program

Matings for the second generation breed production continued in 1989 (Kiss 1987). A note of interest: there was virtually no cone production in 1988, following the extremely heavy production of 1987.

Seedlings resulting from the seed of the comprehensive controlled-crossing program (Kiss 1984) have been raised in 1988 and were outplanted in 1989 on ten test sites throughout British Columbia. Initial heights were recorded and annual height measurements are planned.

ROOTED CUTTINGS RESEARCH AT COWICHAN LAKE RESEARCH STATION AND YELLOW CEDAR AND WESTERN RED CEDAR BREEDING PROGRAMS

J. Russell (2)

Interior Spruce

A technique has been developed for the large-scale production of rooted cuttings from genetically improved families of interior spruce. The technique is described briefly in a FRDA Memo (Russell 1988) and is to be documented fully in an upcoming FRDA grower's manual.

Four interior spruce seedling:rooted cutting comparisons have been outplanted to compare the growth and performance of seedlings and rooted cuttings, and 20,000 genetically improved rooted cuttings have been planted operationally, with another 30,000 planned for 1990.

Yellow cedar

A recent analysis of two seedling:rooted cutting comparisons at ages nine and eleven years, has shown no significant differences in survival, height and diameter between seedlings and rooted cuttings from the same families, and between rooted cuttings from one-, three-, and seven-year-old hedged cutting donors. Two new trials have been established comparing seedlings of yellow cedar (Chamaecyparis nootkatensis [D. Don] Spach.) to rooted cuttings from hedged 12-year-old cutting donors.

A new research initiative has been investigating the effects of maturation level of cutting donors on stock quality of the rooted cuttings using ecophysiological techniques. Stock quality measurements including water stress, net photosynthesis, and stomatal conductance have shown significant correlations with maturation levels of both cutting-donors and rooted cuttings.

Yellow Cedar and Western Red Cedar Breeding Programs

Two new breeding programs have been initiated for yellow cedar and western red cedar (Thuja plicata Donn.). There is very little known on the genetic architecture of both species, so both programs will begin with provenance testing with family structure to aid in the development of seed transfer guidelines, and to assist in the development of a genetic improvement strategy.

An integral component of the yellow cedar provenance study will be the investigation of genetic variability over the short term, at the molecular, physiological and morphological levels. It is anticipated that understanding the genetic control of adaptive traits such as frost hardiness, drought tolerance, and early growth rhythms will help in the early preliminary delineation of seed zones.

GENETIC IMPROVEMENT OF WESTERN HEMLOCK AND SITKA SPRUCE

Jack Woods (2)

Western Hemlock

Advances have been made in several areas of the western hemlock (Tsuga heterophylla [Raf.] Sarg.) breeding program. Ten-year measurements are complete on the first two of three series of the open-pollinated testing project. Results will be used to rogue existing seed orchards, and investigate genotype by environment interactions. Polycross breeding in six seed orchards is progressing well, and sowing may begin as early as 1990.

Cone collections for a range-wide provenance test are continuing. The collection design for this study uses climatic and ecological factors as represented by B.C.'s comprehensive ecological forest-land classification system. Latitudinal bands were defined to allow more intensive sampling from ecosystems which are expected to be of greatest value, and less intensive sampling from the more peripheral parts of the range. On each latitudinal band, cones are collected from all major ecological types (biogeoclimatic variants). To date, 69 provenances have been collected, with some collections remaining from coastal Washington and Oregon, and the central coast of B.C.

Sitka Spruce

In areas where major river drainages intersect the coast mountains in B.C., Sitka spruce (Picea sitchensis [Bong.] Carr.) hybridizes with the interior spruces (P. glauca and P. engelmannii). Reforestation with spruce in these areas of hybridization can result in a number of problems relating to seedlot selection and nursery production. A nursery project was carried out to better define the areas where hybridization occurs, and to assist nursery growers with decisions related to choice of growing regime. In addition, 52+ seedlots representing pure Sitka, pure white and the hybrid complex were established in field tests to estimate field performance and frost damage.

A breeding program for Sitka spruce will be initiated in 1989. Dr. John King (formerly with the Forest Research Institute of New Zealand) will begin development of the Sitka spruce program, as well as take over responsibility for the western hemlock program. This work will begin in June, 1989.

PROVENANCE RESEARCH IN BRITISH COLUMBIA

Cheng C. Ying (1)

Seed transfer of Sitka spruce was the focal point of the provenance research program in the past two years. Ten-year testing results showed a north-south clinal variation in growth, frost hardiness and deer browsing. Increasing provenance growth potential is associated with decreasing frost hardiness from high to low latitude, and the northern provenances also suffered much more severe and prolonged deer browsing than the southern ones. Predicted average volume gain was 1.3 cu m/ha for every one degree latitude of northward transfer. However, frost injury occurred to southern provenances at some sites during the 1984-85 unusual late season cold snap. At one location, provenances from 5^{o} of latitude south of the test suffered needle burning, and at another, provenances from 8^{o} of latitude south of the test lost one season's leader growth. Apparently substantial volume gain can be achieved by northward transfer of Sitka spruce, but not without risk. Differences of opinion have been expressed on the appropriate balance of reward and risk in Sitka spruce seed transfer.

Provenance testing is one of the oldest tree improvement programs in British Columbia, with coastal Douglas-fir plantations now being mostly 20+years old. Those of Sitka spruce are 15, lodgepole pine (Pinus contorta Dougl.) 17 and the true firs (Abies spp.) 10 years old respectively.

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COOPERATIVE SEED ORCHARDS IN BRITISH COLUMBIA, 1987-1989

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Keywords: Seed orchard management, cone induction, seed quality

This report highlights progress made in the cooperative seed orchards in B.C. These orchards fall within the Coastal or Interior Tree Improvement Council (CTIC or ITIC, respectively) programs.

CTIC ORCHARDS

Several coastal orchards reached the producing stage which now comprise nearly half of the 30 orchards in the program (Table 1). Seed production continued to increase and totalled 566 kg over a two-year period (Table 2). On average, over the last five years, 8.1 million seedlings from orchard seed were planted annually on the coast.

Cone production in Douglas-fir, Sitka spruce and Western hemlock orchards is expected to exceed targets, therefore, the emphasis of orchard management is shifting from production to genetic quality. Roguing based on 7 year measurements was carried out in 3 Fdc orchards. Cone induction using girdling, GA and high nitrogen fertilization was selectively applied to families with poor production histories or high general combining ability values (where known).

The contribution of each clone/family to the cone crop was used to calculate the percentage of clones that product 80% of the seed, i.e., 60:80. This percentage, the total number of clones producing, and an estimate of contamination was used to rank the quality of seed each year. Seed users will thus be able to give the best ranked seed priority when excess seed is available.

The Fdc program is moving into second generation orchards. Preliminary selections based on 7 year measurements have been grafted and placed in a holding area where they will remain for five years. About half of these clones will be included in the orchard with final selections to be based on 12 year measurements.

Table 1. Number (and hectares) of CTIC orchards by stage reached.

Species[a]	Developing	Stage Reached[b] Established	Producing	Totals
Ba	1 (2.00)	2 (8.60)		3 (10.60)
Fdc	1 (1.37)	2 (3.87)	6 (29.38)	9 (34.62)
Se		1 (3.63)		1 (3.63)
Sx		1 (0.10)		1 (0.10)
Ss			3 (4.69)	3 (4.69
Hw		6 (15.34)	2 (6.00)	8 (21.34)
Cw		1 (0.05)	2 (1.20)	2 (1.40)
Yc		2 (1.40)		2 (1.40)
Totals	2 (3.37)	15 (32.99)	13 (41.27)	30 (77.63)

[a]
Fdc - Douglas-fir (coastal) (Pseudotsuga menziesii (Mirb.) Franco var. menziessii)
Se - Engelmann spruce (Picea engelmannii Parry)
Hw - Western hemlock (Tsuga heterophylla (Raf.) Sarg.)
Ss - Sitka spruce (Picea sitchensis (Bong.) Carr.)
Ba - Amabilis fir (Abies amabilis (Dougl.) Forbes)
Cw - Western red cedar (Thuja plicata Donn.)
Cy - Yellow cedar (Chamaecyparis nootkatensis (D. Don Spach.)
Sx - Interior spruce (commonly white x engelmann hybrids) Picea sp.

[b]
Developing - site preparation and/or propagation underway (approximate area only)
Established - 80%+ planted
Producing - seed production in any one year at least 40% of annual target

Table 2. Kilograms of seed produced in CTIC orchards.

Species	Year 1987	1988	Totals
Fdc	111.0	386.0	497.0
Hw	11.7	7.8	19.5
Ss	4.9	35.3	40.2
Cw		10.1	10.1
Totals	127.6	439.2	566.8

Three ministry orchards were outplanted between 1987 and 1989 including one each Hw, Se and Fdc. All of these orchards were in holding areas for 5-7 years and the 2-3 m trees were transplanted with few losses (less than 10%).

ITIC ORCHARDS

Parent tree selection is now complete for interior spruce (Sx) in 15 zones; for interior lodgepole pine (P1) (Pinus contorta var. latifolia Dougl.) in 12 zones and is ongoing for interior Douglas-fir (Fdi) (Pseudotsuga menziesii var. glauca (Beissn.) Franco) in 7 zones; for western larch (Lw) (Larix occidentalis Nutt.) in 5 zones; and for western white pine (Pw) (Pinus monticola D. Don) in 4 zones. Total trees selected to date include: Sx 4041, P1 1652, Fdi 1649, Lw 208, Pw 151.

Progeny testing is underway for all zones, including farm field testing to check the validity of ranking based on one site only. Polycrossing was completed and seed sown for progeny testing for two existing Sx orchards and is ongoing for another.

There are now 7 orchard sites (4 company, 3 Ministry of Forests). Orchard establishment is as follows: 12 of 18 planned for in Sx, 7 of 20 planned for in Pli, 0 of 10 planned for in Fdi, 2 of 6 planned for in Lw (Table 3). One Pw plantation, consisting of resistant stock introduced from the United States Forest Service is also being managed as a seed orchard. Of the 21 established orchards most are 1.0 generation, one (Sx) is 1.5 and two (P1) are 1.75. The latter uses selections made in a family provenance test plantation. A container Sx orchard pilot project, with GA applications, heat treatments and root pruning was started in 1988. This project will be continued for 5 years and then evaluated against the traditional, soil-based orchard approach.

Table 3. Number (and hectares) of ITIC orchards by stage reached.

Species	Planned	Stage Reached[b] Developing	Established	Producing	Totals
Sx	4 (24.12)	2 (11.87)	3 (10.56)	9 (25.57)	18 (72.12)
Pl	10 (52.38)	3 (9.41)	4 (16.08)	3 (8.78)	20 (86.65)
Fd	10 (36.04)				10 (36.04)
Lw	4 (6.54)		2 (4.30)		6 (10.84)
Totals	28 (119.08)	5 (21.28)	9 (30.94)	12 (34.35)	54 (205.65)

Sx, Fdi and Lw orchards are established in the southern region of the Province in the vicinity of Kalamalka and Shuswap Lake areas. P1 orchards are being established near Prince George and also in the southern region. Vegetative propagation for the clonal orchards was done mostly by pot grafting and some field grafting.

Supplemental mass pollination as well as airblast sprayers were used in the producing orchards to enhance seedset and pamixia. Fertilizer schedules were based on foliar analysis results. Insect and disease problems were less severe on sites isolated from natural stands. Pest control consisted of detection, sanitation, chemical spray and, where possible, biological control. Site maintenance consisted of covercrop mowing and weed control in the rows.

Water was supplied mostly by trickle irrigation. Withholding water during the period of rapid shoot elongation (bud differentiation) was very effective for crop induction in hot, dry climates and reasonably effective in cooler, moist areas. Orchards located in cooler climates will rely more on GA applications combined with girdling treatments to enhance future cone production.

As on the coast, seed production in the interior orchards is increasing steadily. Since production started in 1982 a total of 35.4 kg (7.6 million potential seedlings) and 147.6 kg (41.3 million potential seedlings) of seed have been generated for Pl and Sx, respectively. Most of this seed was produced in 1987 (Table 4). Germination percentages range from 82 to 97 and 89 to 98 for Sx and Pl, respectively. On average over the last five years, 4.3 million seedlings from orchard seed were planted annually in the interior.

Table 4. Kilograms of seed (and potential seedlings in thousands) produced in ITIC orchards.

Species	Year		Totals
	1987	1988	
Pl	9.6 (2,078)	7.8 (1,678)	17.4 (3,756)
Sx	137.8 (38,571)	0.7 (192)	138.5 (38,763)
Totals	147.4 (40,649)	8.5 (1,870)	155.9 (42,519)

PACIFIC FORESTRY CENTRE 1987-1988

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Keywords: cone slicing, seed counts, Douglas-fir cone moth, Douglas-fir seed chalcid, pheromones, seed certification and testing, seed sorting, spruce cone maggot, spruce seed moth.

Research studies at the Pacific Forestry Centre, on seed quality, and the seed testing and certification programmes, together with studies on cone and seed insects, are outlined.

IMPROVING CONIFER SEEDLOTS

D.G.W. Edwards

Further tests to determine the operational applicability of the IDS seed sorting method to conifer seedlots were carried out at the newly completed British Columbia Ministry of Forests Seed Centre near Vancouver. These tests indicated that commercially-built equipment could be used to dry seeds in layers up to 25 cm deep, and that drying times could be as little as 3 hours at ambient temperatures. Other specially-designed drying equipment was built and a trial, using 6 Pinus contorta Dougl. lots, was conducted. Sorted seeds were operationallysown in containers, and raised in two industrial nurseries. Preliminary results are encouraging. A survey, conducted under a FRDA contract, of almost 100 spruce seedlots to determine which showed the most potential for upgrading by IDS on an operational scale was completed.

Work on Pinus monticola Dougl. and Chamaecyparis nootkatensis (D.Donn) Spach indicated improved germination following prolonged soaking in water at room temperature. Hydration periods of 10 days, followed by 8 weeks stratification at 2°C, produced essentially the same results as soaking for 2 days, keeping the hydrated seeds at room temperature for 4 weeks, then chilling for 8 weeks. Tests using longer hydration times are in progress.

The effects of supplemental-mass-pollination (SMP) and overhead cooling (to delay flowering) on seed yield and germination in a Douglas-fir seed orchard were conducted in collaboration with Dr. Y.A. El-Kassaby (Canadian Pacific Forest Products). No significant differences were found in potential seed yield per cone, the average number of successful fertilizations, or the average number of filled

seeds per cone due to SMP and water-cooling. Small, non-significant effects on germination capacity and germination rate, and on abnormal germinants, were related to the water-cooling treatment.

Variations due to treatments were very small compared to variations among trees within treatments. Two manuscripts have been submitted to Forest Science.

CONE AND SEED INSECTS

G.E. Miller

In the absence of an active study leader, the level of work on cone and seed insects decreased over the last 2 years. Further, with the retirement of Doug Ruth in June 1989, the research on cone and seed insects at the Pacific Forestry Centre will be suspended until our strategic plan has been developed, and decisions have been made on position staffing.

Evaluation of cone slicing as a method of indexing the number of seeds in cones has been completed for 15 British Columbia conifers. A manuscript is in preparation.

Studies on the type, spacing and placement of pheromone traps for Douglas-fir cone moth were completed; a manuscript is in preparation.

Forest Insect and Disease Survey data and other data on cone and seed insects in B.C. (collected for over 30 years in the case of Douglas-fir) were summarized and presented at the IUFRO Cone and Seed Insects Working Party Conference hosted in Victoria in June 1988. Attempts to trap Douglas-fir cone moth with volatiles mimicing Douglas-fir "flowers", in collaboration with Dr. Mike Benn of the Universtity of Calgary, were only marginally successful.

Dr. Jon Sweeney, a Post-Doctortal Fellow, began development of a damage prediction system, based on egg counts, for spruce cone maggot and spruce seed moth on white and Engelmann spruces. Attempts to trap spruce cone maggot and Douglas-fir seed chalcid on coloured sticky traps were unsuccessful.

OFFICIAL CERTIFICATION AND TESTING OF TREE SEEDS

D.G. Edwards, F.T. Portlock and D.W. Taylor

As the Certifying Authority under the OECD scheme for the Pacific and Yukon Region, 142 certificates of provenance for 947 kg of seeds in the source-identified category were issued in 1987. The majority of the seeds certified was Pinus contorta (911 kg), together with small amounts of Picea glauca (Moench) Voss and Picea mariana (Mill.) B.S.P. In addition, 54 kg of Pseudotsuga menziesii (Moench.) Franco seeds in the untested seed orchard category were certified. Under the ISTA seed

testing rules, 90 certificates of seed quality were issued in 1987; these represented over 1100 kg of seeds from 19 species, with Pinus contorta accounting for 85% of the total weight.

In 1988, 2510 kg of source-identified category seeds were certified. This included Abies grandis (Dougl.) Lindl. (1195 kg), Picea sitchensis (Bong.) Carr (569 kg) and three other species. In addition 98 kg of Pseudotsuga menziesii untested seed orchard seeds were also certified. Concurrently, 74 ISTA certificates of seed quality, for 4262 kg of seeds of 10 species were issued; Pinus contorta, Abies grandis, Pinus ponderosa Laws., Picea sitchensis and Pseudotsuga menziesii were the major species.

A five year summary report (1981-1985) for OECD and ISTA activities, the "Forest tree seed inspectors manual", and the manual "Methods and procedures for testing tree seed in Canada" were published. This manual was used extensively during the Tree Seed Testing Workshops held in 1987/88 at PNFI (twice), in Nova Scotia and at PFC. The PFC workshop was attended by 42 people from British Columbia, Alberta and the Yukon, and a number of overseas scientists. "A Guide to Collecting Cones of British Columbia Conifers" has been rewritten and published. "Guidelines for grading and labeling forest tree seeds in Canada" have been published in the Forestry Chronicle. The Forestry Canada OECD Officer (D.G. Edwards) attended the biennial OECD meeting of Designated Authorities in Paris, France, in February 1989.

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WESTERN WHITE PINE IMPROVEMENT PROGRAM FOR BRITISH COLUMBIA 1987-1989

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Keywords: Pinus monticola, Cronartium ribicola, pine-rust genetics, chloroplast DNA, plant proteins

"Operational" program of selection and testing

Selection continued toward the targets of 300 trees from each of the coastal and inland portions of white pine's (Pinus monticola Dougl. ex D. Don) range in British Columbia. 306 coastal and 168 inland trees were selected by January 1, 1989. Most trees selected are canker free, but some showing "incomplete bark reactions" are included. Tree selection, seed collection, extraction, sowing and cultivation during observation are supported by the British Columbia Forest Service.

Successful inoculation of 2-year-old seedlings from open pollination on the parent trees has been achieved for both the 1987 and 1988 runs. Stock showing specific reactions from "low-spotted" families are transplanted to a nursery for further observation. Based only on the 1987 inoculation, the frequency of "low-spotted" families and seedlings is low. After four years of observation, selected seedlings will be transferred to the B.C. Forest Service for the establishment of a seed orchard for each of the coastal and inland portions of the species' range in B.C.

The Ribes garden on C.I.P. land near Victoria now is well established, but most infected leaves for rust inoculation still come from natural Ribes groves inoculated by hand using aeciospores collected each spring from several locations.

Seed production areas, entailing the removal of rust-infected white pines from accessible stands showing a good record of cone production and the cultivation of the remaining trees for frequent cone crops, are being developed by forest companies and the B.C. Forest Service to deliver seed containing a low, but useful, level of rust resistance until seed orchards are producing. To date, three such areas have been designated, and more are being evaluated.

Forestry Canada, the British Columbia Forest Service and Westar Corp. organized a 3-day symposium on the management of western white pine attended by 119 people from throughout B.C. and bordering U.S. states. A limited supply of the Proceedings is available from R. Hunt.

Forest managers were canvassed for information concerning their sustained planting program when rust-resistant seed is available; the figure of 5.4 million trees per year is much higher than estimated in 1985 (640 thousand trees/year).

Research programme

Two series of plantations were established in 1987-88 using FRDA and B.C. Forest Service funds to test white pine against environmental factors. Nine sites were planted with range-wide population samples within and beyond the species' B.C. range on sites known to be infested with root rots. Our objective is to compare their performance against local species. In the second series, six sites were planted with a more-restricted set of populations, in which family structure was maintained, to test the impact of rust and the environment on their survival and growth. These sites may yield future selections for seed orchards or the breeding population.

A survey of chloroplast DNA variation showed that frequencies of two variants of the chloroplast genome are significantly different in interior versus coastal populations, indicating a difference in coastal and interior pollen clouds. Chloroplast DNA is predominantly paternally inherited in white pine, as in other conifers, though some maternal contribution was detected.

Through a Canada-B.C. Forest Resource Development Agreement contract, a UBC graduate student will investigate the phenology and frost tolerance of range-wide seedling samples in order to estimate limits of seed transfer.

Another aspect of seed transfer - rust variation - is being investigated in co-operation with the U.S. Forest Service. Twelve U.S. seedlots of known rust susceptibility and 12 untested B.C. seedlots have been reared in both B.C. and at Coeur d'Alene, Idaho, then exposed to rusts collected in different locations. Early results indicate high success in inoculating the seedlings. Monitoring will continue for three more years.

DNA variation in the rust is being examined to obtain cloned DNA fragments suitable as markers of rust races. Aeciospore samples have been collected with support from the B.C. Forest Service and industry. DNA has been extracted and cloned fragments are being screened to determine whether they contain sequence variation useful for distinguishing rust races.

Natural inbreeding in the seed crops from a single stand has been investigated for two more seed years. Both stable and unstable "inbreeders" have been found. Measurements on seedlings will be taken this fall to correlate inbreeding estimate to family height, diameter and dry weight.

The possibility that white pine's resistance to Endocronartium harknessii is mediated by differential gene expression is being examined by comparing cDNA libraries produced before and after fungal attack. The same approach will be used to identify genes active in resistance to Cronartium ribicola when sufficient highly resistant seed is available.

The inoculation process followed by rust spores on white pine

Studies of the effects of environmental factors such as light, CO_2 and humidity levels on the germination of basidiospores and subsequent germ tube growth on foliage of intact white pine seedlings continue toward the goal of developing more-reproducible, controlled inoculations in progeny testing.

Protein biochemistry and immunochemistry in the western white pine improvement program

Methods are being developed for the extraction of pine needle proteins in an attempt to identify unique proteins of western white pine which may be associated with rust resistance. Proteins extracted from the needles of four western white pine trees contained an unusually high amount of glycine. Since glycine-rich proteins of some other plant species might be involved in their defense mechanism, the present effort will be concentrated on identifying, isolating and characterizing the glycine-rich proteins of western white pine needles and establishing the role (if any) of these proteins in disease resistance. Studies of variation in protein profiles among white pine provenances are planned.

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CANADIAN PACIFIC FOREST PRODUCTS LIMITED TAHSIS PACIFIC REGION'S TREE IMPROVEMENT PROGRAM AND FOREST GENETICS ACTIVITIES 1987-1989

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Keywords: seed orchards, progeny testing

Canadian Pacific Forest Products Limited has been involved in several tree improvement and research activities in the period covered by this report, including progeny testing, orchard establishment and management, and several support research projects.

PROGENY TESTING

A total of 210 full-sib families are being tested to evaluate the breeding value of both the high- and low-elevation Douglas-fir [Pseudotsuga menziesii (Mirb.) Franco] private breeding populations. A disconnected diallel mating design was adopted with seven diallel units, each with six parents, for each breeding population. The conventional testing program was complemented with early test trials (farm field). Ortets from the three co-operative seed orchards, Douglas-fir, Sitka spruce [Picea sitchensis (Bong.) Carr] and western hemlock [Tsuga heterophylla (Raf.) Sarg.], are being evaluated using open-pollinated tests established at Gold River. The breeding populations of the three co-op orchards are part of the Ministry of Forests' breeding programs.

SEED ORCHARDS

Two new private orchards were established, one western hemlock and one yellow cypress [Chamaecyparis nootkatensis (Don) Spach] (Table 1). The yellow cypress orchard was also duplicated at a high elevation site in Sooke, B.C. The establishment of this orchard with the same material and design will be of great importance to address the early cone maturation phenomenon observed at low elevations. The selection and propagation of a second-generation Douglas-fir private orchard have been completed and site development is in progress. The co-op Douglas-fir orchard has been rogued using the Ministry of Forests progeny test information and presently this is the only 1.5 generation in B.C. In

addition, the private Douglas-fir Nootka seed orchard has been removed and the site is now being managed as an amabilis fir orchard. The seed production, clonal/family representation, area and operational status of these various orchards are listed in Table 1. It is noteworthy to mention that the 1988 private Douglas-fir cone collection and seed extraction were conducted on a clonal and/or family basis.

RESEARCH

The seed orchard research program is advancing and several studies have been completed. These include: the effect of cooling on reproductive phenology (Fashler and El-Kassaby 1987), seed germination (El-Kassaby et al. 1989b) and rate of outcrossing (El-Kassaby and Davidson 1989b); the effect of reproductive phenology on outcrossing rate (El-Kassaby et al. 1988b) and date of cone collection (Edwards and El-Kassaby 1988); genetic variation in fruitfulness in clonal/seedling orchards (El-Kassaby et al. 1989c); parental balance (Reynolds and El-Kassaby 1989); the relation between reproductive phenology and reproductive output (El-Kassaby and Askew 1989); cost of reproduction (Barclay and El-Kassaby 1988; El-Kassaby and Barclay 1989); impact of crop management practices on the genetic quality and seed yield (El-Kassaby and Davidson 1989a; El-Kassaby and Reynolds 1989; El-Kassaby et al. 1989a), the relation between outcrossing and contamination (El-Kassaby et al. 1989d); and the genetic consequences of combining selective cone harvesting with genetic thinning (Lindgren and El-Kassaby 1989).

The temporal and spatial variation of the mating system in a natural stand of white pine was evaluated (El-Kassaby et al. 1987b, unpublished). Quantitative and statistical genetics reesearch addressed the effect of family size and number on the accuracy and precision of the estimates of genetic parameters (El-Kassaby et al. 1987a), use of trend surface analysis in progeny test trials (Thomson and El-Kassaby 1987), multivariate variation of Douglas-fir common gardens (Scagel et al. 1987; Maze et al. 1989) and the relation between family x fertilization interaction in Douglas-fir (van den Driessche and El-Kassaby 1988).

Molecular genetics research aimed at investigating the utility of chloroplast DNA variation as a tool for spruce seedlot identification (El-Kassaby et al. 1988b; Szmidt et al. 1988; Sutton et al. 1989).

During the past two years the senior author was invited to present papers in the Frans Kempa Symposium on Molecular Genetics of Forest Trees, Umea, Sweden (El-Kassaby et al. 1988b), the IUFRO International Workshop of Plant Biology on Biochemical Markers in the Population Genetics of Forest Trees, Orvieto, Italy (El-Kassaby 1988), and the 20th Southern Forest Tree Improvement Conference, Charleston, South Carolina (El-Kassaby 1989).

The Saanich Forestry Centre has continued to provide facilities to university students and professors (U.B.C. and U.Vic.), B.C. Ministry of Forests researchers, Forestry Canada scientists, and B.C. Research. Recently, a new seed/seedling laboratory has been established to provide lab services for the expanding tree improvement and nursery programs.

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Table 1. Seed Orchards Information List

Orchard Complex	Status	Type	Species	Area (ha)	# Clones/ Families	Estab. Date	Seed Production 1987	Seed Production 1988
Saanichton	Private	C/S	Douglas-fir	3.40	80	1965/69	32.45	11.76
	private	C/S	Douglas-fir	1.30	71	1965/69	3.94	8.91
	Private	S	Douglas-fir	6.00	112	1973	73.48	53.17
	Private	S	Yellow cypress	0.14	8	1974/75	-	-
	Private	C	Yellow cypress	0.17	20	1989	-	-
	Private	C	Western hemlock	1.00	40	1989	-	-
Nootka	Co-op	C/S	Douglas-fir	3.04	120	1970	-	26.12
	Co-op	C	Sitka spruce	1.29	138	1971	2.06	17.95
	Co-op	C	Western hemlock	0.81	84	1977	2.52	0.22
	Private	C	Amabilis fir	1.50	83	1977	-	-
	Private	C	Sitka spruce	0.23	50	1971	0.17	1.64

a C = clonal; S = seedling; C/S = clonal/seedling
b Experimental seed production area
c B.C. Ministry of Forests and Industry Tree Improvement Co-operative Program
d Cone crop was aborted.
e This orchard was under-planted in a private Douglas-fir orchard that was removed in 1988. The Douglas-fir orchard produced 1.6 and 11.8 Kg of seeds in 1987 and 1988, respectively.

MACMILLAN BLOEDEL LIMITED PROGRESS REPORT 1988-1989

B.G. Dunsworth

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Keywords: Seed Orchards, Cone Induction, Progeny Testing.

MacMillan Bloedel Limited (MB) has been involved in several tree improvement/forest genetics activities during the period covered by this report. These activities included seed orchard management, cone induction research, and progeny testing.

Personnel changes occurred during 1988/89 with R.C. Bower moving to a forest genetics position with MB Inc. (Alabama). B.D. (Glen) Dunsworth is now the coastal geneticist and Diane Nicholls is the new seed orchard supervisor.

SEED ORCHARDS

MacMillan Bloedel Limited is a member of the Coastal Tree Improvement Cooperative (CTIC) and is managing five clonal seed orchards:

- western hemlock (Tsuga heterophylla (Raf.) Sarg.)
- Pacific silver fir (Abies amabilis (Dougl.) Forbes)
- western red cedar (Thuja plicata Donn)
- yellow cypress (Chamaecyparis nootkatensis (D. Don) Spach)
- Sitka spruce (Picea sitchensis (Bong.) Carr.)

We are currently conducting two operational trials: one in western hemlock containerized seed orchards (soil based, container comparison); the other in the cost effectiveness of controlled pollination for operational seed production.

Our six, private Douglas-fir seed orchards are 10 years old and produced the first operational crop of approximately 100 kg in 1987. This is about a three year supply of seed, based on current planting needs on our private land.

During 1987-88 Dr. R.C. Bower was moved to our Alabama operation as forest geneticist. Shortly after that, Phyllis Harvey, our seed orchard supervisor, also left. Glen Dunsworth has taken Dr. Bower's coastal breeding responsibilities, and Ms. Harvey has been replaced by Diane Nicholls.

RESEARCH

Upon completion of the projects listed below, the research component of the tree improvement programme will be brought to a close. Future research efforts will be directed at improvements in operational efficiency and maximization of genetic quality.

Cone Induction

These projects have been done in conjunction with Dr. S. Ross and Dr. J. Webber with the B.C. Ministry of Forests, Research Branch:

- **Objective: to determine if the dormancy phase for reproductive development in yellow cypress requires a specific chilling period.** Pollen viability tests indicate chilling reduces pollen germination. Cones will be collected and tested in 1989. Results will be used to assess the need for chilling in an operational setting.

- **Objective: to compare the effectiveness of biennial retreatment of girdling plus GA 4/7 versus a first-time treatment and to assess treatment effects on cone and seed efficiency.** Cones have been collected. Treatment differences in yield and viability will be assessed in 1989. Economic benefits will be assessed and optimum treatments selected for operational use.

Progeny Testing

These projects have been conducted with the assistance of Dr. A. Yanchuck, Chris Heaman and Jack Woods of the B.C. Ministry of Forests, Research Branch:

- **Objective: to provide the genetic information required to rogue inferior clones from MB's Douglas-fir seed orchards.** 253 families have been planted and first season spring and fall measurements completed. Five-year results will be used to remove inferior parents from the first generation Douglas-fir seed orchard.

- **Objective: to provide good estimates of GCA and other genetic components to rogue inferior clones from western hemlock CTIC orchard #32.** Seventy polymix crosses were completed. Progeny from these crosses will be included in the B.C. Ministry of Forest's progeny test programme. Results of the progeny test will be used to remove inferior parents from the first generation western hemlock seed orchard, and to select superior parents for the second generation orchard establishment.

FOREST GENETICS ACTIVITIES AT THE UNIVERSITY OF BRITISH COLUMBIA, 1987-1989

Jack Maze
Department of Botany

Oscar Sziklai, Donald T. Lester, Judy A. Loo-Dinkins, and John Carlson, Faculty of Forestry

University of British Columbia
Vancouver, B.C. V6T 2B1

Keywords: Douglas-fir, teaching, lodgepole pine, variation, wood quality, provenance, stress tolerance, wide crossing, neighborhood environmental effects, genotype by environment interaction, forest biotechnology, genome mapping, genetic engineering

JACK MAZE

Variation in Growth in Conifers

S. Banerjee is completing his M.Sc. thesis in the Department of Botany on the variation in open-pollinated families of yellow cedar (Chamaecyparis nootkatensis,(D. Don) Spach). He is analyzing needle morphology of parents and offspring as well as development (mainstem growth and number of needle whorls produced) in the offspring. All data are being related to site of origin of the parent trees (swamp or midslope), trees within sites, and position within the crown of the tree (top, middle, or bottom third). The factors which have the greatest impact on the data are within and among thirds of the crowns on individual trees. The developmental variables respond differently over time likely due to different events associated with mainstem growth (cell elongation) and needle production (cell division).

Three studies on variation in growth within and among full-sib families of Douglas fir (Pseudotsuga manses (Mirb.) Franco) growing in common gardens have been published (Banerjee and Maze 1988; Maze and Banerjee 1989; Maze et al. 1989); most of that variation is within families. As well, the variation within full-sib families equals that within a heterogeneous seedlot growing in the same site. A comparison of mainstem growth from 1987 and 1988 for the same families shows that both individual trees and families responded differently in successive years. Data gathered in 1989 will allow us to determine if this response is due to nursery effect or planting shock expressed in 1987.

A multivariate analytical study of needle growth, based on measurements of sectioned apical buds of lateral branches, on some of these same full-sib families has been started. Preliminary analyses indicate the high within full-sib family variation is expressed as covariances as well as means and variances.

OSCAR SZIKLAI

Since this is my last active member's report, I intend to summarize the forest genetics activities from the programme's inception, including my 33 years involvement.

Teaching

Undergraduate: Since 1949, when U.B.C. introduced a required genetics course into the undergraduate forestry curriculum, approximately 1000 students have been exposed to the principles of genetics. The course has been offered every year. The maximum number of students was 36 in 1967/68 and the minimum was 5 in 1986/87. Presently - 40 years later - 12 students are taking the course, 2 of them from the Faculty of Science.

Graduate: The first advanced degree (Ph.D.) in forest genetics was awarded to Orr-Ewing in 1956. Since that time, 29 graduate degrees have been conferred; 15 M.F., 5 M.Sc. and 9 Ph.D. Twenty-three of these were under my supervision.

Research

Earlier in Hungary, I concentrated on selection of Salix clones for willow baskets and energy; later in Canada, Douglas-fir and lodgepole pine (Pinus contorta Dougl.) selection and breeding were my main interests.

Although 32 years ago, we had Drs. Orr-Ewing and Allen's 5 selected Douglas-fir trees, Dr. Haddock's provenance trials and Dr. Griffiths' 154 Douglas-fir trees at the U.B.C. Research forest, no progenies were available for variation and heritability studies. Complete diallel crosses of 4 Douglas-fir trees provided the first seed crop in 1960, but the first growth chamber studies did not begin until 1964. Progeny tests were established from these crosses at the U.B.C. Research Forest, and on Campus in 1966, and now we have the F_2 seed in our hands. This pedigreed material is already incorporated into Dr. Carlson's programme at the recently established U.B.C. Biotechnology Laboratory.

Cooperation with IUFRO, Section 22 (now 02), provided us with a collection of Douglas-fir cones from 1818 trees across its natural range. An international provenance-progeny test was established in 22 countries, part of it at the U.B.C. Research forest. It is now entering the 19th growing season and has provided research material for 4 masters and three bachelors theses. Cone, seed characteristics and DNA content of the IUFRO Douglas-fir collection reveals wide variation within provenances. Using these as benchmarks, we have been able to identify the probable origin of stands growing in Poland and Switzerland. The provenance - progeny test is now providing survival and growth data which is being collated and analysed in France. The early results were discussed at the Working Party meeting in Vancouver (1978), in Vienna (1985), and will be on the agenda in Tacoma (1990). Our role in this working party is

substantial, particularly since the 1985 meeting, when it was decided that further seed collections from the Pacific North West would be from individual trees, based on U.B.C. and French findings.

The increased interest in lodgepole pine by the Swedish SCA and Stora Kopperberg companies commenced in 1964. With our help, 225 plus trees were selected for the two companies. Twenty-one years later, in 1985, a cooperative progeny test was established from the first crop obtained in the Swedish seed orchard on 5 test sites in Canada and 3 sites in Sweden.

Contact in China, besides teaching and advising on breeding of (Paulownia and the 3 North East conifers, has given me the opportunity to obtain seed from 5 of the 6 Asian Pseudotsuga species.

Earlier studies on DNA content, cone and seed morphology, isozymes and cytogenetics gave us results to be presented at local, national and international meetings. A total of 32 papers have appeared in refereed journals, 32 in conference proceedings, and 38 in report form. Also one book on forest genetics was published with my colleague in Budapest (1981).

DONALD T. LESTER

Program emphasis currently is on inheritance of wood quality traits, geographic variation in growth and physiological traits in lesser-known species, and wide crossing in spruce.

Wood Quality

Interest in wood quality has been stimulated, in part, by provincial workshops at which a variety of wood quality traits were evaluated for inclusion in tree breeding programs. For some traits, additional study is needed on the amount of genetic variation available for selection and on efficient ways to measure variation. For other traits such as relative density, in-depth study of trait components may provide a better understanding of genetic variation.

Ms. Donna Robertson is completing an M.Sc. study of the impact of cone production on wood quality of lodgepole pine in a clonal seed orchard. Data on growth and some wood quality traits of progeny from the orchard clones are being used to estimate parent-progeny regression. Mr. Mathew Koshy has initiated work toward the Ph.D. using control-pollinated progenies of Douglas-fir to estimate genetic effects for shrinkage, fibril angle, spiral grain and warp. X-ray densitometric data are being used to study clonal parent and progeny variation in annual ring components for parental clones and progenies of interior spruce (Picea glauca (Moench) Voss and (Picea engelmannii Parry).

Provenance and Family Variation

Ms. Marilyn Cherry is completing an M.Sc. study of provenance and progeny variation in yellow cypress using traits of seedling growth pattern, size and cold tolerance. Mr. John Russell has begun a Ph.D. project on yellow cypress with a much larger sample of the species range and with emphasis on variation in drought and cold tolerance. Ms. Barbara Thomas is testing coastal and inland provenances and progenies of western white pine (Pinus monticola Dougl.) for genetic differences in acclimation to cold.

Exploratory Crossing in Spruce

Mr. David Kolotelo is working on an M.Sc. study of crosses among several parents each from two coastal spruce (Picea sitchensis (Bong.) Carr) populations and two interior spruce populations. Phenological traits, size and acclimation to cold are the traits of interest.

Decision Analysis in Seed Transfer of Sitka Spruce

A decision framework is being developed to estimate the benefits (from increased volume growth) and risks (from injury during unseasonable cold) from northward transfer of seed.

JUDY LOO-DINKINS

Research during the past two years includes examining Douglas-fir provenances to determine whether a nonlocal source continues to out-perform local ones; attempting to improve the quality of data from variable progeny test sites; using a genetic correlation approach to examine genotype by environment interaction; and examining genetic control of relative density profiles below breast height in Douglas-fir.

Douglas-Fir Provenances

Incremental and cumulative volume from ages 7 to 16 years and relative density at age 16 were examined for 5 standard and 1 local provenances at each of 3 B.C. Ministry of Forests test sites in cooperation with C. Ying and E. Hamm. A provenance from Hoh, Washington has continued to grow more rapidly than the other provenances. There is a negative correlation between relative density and volume, however. This could potentially decrease the advantage of the Washington provenance if strength becomes an important issue in value of coastal Douglas-fir.

Separation of Genetic from Environmental Effects

Volume of data from 10 coastal Douglas-fir progeny tests in the B.C. Ministry of Forests breeding program were adjusted to reduce the effect of microsite variability within sites (neighborhood effects), in collaboration with Jack Woods of the Ministry of Forests. Data for each tree were adjusted by subtracting the mean value of surrounding trees. The procedure was evaluated using a simulation model and the difference in selection accuracy after adjustment was estimated. Simulation model results indicate that accuracy could be improved at 7 of the 10 sites, and genetic gain would be increased by 2-3% if adjusted data were used for selection at those sites.

The 10 progeny test plantations used in the above study were also examined for the presence and relative importance of genotype by environment interaction. The genetic correlation approach was used whereby a genotype by environment interaction is assumed when the genetic correlation between family means for a single trait at two sites is less than 1.0. The importance of the interaction was assessed using indirect selection theory, by estimating the efficiency of selecting in one plantation for planting at a secondary site, relative to that of selecting at a plantation representative of the site to be planted. Results indicated a broad range in relative efficiencies among pairs of sites. Average efficiencies for test sites ranged from 46 to 92% suggesting that if care is taken in choosing a plantation with high average efficiency of selection over all sites, genotype by environment interaction may not be a serious problem. The work was done by graduate student, Dave Kolotelo.

Genetic Control of Relative Density Profile

Relative density of Douglas-fir wood is difficult to assess in young progeny tests. Wood samples have traditionally been taken at breast height but two or three additional growth rings could be sampled if cores were taken as close as possible to the ground. A study is in progress in collaboration with Josefina Gonzalez of Forintek Canada Corp. to determine whether the genetic control of relative density at a given number of rings from the pith is the same close to the ground (40 cm) as at breast height.

JOHN CARLSON

The focus of my research is on the application of molecular genetics and plant biotechnology to forestry, particularly in the areas of tree improvement and developmental gene expression. The following projects were recently initiated:

Genome Mapping

Classification of genotypes, determination of genetic variability, and establishing inheritance of genetic traits, including quantitative trait loci, by genomic DNA cloning, RFLP (Restriction Fragment Length Polymorphism) analysis of nuclear and organelle DNAs, and

molecular cytogenetics. (students: Jeff Glaubitz - Western red cedar (Thuja plicata Donn); Kowit Chaisurisri and Bundit Ponoy - Douglas-fir; Prachote Soonhuae - Thailand rose wood (Dalbergiaa cochinchinensis).

Somatic Embryogenesis

Inducing embryo formation in vitro for specific genotypes of Douglas-fir. We are currently focusing on haploid systems. (student: Liwen Jiang).

Genetic Engineering

Evaluating techniques for efficient gene transfer with protoplasts and tissue explants of several conifer species. The goal is enhancement of genetic stocks of forest species by delivering "foreign" genes encoding valuable traits, including genes for growth enhancement. (Research assistant - Victor Luk).

Gene Expression

Characterization of genes differentially expressed during seedling development, in response of seedlings to stress and/or transition from juvenility to maturity. (student: Cherng-Hsi Ling; Research assistant - Victor Luk; Postdoctoral Research Associate - to be named).

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RESEARCH AT FORINTEK CANADA CORP. RELATING TO TREE IMPROVEMENT

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Keywords: wood quality, relative density, early prediction, heritability, genetic improvement, juvenile-mature transition, end-product value.

Forintek's Wood Science Department has oriented its effort toward bridging the gap between the forest resource and tomorrow's wood products industry. Evidence of our emphasis in this direction is the contribution that we made to the establishment of the Wood Quality Working Group within CTIA at the 1985 meeting in Quebec. In the meantime, we contributed to the programme at Truro (1987) with several papers on wood quality and have increased our membership in CTIA from two to four persons. During the last two years, we have continued to work on matters relating to tree improvement and a summary of the results of some of our studies is presented in the following report.

Technical Support to the B.C. Tree Improvement Council

(1) Wood density analysis was carried out for 123 lodgepole pine parent trees. The average, extractive-free relative density of the inner half samples was 0.385 ñ 8.0%. Corresponding values for the outer half samples were 0.420 ñ 7.3%. Selection to achieve genetic gain in this trait can be justified mainly on the basis of its high heritability. The lower relative density of the inner half portion of the discs reflects the lower density of juvenile wood in lodgepole pine.

(2) Preliminary observations were made on the pith-to-bark wood density profiles in western larch. Density rose rapidly from about 0.40 at the pith to about 0.47 in mature outer wood. The transition appeared to take place at the relatively young age of 10-15 yrs.

(3) Wood density studies on ramets of 12 lodgepole pine clones showed good agreement between the clonal and parent tree rankings.

Wood Density Survey of Important Canadian Species

Financial support was obtained through the ENFOR program to bring together all available information on wood density of Canadian species. A final report on this project will be prepared during the current year.

Commercialization of the Forintek Wood Density Tester

A fully operative prototype field wood density tester has been constructed and tested at the Vancouver laboratory. A set of working drawings is being prepared so that interested users can make their own arrangements for fabrication. An agreement has recently been made with the B.C. Ministry of Forests to have a density tester built for them and evaluated in field trials.

Relative Density Profile Below Breast Height in Young, Vigourous Coastal Douglas-fir Trees

Investigations are underway to determine whether wood density determinations near the base of the stem correlate well with breast-height data and therefore provide a means of evaluating density for progeny selections at a somewhat earlier age. Previous experience has indicated that about 12 to 15 years of growth at breast height are required for reliable ranking of wood density. It would be helpful to tree breeders if this could be reduced by a few years simply by sampling at a lower level in the stem.

Jack Pine Heritability Studies

This project was initiated in 1988 in collaboration with the tree breeding project at the Petawawa National Forestry Institute to study the variability of specific tree and wood quality characteristics and to evaluate the heritability of selected traits in an established experiment involving 100 half-sib families of Ottawa Valley jack pine. Fifty-five families were sampled in one plantation in 1988 and ten of these families were sampled in each of two other plantations in 1989. Information being gathered includes height, diameter, stem form (taper), percent heartwood, wood density, compression wood, extractives content and longitudinal shrinkage.

Financial Evaluation of Selection Strategies

This is a joint study between Forintek and the B.C. Ministry of Forests being carried out by Dr. P.A. Jefferson. The work is being guided by Dr. R.M. Kellogg and Dr. D.T. Lester. Dr. A. Yanchuk is responsible for the project at the Ministry of Forests. The objective of the project is to determine the effects of genetic selection for trees and wood quality traits on end-product value by using a system of models (SYLVER), developed from the Douglas-fir Task Force.

SYLVER runs at planting densities of 400, 750 and 1100 trees per hectare were used to evaluate genetic improvements in terms of end-product value. The effects of genetic improvement were simulated by reducing transition age at breast height by five and ten percent. Simulated stands were harvested at 60 years. Planting density shows a significant effect on economic value and return on investments. Tree size is a significant factor in harvesting and manufacturing costs. The effect of change in the juvenile wood core brought about by changing planting densities is confounded with tree size. Separate economic values for the two effects cannot be determined. Predicted lumber value increases due to genetic selection are greater for the higher stocking densities.

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M. Leitch	Phytohormone effects on tracheid parameters during tracheid differentiation
M.D. Meagher	Temporal variation in natural inbreeding in a western white pine population
C. Nielsen	Developing techniques for an operational accelerated breeding program
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O.P. Rajora	Growth characteristics and Melampsora rust resistance of intraspecific and interspecific full-sib families of poplars, and relationship with allozyme heterozygosity
O.M. Rajora	Allozymic, molecular, reproductive, and morphological relationships of Populus deltoides, P. nigra, and P. maximowiczii
F. Schnekenburger	Flower induction in white pine and white spruce
B. Sutton	Use of DNA probes for the analysis of hybrid mixed seedlots of spruce
B. Sutton	Prospects for operational use of somatic embryogenesis
B.S.P. Wang	Accelerated aging is effective to predict seed storage potential
P. Knowles	Genetic traits of damaged and healthy sugar maple and aspen
J. Schilf	Early flowering and seed production in a lodgepole pine seedling seed orchard in central Alberta
D.L. Rogers	Ontario's black spruce clonal forestry program
J. King	Forty years of tree improvement in New Zealand radiata pine - developments to a third generation of selection
J. King	Production population gains in New Zealand radiata pine - new orchard developments and clonal forestry options

J. Woods	The mating design for advanced generation breeding of coastal Douglas-fir
M. Stoehr	Induction of haploids in Populus maximowiczii by anther culture
A.E. Raj R.H. Ho W. Gibbs A. Baird	In vitro studies on adventitious shoot formation from embryonic shoots of black spruce
R. Smith R. LeBlanc K. Tosh	Operational cone induction trials in black spruce seedling seed orchards
A.M. Nanka J.I. Klein	Mass selection seed orchards for northern Manitoba
A. van Niejenhuis W.H. Parker	Phenological and height growth variation in jack pine from the north central region of Ontario
B.S.P. Wang J.A. Pitel J.M. Schilf	Accelerated aging is effective in predicting seed storage potential
J.M. Schilf N.K. Dhir	Early flowering and seed production of a lodgepole pine seedling seed orchard in central Alberta

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