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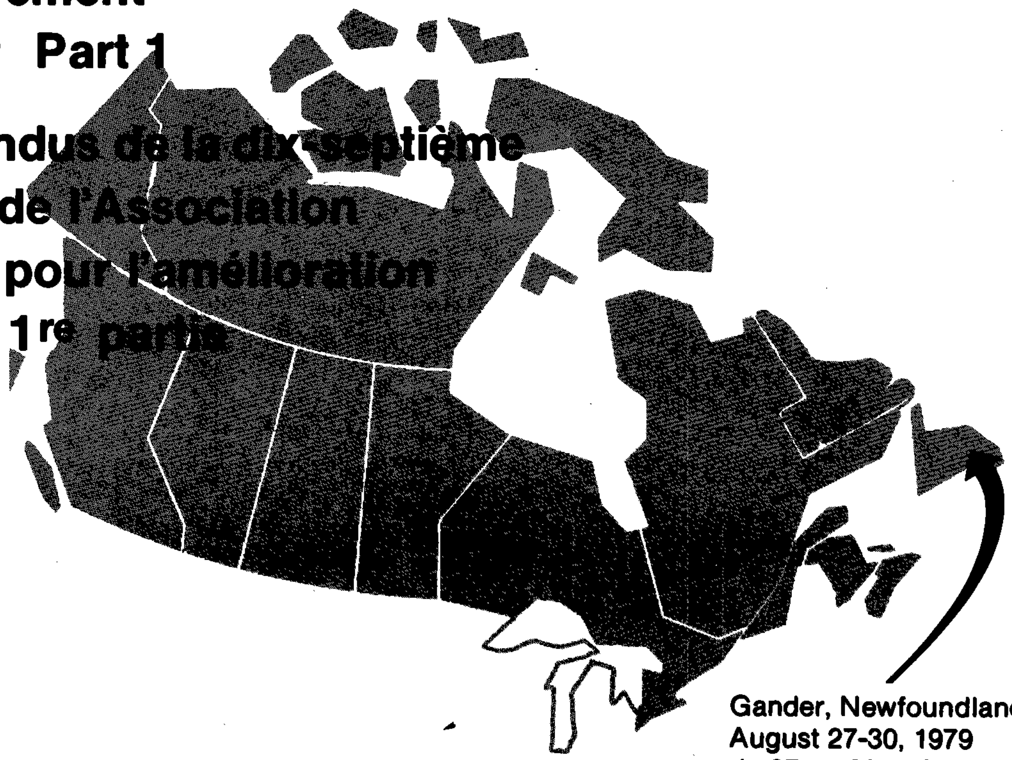
Proceedings of the seventeenth meeting of the Canadian Tree Improvement Association: Part 1

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



Gander, Newfoundland
August 27-30, 1979
du 27 au 30 août 1979

Minutes and members' reports

Procès-verbaux et rapports

PROCEEDINGS

OF THE

SEVENTEENTH MEETING

OF THE

CANADIAN TREE IMPROVEMENT ASSOCIATION

PART 1:

MINUTES AND MEMBERS' REPORTS

HELD IN
GANDER, NEWFOUNDLAND
AUGUST 27-30, 1979

EDITOR: C.W. YEATMAN

Part 1. Minutes and Members' Reports.

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

Part 2. Symposium: Tree Improvement in the Boreal Forest: Today and Tomorrow

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

Produced by
Canadian Forestry Service,
Environment Canada,
for the
Canadian Tree Improvement Association,
Ottawa, 1980

COMPTES RENDUS

DE LA

DIX-SEPTIÈME CONFÉRENCE

DE

L'ASSOCIATION CANADIENNE POUR L'AMÉLIORATION DES ARBRES

1RE PARTIE:

PROCÈS-VERBAUX ET RAPPORTS DES MEMBRES

TENUE À
GANDER TERRE-NEUVE
DU 27 AU 30 AOÛT 1979

RÉDACTEUR. C.W. YEATMAN

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

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

2e partie. Symposium: l'amélioration des arbres de la forêt boréale: aujourd'hui et demain.

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

Publié par
le Service canadien des forêts
Environnement Canada,
pour
l'Association canadienne pour l'amélioration des arbres,
Ottawa, 1980

PROCEEDINGS OF THE SEVENTEENTH MEETING OF

THE CANADIAN TREE IMPROVEMENT ASSOCIATION

With the compliments of the Association

Enquiries may be addressed to the authors or to Dr. N.K. Dhir, Executive Secretary, C.T.I.A./A.C.A.A.

The Eighteenth Meeting of the Association will be held in Victoria, British Columbia, August 18-21, 1981. The agenda for the meeting includes: Day 1, "Provincial Roundup" - a synopsis of progress among all active agencies in each province and field excursion to two seed orchards; Day 2, Panel Discussion and excursion to Cowichan Lake Experiment Station; Day 3, C.T.I.A. Symposium on Seed Orchards. Canadian and foreign visitors are welcome. Further information will be distributed in fall, 1980, to all members and to others on request. Enquiries regarding the Eighteenth Meeting should be addressed to Dr. D.F.W. Pollard (Vice-Chairman, Symposium), Pacific Forest Research Centre, 506 West Burnside Road, Victoria, B.C. or to Mr. M. Crown (Vice-Chairman, Local Arrangements), B.C. Forest Service, Box 816, Duncan, B.C.

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TO : Dr. N.K. Dhir, Executive Secretary
Canadian Tree Improvement Association
Alberta Forest Service
Energy and Natural Resources
Petroleum Plaza
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COMPTES RENDUS DE LA DIX-SEPTIÈME CONFERENCE DE L'ASSOCIATION

CANADIENNE POUR L'AMELIORATION DES ARBRES

Gracieusete de l'Association

Les demandes de renseignements peuvent être adressées aux auteurs ou à Dr. N.K. Dhir, secrétaire exécutif, A.C.A.A./C.T.I.A.

La dix-huitième conference de l'Association aura lieu à Victoria, C.-B. du 18 au 21 août 1981. L'ordre du jour de la réunion comprend: Jour 1, "Rassamblements provinciaus" - un synopsis des progrès au sein de tous les organismes actifs dans chaque province et une excursion sur le terrain de deux vergers à graines; Jour 2, Discussion le groupe et excursion à la Station d'experimentation de Cowichan Lake; Jour 3, Symposium de l'A.C.A.A. sur les vergers à graines. Les visiteurs canadiens etautres sont les bienvenus. De plus amples renseignments seront communiqués à l'automne 1980, à tous nos membres et aux autres sur demande. Les demandes concernant la dix-huitième réunion devront être adressées à Dr. D.F.W. Pollard (vice-président du symposium) Centre de recherches forestières du Pacifique, 506 West Burnside Road, Victoria, C.-B. ou à M. M. Crown (vice-président arrangements locaux), B.C. Forest Service, Box 816, Duncan, C.-B.

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Les autres qui seraient intéressés à recevoir les comptes rendus, les avis de réunions, etc., peuvent retourner leur formule pour être reçus membres correspondants (Canadiens) ou être placés sur la liste postale pour les comptes rendus seulement (bibliothèques, institutions, destinataires étrangers).

À : Dr. N.K. Dhir, secrétaire exécutif
Association canadienne pour l'amélioration des arbres
Alberta Forest Service
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Petroleum Plaza
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Edmonton, Alberta, T5K 2C9

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Signé ....

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ACTIVE MEMBERS

1979

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Dr. Cheng Ying	Research Division B.C. Forest Service 516 Government Street Victoria, British Columbia, V8V 1X5
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Dr. L. Zsuffa	Forest Research Centre Ontario Ministry of Natural Resources Southern Research Station Maple, Ontario, LOJ 1EO

BUSINESS MEETING - MINUTES

M.F. Squires chaired the 17th Business Meeting of the C.T.I.A. which was called to order at 8:00 p.m. August 28, 1979.

198. MINUTES OF THE LAST MEETING

Motion: That the minutes of the 16th meeting be adopted as published Moved by J.P. Hall, seconded by C.W. Yeatman. Carried.

199. MEMBERSHIP

The name of prospective members and those changing status was presented as follows:

a) New Members

1) Sponsoring

Mr. W.D. Brown	Chief Forester New Brunswick C.I.P. Co. Dalhousie, N.B.
Mr. B. Devitt	Chief Forester Pacific Logging Ltd. Victoria, B.C.
Mr. F.W. Flavelle	Dept. of Tourism and Renewable Resources Prince Albert, Saskatchewan
Mr. R.J. Pearson	Chief Forester North Canadian Forest Industries Grande Prairie, Alberta
Mr. J.D. Smith	Senior Director Dept. of Lands and Forests Nova Scotia
Mr. M. Summers	Resource Development Manager Simpson Timber Company Whitecourt, Alberta

2) Active

Mr. B.P. Adams	North Canadian Forest Industries Grande Prairie, Alberta
Dr. R.C. Bower	McMillan Bloedel Ltd. Nanaimo, B.C.
Mr. F.W. Daniels	Simpson Timber Co. Whitecourt, Alberta
Mr. B.D. Haddon	Canadian Forestry Service Chalk River, Ontario
Mr. R.E. Holmes	Procter & Gamble Cellulose Grande Prairie, Alberta

Mr. T.M. McDonough	Department of Forestry & Agriculture Grand Falls, Newfoundland
Mr. R.J. Orynik	Prince Albert Pulpwood Co. Prince Albert, Saskatchewan
Dr. Y.S. Park	Canadian Forestry Service Fredericton, N.B.
Mr. J. Schilf	Alberta Forest Service Edmonton, Alberta
Mr. R.F. Smith	Canadian Forestry Service Fredericton, N.B.
Mr. J. Thompson	Department of Renewable Resources Prince Albert, Saskatchewan
Mr. W. vanBorrendam	Alberta Forest Service Edmonton, Alberta
Dr. J.E. Webber	Ministry of Forests Victoria, B.C.
Mr. D.A. Winston	Canadian Forestry Service Chalk River, Ontario
Mr. D. Young	Procter & Gamble Cellulose Grand Prairie, Alberta

3) Corresponding

Mr. R.F. Ackerman	Petawawa National Forestry Institute Chalk River, Ontario
Mr. K.A. Armson	Ministry of Natural Resources Toronto, Ontario
Mr. D.N. Bacala	Department of Renewable Resources Winnipeg, Manitoba
Mr. J.E. Barker	Lakehead University Thunder Bay, Ontario
Mr. T.J. Beechey	Ministry of Natural Resources Toronto, Ontario
Mr. R.D. Bettle	Department of Natural Resources Fredericton, N.B.
Mr. H. Bitto	International Canadian Paper Co. Greenville, Quebec
Mr. J.D. Bourque	Fraser Company Ltd. Edmunston, N.B.
Mr. P.I. Bourque	Botanical Garden Montreal, Quebec
Ms. J. Brown	Royal Botanical Garden Hamilton, Ontario
Dr. D. Burger	Ontario Forest Research Centre Maple, Ontario
Mr. E.C. Burton	Price Pulp and Paper Ltd. Grand Falls, Newfoundland
Mr. J.M. Butler	Department of Forestry & Agriculture St. Johns, Newfoundland
Dr. L.W. Carlson	Canadian Forestry Service Ottawa, Ontario

Mr. B.M. Carter	Department of Lands and Forests Baddeck, Nova Scotia
Mr. D. D'Amico	Simpson Timber Company Whitecourt, Alberta
Dr. R.C. Dobbs	Canadian Forestry Service Ottawa, Ontario
Dr. Janet Dugle	Atomic Energy of Canada Pinawa, Manitoba
Mr. G. Dunsworth	McMillan Bloedel Ltd. Nanaimo, B.C.
Mr. P.G. Etheridge	J.D. Irving Company St. John, New Brunswick
Mr. P. Flinn	Alberta Forest Service Edmonton, Alberta
Dr. A. Fortin	Laval University Quebec, P.Q.
Mr. B.W. Fraser	Georgia Pacific Co. St. Croix, New Brunswick
Dr. R. Green	Canadian Forestry Service Sault Ste. Marie, Ontario
M. L. Grenier	Assoc. Forestiere Quebecoise Quebec, P.Q.
Mr. P. Higgins	Price Newfoundland Pulp & Paper Co. Grand Falls, Newfoundland
Prof. Lakshminarayan	University of Moncton Moncton, New Brunswick
Mr. P.E. Langille	Bowater Mersey Paper Co. Liverpool, N.S.
Mr. R.B. Latimer	Ministry of Natural Resources Angus, Ontario
Prof. P. Maltais	University of Moncton Moncton, New Brunswick
Mr. L. May	Canadian Forestry Service St. John's, Newfoundland
Mr. P.A. McKinley	Fraser Company Edmunston, New Brunswick
Mr. K.M. Murray	Acadia Forest Products Nelson-Miramichi, New Brunswick
Dr. R.M. Newnham	Director Petawawa National Forestry Institute Chalk River, Ontario
Dr. G. Paillé	Canadian International Paper Co. Montreal, P.Q.
Mr. D. Rannard	Department of Renewable Resources Winnipeg, Manitoba
Mr. W.E. Raitanen	Ministry of Natural Resources Brockville, Ontario
Dr. C.L. Scheuplein	Ministry of Forests Victoria, B.C.
Dr. J. Soos	Alberta Forest Service Edmonton, Alberta

Mr. D. Thibault	Atomic Energy of Canada Pinawa, Manitoba
Mr. C. Turmel	E.B. Eddy Forest Products Hull, P.Q.
Mr. G.P. Vandusen	Bowater Newfoundland Ltd. Corner Brook, Newfoundland
Dr. G. Weetman	University of British Columbia Vancouver, B.C.

b) Retiring Active Members

Dr. W. Cram
Mr. W.G. Dyer
Mr. C.H. Lindquist

c) Change of status from active to corresponding

Dr. J.W. Andresen
Mr. R.K. Vincent

Motion: That the prospective sponsoring, active and corresponding members (as listed) be duly elected.

Moved by J.I. Klein, seconded by F. Yeh. Carried.

Obituary

The early death of Dr. D.B. Mullick was noted with regret. Dr. Mullick was an active member of the Association and was well known for his work on host-pathogen relationships.

Honourary Membership

Dr. A. Orr-Ewing, who recently retired from active memberhips, was sponsored for honourary membership. A letter of recommendation describing Dr. Orr-Ewing's professional accomplishments and outstanding contributions to forest genetics and tree breeding in Canada was read and accepted.

Motion: That Dr. A. Orr-Ewing be elected to honourary membership.

Moved by J.C. Heaman (in absentia), seconded by D.P. Fowler. Carried.

200. FINANCIAL STATEMENT

C.W. Yeatman informed that the Association's saving account (maintained at the Bank of Montreal, Deep River Branch, Deep River, Ontario) showed a balance of $188.36 as of August 28, 1979. Money from this account is used for incidental expenses, such as stationery, printing, etc. M.A.K. Khalil informed that several sponsoring organizations kindly contributed money to pay for for travelling expenses of invited symposium speakers. Contributions were received as follows: Government of Newfoundland ($2600.00), Environment Canada ($2000), Price (Newfoundland) Pulp & Paper, Ltd. ($600.00), Bowater Newfoundland Ltd. ($600.00).

Motion: That the chairman of CTIA write to contributing sponsors expressing the Association's appreciation for the financial support.

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

201. BUSINESS ARISING FROM PREVIOUS MEETINGS

a) ADDRESS LABELS

C.W. Yeatman explained that mailing labels could be printed from the Association's computer listing of members and addressees but it would require special funding for them to be generally available on request. The demand by members for this service apparently is very limited. The Association publishes its mailing list reqularly and an address label service was not needed. This explanation was accepted by the meeting assembly, and no further action on this subject is required.

b) LETTERHEAD

The chairman informed that a new letterhead has been printed and was being used for Association's correspondence.

c) FOREST GENETICS SCHOLARSHIP FUND

The chairman called to attention the motion passed by the 16th business meeting to pursue the possibility of establishing a scholarship fund for university education in forest genetics. He informed that as a follow-up to this motion the Chief Executive Officers of the member Companies of the CPPA (Canadian Pulp and Paper Association) were approached for possible contributions to such a fund. Several Companies gave encouraging responses and requested further details. A Committee was appointed to draw up the terms of reference for the proposed scholarship fund, which it was suggested be co-sponsored and administered by the CPPA. The Committee consisted of:

Dr. C.W. Yeatman	Canadian Tree Improvement Association
Dr. H.S.D. Swan	Canadian Pulp and Paper Association
Dr. A. Fortin	Association of University Forestry Schools of Canada

The terms of reference were drawn up by the Committee at a meeting in Montreal. The Canadian Pulp and Paper Association and the Canadian Forestry Association were then approached in turn to determine their interest in joining with the C.T.I.A. to operate the fund. The response from both Associations to this request was negative.

Motion: Be it resolved that:

1. The Canadian Tree Improvement Association endorses the proposed terms of reference for a Canadian Cooperative Scholarship Fund in Forest Genetics;

2. A standing Committee on Forest Genetics Education be established to consist of at least three Association members.

3. The committee be instructed (a) to complete, if possible, an agreement on terms of reference with appropriate co-sponsors, for ratification by the Association's executive and, subsequently, (b) to solicit contributions for the Scholarship Fund in accordance with the accepted terms of reference.

Moved by C.W. Yeatman, seconded by H.S.D. Swan. Carried.

Motion: that the members of the Genetics Scholarship subcommittee, that is, Dr. Fortin, Dr. Yeatman, and Dr. Swan, plus the present Association Chairman, Mr. Squires, and additionally Mr. B. Devitt, be appointed to the Standing Committee on Forest Genetics Education.

Moved by J.I. Klein, seconded by J. Farrar. Carried.

d) BYLAWS COMMITTEE REPORT

The chairman stated that the 16th meeting appointed a bylaws committee (J. Klein, B. Dancik and N. Dhir) to examine the bylaws and recommend changes, and asked J.I. Klein to present bylaws committee's report. J.I. Klein informed the meeting that the revised bylaws were circulated to members for comments and suggestions, and appropriate changes made. Proposed revised bylaws were presented for approval by the members.

Motion: That the proposed ammendments to the constitution and bylaws of the Canadian Tree Improvement Association be adopted.

Moved by J.I. Klein, seconded by B.P. Dancik. Carried.

202. FUTURE MEETINGS

a) LOCATION OF 1981 MEETING

The chairman called to attention the resolution passed by the 16th meeting which stated that the 18th meeting of the Association be held on the Vancouver Island in 1981. Subsequently, a letter was received from Mr. W. Young, Chief Forester, Ministry of Forests, Province of B.C. inviting the Association to hold its 1981 meetings in B.C. It was reafirmed that the 1981 meeting will be held on the Vancouver Island.

b) THEME FOR 18TH MEETING

The chairman asked for suggestions for the symposium theme for the 18th meeting. Several suggestions were made. D. Pollard suggested "seed orchard planning and management". J.I. Klein suggested "technical problems relating to establishment of test plantations". R.M. Rauter suggested that perhaps both of the topics can be combined. D.P. Fowler recommended the new Executive take these suggestions into consideration to decide an appropriate theme.

c) LOCATION OF 1983 MEETING

N.K. Dhir informed that the location of 1983 meeting had to be decided in accordance with the motion adopted at the 16th meeting (Minute No. 189). Ontario and Quebec were suggested as possible locations at that time, and letters of invitation were requested from both provinces for consideration by the present meeting. R.M. Rauter confirmed that the Ontario Ministry of Natural Resources would like to host the 1983 meeting and suggested Maple as the probable location.

Motion: that Ontario's offer to host 1983 meeting be accepted.

Moved by C.W. Yeatman, seconded by B.P. Dancik. Carried.

d) LOCATION OF 1985 MEETING

Suggestions were requested for possible location of 1985 meeting. C.W. Yeatman suggested that 1985 meeting be held jointly with North Central Tree Improvement Association in Thunder Bay area in Ontario; N.K. Dhir and J.I. Klein suggested Edmonton, Alberta; T. Mullin suggested Nova Scotia.

e) JOINT MEETING WITH NORTH CENTRAL TREE IMPROVEMENT ASSOCIATION

Dr. R.B. Hall, Chairman, NCTIA also attended the business meeting as an observer and suggested that CTIA and NCTIA hold a joint meeting in 1983 or 1985.

Motion: that CTIA invite NCTIA to hold its 1983 meeting jointly with CTIA.

Moved by J.I. Klein, seconded by B.P. Dancik. Carried.

203. ELECTION OF OFFICERS

D.P. Fowler was appointed as a one-man nominating committee and proposed the following slate of officers for election.

Chairman:	Mr. J.C. Heaman
Vice-Chairman (Symposium)	Mr. D.F.W. Pollard
Vice-Chairman (Local Arrangements)	Mr. M. Crown
Executive Secretary	Dr. N.K. Dhir
Editor	Dr. C.W. Yeatman

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

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

Moved by L.W. Carlson, seconded by R.M. Rauter. Carried.

204. NEW BUSINESS

Proposal for committee on Tree Seed

Motion: In view of the large quantity of high-quality seed required annually for reforestation and tree improvement programs and the urgent need for close coordination and cooperation among the various Forest organizations in Canada, in seed procurement, production, harvesting, handling, processing, testing, storage, and the control of cone and seed insects and diseases, we move that a committee be formed as a National Tree Seed Council within the structure of the Canadian Tree Improvement Association to meet that need. The Committee should consist of a Chair-Person, Vice-Chairperson and three members.

Moved by D.A. Winston, seconded by J. Thompson. Following some discussion concerning the need for, and possible function of, a distinct seed group within C.T.I.A., the motion was Defeated.

205. ADJOURNMENT

Motion: That the 17th Business Meeting of the C.T.I.A. be adjourned.

Moved by A. Gordon, seconded by L. Carlson. Carried.

206. APPRECIATION

The meeting accepted a resolution at the conclusion of the final day of the meeting.

Motion: Be it resolved that the 17th meeting of the CTIA expresses its thanks and congratulation to the 1978-79 executive for a lively and enjoyable meeting in Gander, Newfoundland, August 27-30, 1979.

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

N.K. Dhir, Executive Secretary
C.T.I.A./A.C.A.A.

FIELD TRIP TO

NORTH POND FOREST EXPERIMENTAL AREA

WEDNESDAY, AUGUST 29

C.T.I.A./A.C.A.A. FIELD TRIP '80
NORTH POND

YVES LAMONTAGNE hidden among the spruce boughs while listening with MAC SQUIRES, Chairman '78-'79, to PETER HALL, V. Chairman, giving a rundown on performance to date.

ROBERT BEAUDIN, ANTE STIPANICIC and ARMAND CORRIVEAU debating a point.

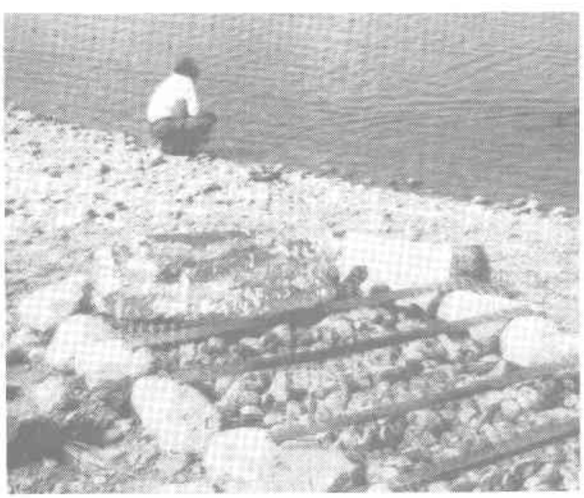
Nature and our hosts tried to outshine each other for the baked cod and salmon picnic at North Pond.

RICK HALL, right, samples the salad while GORDON MURRAY, CARL HEIMBURGER and MIKE ROBERTS (CBC St. Johns) wait their turn.

SPECIES AND PROVENANCE TRIALS NEWFOUNDLAND

RICK HALL (Iowa State University) and NARINDER DHIR (Exec. Secretary) pause by the refreshment wagon as ROSE MARIE RAUTER returns to the picnic tables.

BOB KELLISON (North Carolina State University) follows KRIS MORGENSTERN and PETER FERET (Virginia Polytechnic Institute and State University) back to lunch.



TOM CONKLE checks the waters of North Pond while the baked cod and salmon keep warm over the coals.

BOB KELLISON, HANS NIENSTAEDT (U.S.F.S., Rhinelander, Wisconsin) BRUCE DANCIK, RICK HALL and PETER FERET discuss problems of plantation growth in Newfoundland.

NORTH POND FOREST EXPERIMENTAL AREA

The North Pond Forest Experimental Area was established by the Canadian Forestry Service following the disastrous wildfires which swept central and east-central Newfoundland in the summer of 1961. It was intended to be used as a site for reforestation experiments and as a demonstration area for successful reforestation techniques.

This area, which forms part of the Mint Brook Valley, was for many years a source of pulpwood and sawlogs. Clearcutting operations began during the 1940's in what is now the experimental area. The forest is typical of much of that in central Newfoundland. Most of the areas on which the Canadian Forestry Service experiments are located were clearcut for black spruce and balsam fir between 1954 and 1959. In the summer of 1961 the area was swept by wildfire which burned nearly all clearcut areas and some small patches of standing timber. A small part of the experimental area is located in an area untouched by this fire and the stands on it originated from previous fires in 1886 and 1941.

Following the 1961 fire, most of the area restocked naturally to a mixture of black spruce, white birch, and aspen. The stocking is variable with some areas completely unstocked and others covered with dense regeneration. Under some circumstances a dense growth of alder has become established, another common result of wildfire in central Newfoundland.

Experiments established on these sites require cleaning and tending in their early stages. However, it has not been possible to maintain these sites as they should be and some are now choked with natural regeneration. In addition to making remeasurements difficult it also makes interpretation of the results more uncertain.

Most of the experimental area (19 km^2) has been classed by the Canada Land Inventory as predominantly 4^F - sites with limiting fertility factor and capable of producing from 214 to 294 cubic metres/hectare on a 60-year rotation.

Soil parent materials consist of deep well-drained glacial tills with a loamy texture. Soil profiles are of the podzolic order.

The climate is influenced both by the continental air masses and by the cold waters of the Labrador current. The latter moderates winter and summer temperatures and causes milder winters and colder, wetter summers than is normally the case in other parts of the boreal forest at similar latitudes (48°45'N).

Average monthly temperatures for June, July and August are 11.2°, 16.8° and 16.1°C respectively. Total monthly precipitation for these months is 7.7, 8.1 and 9.6 cm. The average frost-free period is 120 days and the vegetative season 150 days.

Delegates left Gander at 9:00 a.m. by bus and covered the 47 km journey over dusty roads stopping first at the White Spruce Provenance Trial.

This study was established in the spring of 1963 with 2 + 2 seedlings which had been grown at the Petawawa Forest Experiment Station (Chalk River, Ontario) and shipped to the Island. Thirty-one provenances from the Great Lakes-St. Lawrence Forest Region and one provenance from Newfoundland (consisting of 3 to 5-year old wildlings) were planted in 40 seedling plots at a spacing of 1.8 metres. The experimental design is a six-replicated randomized complete block. Results after 20 years from seed have shown that a group of provenances from eastern Ontario and western Quebec have grown best on the site and also have grown 20-30% faster than the Newfoundland provenance.

Seed has been collected from most of the better provenances. Collection will continue as seed becomes available, and will be used in seedling seed orchards. In general, it is the better growing provenances which have flowered.

Leaving the plantation site many delegates were struck by the proliferation of a local delicacy the partridgeberry (_Vaccinum vitisidaea_ to non-Newfoundlanders). Unusual but significant site-genotype interactions were later reported.

The second stop consisted of a visit to a plantation of several exotic _Pinus_ species. The plantation was established in October 1966 to test the suitability of planting various species of _Pinus_ under typical Newfoundland forest conditions. All species had previously been planted as ornamentals or in small _ad hoc_ trials in various parts of eastern and central Newfoundland. It was hoped that, if successful, one or more of these species could be used to supplement the limited number of indigenous conifers available for reforestation programs.

The plantation consists of 64 plots (15.3 m x 30.6 m) arranged in a randomized complete block design made up of 8 plots in each of 8 blocks. Each plot contains 128 trees (spaced at 1.8 m) of one seedlot. Included in the plantation are _P. sylvestris_, _P. banksiana_, _P. contorta_, _P. resinosa_, _P. albicaulis_, _P. cembra_ and _P. nigra_ v. _corsicana_.

Results 12 years from seed indicate that jack pine and Scots pine strains would be considered useful for further, more extensive trials before large scale use as a reforestation species. It was observed during the last remeasurement that both species compared quite favourably with growth rates of indigenous black spruce regeneration on the site.

One feature of the plantation area, (typical of many sites in central Newfoundland), is the variation in site types over a very small area. The plantation consists of approximately 3 hectares but site variation within the area has resulted in growth differences of 200 to 300 per cent between plots containing the same species.

This stop was followed by the long trek back to the bus to go to the lunch stop. On the road to the lunch stop delegates passed through an area successfully re-seeded 14 years previously. Black spruce and jack pine seed was spread using a helicopter fitted with a seed scattering device. The area is now fully stocked to both species although the jack pine predominates. The experiment demonstrates the efficacy of direct seeding methods in Newfoundland where large burned productive areas are quite common.

At this point the pangs of hunger were assuaged by some Newfie victuals including fresh salmon, cod, home baked beans and bread with partridgeberry jam. Some other well-known local products were made available to keep the dust down to tolerable levels.

Following this splendid repast delegates were once more bundled aboard the busses and after a creaky start proceeded to the fourth stop of the day - more species trials and demonstration seed production areas.

The species trials consisted of small plantings of *Larix laricina*, *L. kaempferi* and *L. decidua* and of *Pinus sylvestris*, *P. banksiana*, *P. contorta*, *P. resinosa* and *P. monticola*. Results from these plantings (12-14 yrs. from seed) indicate that the larches and *Pinus sylvestris* would be quite suitable for planting under local conditions. The four different lots of *P sylvestris* grew at different rates - wide scale use of this species would require extensive provenance testing.

Also in the immediate area are the Canadian Forestry Service demonstration seed production areas. Most of the sites in this area have regenerated to black spruce, aspen, birch, cherry and alder. In October 1977 it was decided to establish three areas as demonstration seed production areas. All hardwoods were removed, the spruce was untouched except in places where the density was high. The areas thinned are typical of the SPA's which we hope to establish and manage in central Newfoundland over the next few years. Density and percentage stocking of black spruce was quite variable.

Cones were collected in the SPA's from about 30 trees in October 1978. This year several more trees have flowerd and have produced more cones than in 1978. The trees in 1978 yielded about eight viable seed per cone.

The final stop on the tour consisted of a visit to a provenance trial of red spruce (*P. rubens* Sarg.). Red spruce is not native to Newfoundland but forms a significant component of the productive forests of the nearby Maritime Provinces. The species is also quite variable over its natural range and is believed to hybridize with black spruce where the ranges of the two species overlap. This plantation consists of 30 provenances and was established with 2 + 2 planting stock in May 1964 in a 10-replicated complete block design. Spacing is 1.8 m with four trees planted per plot. Unfortunately, no local source of black spruce or white spruce was available at the time for use as a comparison.

Seed for this trial was obtained from New Brunswick (10 provenances), Nova Scotia (16 provenances), Maine (2 provenances) and West Virginia (2 provenances).

Results 13 years from seed indicated that the better provenances came from central New Brunswick and scattered locations in Nova Scotia. A noticeable feature of the plantation is the large within provenance variation and the presence of some obvious 'black spruce phenotypes' among the red spruce.

Following this the delegates headed homeward to Gander dustier and hopefully wiser in the ways of the Newfoundland forest.

J. Peter Hall
Newfoundland Forest Research Centre

WORKING GROUP REPORTS

COOPERATIVE TREE IMPROVEMENT IN CANADA

COOPERATIVE TREE IMPROVEMENT PROGRAMS IN CANADA

Chairman: J. Peter Hall

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

During recent years, the greatly increased emphasis on more intensive forest management has made many forest managers more aware of the value of tree improvement as an important tool in forest management. Most forest managers are aware, in a general sense, of the spectacular rates of growth and improvements in quality achieved and work undertaken closer to home. Thus we have a situation with a large bank of knowledge available and many people wanting to use it. In many situations it has been felt that the best way to satisfy these needs is through a cooperative effort. These efforts may take the form of Cooperatives, Councils or Working Groups, which are composed of wood-using organizations and the forest management and research organizations.

In recognition of this development in tree improvement work the C.T.I.A. has decided to include in this meeting a discussion on cooperative programs. We have speakers from the forest products industry and from the provincial and federal governments, from all parts of Canada. There are discussions on how the various tree improvement organizations were established, how they function in their particular situations and the types of problems which have arisen since their establishment. They reflect different forest managment practices in Canada and the variety of species being studied which are primarily Douglas-fir, lodgepole pine, jack pine, Sitka spruce, white spruce and black spruce. The programs described are in different stages of development from the well-established programs in B.C. to the recently established program in Newfoundland.

These papers are designed to stimulate discussion between researchers and management foresters to gain the most for forest improvement from the experiences of those working most actively in this field.

FIFTEEN YEARS OF DOUGLAS-FIR TREE IMPROVEMENT AT PACIFIC LOGGING'S SEED ORCHARD AT SAANICHTON, VANCOUVER ISLAND

B. Devitt

Chief Forester
Pacific Logging Co. Ltd.
Vancouver Island

PACIFIC LOGGING COMPANY LIMITED

Pacific Logging is a wholly owned subsidiary of Canadian Pacific Investments which harvests and tends trees on 121 408 ha of forest land located in southeastern Vancouver Island. This area is 0.22% of B.C.'s forested acreage.

Our tree improvement activities are basic to our intensive forest management program in which 3 ha are treated silviculturally for each hectare harvested at an annual cost of $7.50 to $8.00 per ha over the total area.

FOREST SITES AND PLANNING

In planning the total forestry program, emphasis is placed on biophysical forest site mapping and classifying forest condition. These two components dictate priorities for required crop tending treatments and forest site maps have been prepared and data on the forest condition are being collected.

Soon we will be able to evaluate and adjust our tree improvement program using these data. At present 60% of our land base is best suited to growing Douglas-fir at elevations between 150 m and 1 100 m above sea level (ASL). The remaining land is best suited for western hemlock and Pacific silver fir at elevations over 600 m.

TREE IMPROVEMENT OBJECTIVES

The first objective is seed supply. Seed is the cornerstone of our intensive forestry program that includes the prompt reforestation of 600 - 1 200 ha of cutover annually. For the purpose of securing this seed supply we:

(a) supervise collections and select trees for wild collections. The species involved include, Douglas-fir, western hemlock, *Abies amabilis*, *A. grandis*, western red cedar and yellow cedar;

(b) have developed over 8 ha in three specific areas as seed production areas of Douglas-fir. The elevation ranges from 460 m to 1 000 m ASL;

(c) have developed 11.2 ha for a low and high elevation Douglas-fir seed orchard on a 26.3 ha property near Saanichton, Vancouver Island.

The second objective is long term and genetic. It includes increased wood production, maintenance of genetic diversity and preservation of the gene pool.

PACIFIC LOGGING COMPANY DOUGLAS-FIR SEED ORCHARDS

(a)	High Elevation - Clonal, open pollinated seedlings	3.4 ha
(b)	Low Elevation - Clonal	1.8 ha
(c)	High Elevation - Second phase controlled crosses	6.0 ha
	TOTAL	11.2 ha

Initial spacing is 3.8 m within rows and 6.7 m between rows or 300-400 trees per ha.

TREE IMPROVEMENT AND SEED ORCHARD COMPONENTS

(a) Plus Tree Selection

Cooperation among agencies commenced in the mid-fifties with the formation of the Plus Tree Board. Its objective was to cruise for Douglas-fir plus trees. Subsequently, it became the Tree Improvement Board and 655 coastal Douglas-fir plus trees were selected. Cooperation continued with sharing of pollen, seed, and vegetative material.

For our program we have chosen, from the trees selected, 135 Douglas-fir trees and we are now selecting to increase this number to 300. We are also now including western hemlock and *Abies* in our program. We fully support the cooperative program at the level of both the Tree Improvement Council and the Tree Improvement Board.

(b) Rooted Cuttings

In order to preserve the clonal option and with the problems of overgrowth in grafting, we pioneered, with the help of the Saanichton Agriculture Experiment Station, the rooting of Douglas-fir cuttings. Presently, using the commercial plant hormone "Dip-N-Grow" (IBA) we have obtained the following results:

Diam. of Cutting	ppm "DIP-N-GROW"	Cutting Survival
5 mm +	2,000 ppm	39%
3-5 mm	1,000 ppm	33%
0-3 mm	500 ppm	25%

The cuttings are usually collected in January after some winter chilling. Bottom heat is also provided.

(c) Pollen Contamination

Water cooling to delay flower bud opening beyond the local pollen flight period has proven to be effective on 75% of the clones. This coupled with booster pollination, using within orchard pollen, minimizes the effects of outside pollen sources and improves seed set. 15 ha of orchard are under solid set irrigation for this purpose.

(d) Orchard Pollen

Through trial and error and much ingenuity, pollen collection, extraction, and cleaning is no longer a problem.

Timing its collection for the right stage is the most important factor. However, more research on pollen storage is still required. We need a five year storage capacity.

Currently our seed set is 29 filled seeds per cone compared to 11-15 in nature.

(e) Controlled Crossing

Our controlled crossing program is similar to that described by Heaman (1979) in the Members' Report to the 17th meeting. We will have completed 9 sets and will be able to initiate our first test plantations shortly.

Many of our trees through sharing of flower crops with the B.C. Forest Service are already included in Heaman's program, demonstrating another example of cooperation.

(f) Insect Control

Flower bud delay during good crop years is providing a measure of insect control (Miller 1978). However, during off years when crops are light, insects can still destroy the crop. More research is definitely needed in this field.

(g) Other Research Activities Required

(i) fertilization schedules to stimulate flowering and to feed developing cone crops.

(ii) Calibration of irrigation system for cooling to cut down on excessive water use and to cause moisture stress to set up flower crops.

(iii) Pollen application.

(iv) Cone collection.

CONE PRODUCTION

	Open Pollinated Seedlings	Clonal	Total
1976	60,992	12,359	73,351
1977	20,363	1,979	22,342
1978	91,790	16,764	108,554
	173,145	31,102	204,247

SEED PRODUCTION

1971 +	4.000 Kilograms
1976	15.850 Kilograms
1977	2.124 Kilograms
1978	23.325 Kilograms
	45.299 Kilograms

ANNUAL COST OF PRODUCTION

Equals 1.6 km of road (total capital equals 8 km of road)

Operating	$ 1,600/ha
Capital	1,000/ha
	$ 2,600/ha

Maintenance	41%
Breeding & Propagation	31%
Records	7%
Pruning	2%
Cone Picking	2%
Extraction	2%
Miscellaneous Services	15%
	100%

COST PER 1,000 TREES PRODUCED

Costs equate to $3.85 per 1,000 trees or about twice that for wild collections or compared to planting at $200.00 per 1,000 trees.

FUTURE

In 15 years, we have successfully reached our first objective which is to produce seed for reforestation projects. The breeding and selection program is just getting under way, however. Emphasis in the future will be placed upon evaluation for gain and reselection through progeny testing. Equally important we need to maintain genetic diversity and veracity within our program.

PEOPLE AND COOPERATION

I will conclude with a few comments based upon 23 years of growing up with government and industry tree improvement programs.

The current objective of government, in general, is to get industry to do the work. Cooperative programs have and are being initiated. Unfortunately, government gets its regulatory and management roles mixed and industry is asked to participate in a one-sided partnership with basically a timber-supply-withdrawal gun at their temple.

It is also ironic that government, which relied upon industry to sell the intensive forestry expansion program to the politicians in the first place, should now not trust industry to do the tasks they have already demonstrated they can do. I hope the forestry-cost and regulatory quarrels do not frustrate a truly cooperative approach to implementing the needed basic silvicultural programs.

The expansion into intensive forestry across the country is also going to be deterred through the lack of competent people. Our training and research sections are at their weakest at a time when they should be at their strongest. All of us need to request and demand that politicians, governments, and training institutions coordinate and develop compatible policies in the funding of research and the development of trained people.

In addition, scientists have a basic responsibility to do pertinent research on a "need to know" rather than "nice to know" basis. Communication of important findings to user groups should be in a language and format easily understood.

The politicians and the general public will also be demanding the best of scientific advice and your challenge as scientists will be to provide it.

REFERENCES

Heaman, J.C. 1979. A Breeding Program in Coastal Douglas-fir (*P. menziesii* Mill Franco). 17th Meeting Canadian Tree Improvement Association Members' Reports.

Miller, G. 1978. Management of Cone and Seed Insects. Progress Report, B.C. Forest Service, Victoria, B.C.

Kvestich, A. 1978. Reducing Pollen Contamination by Using Water-Cooling to Delay Flowering in a Douglas-fir Seed Orchard. Pacific Logging Co. Report to Forest Genetics Annual Meeting, Vancouver, B.C.

DISCUSSION

Brown: In your slide you have shown a potential gain of 3 times current volume. Can you tell us the basis for this?

Devitt: It is based on twenty years of experience, an increment borer and knowledge of stands. It is not based on any research but I believe that it's pretty close to what's going to happen.

George Warrack has just published a paper based on 50 years thinning at the Cowichan Lake Experiment Station in which he indicates that the gross volume stays the same but you gain by creating larger trees in a shorter period. He showed from this work that there was a threefold increase and that is what my data have shown.

B.C. Forest Products has shown that a gain of around 11 to 12 thousand cubic feet is possible; I have indicated that 15 thousand is possible. We know that in the next rotation we're going to at least double our production even if we can't triple it and our planning is based on doubling it.

Fowler: I was surprised to hear that seedlings of Douglas-fir produce more seed than your grafted Douglas-fir.

Devitt: Orr-Ewing found this too, and attributed it to the amount of vegetative area. In the early days many plus trees had poor scion material and grew like branches - not trees.

Fowler: Does this push your program to seedling production?

Devitt: For seed production, yes - but with younger trees you can go to rooted cuttings and so we're pushing that for our clonal option.

Conkle: Do your comments about seed production in seedlings consider age? Work from Oregon suggests that clonal material produces seed 3 to 5 years before seedlings.

Devitt: The clonal material will produce flowers for breeding purposes early, after 2 to 3 years. For seed production the seedling component in the orchard began producing at 7 to 8 years and now produces almost 900 cones per individual each year at age 12 to 13.

THE COASTAL TREE IMPROVEMENT COUNCIL (C.T.I.C.) SEED ORCHARD PROGRAM (1979) IN BRITISH COLUMBIA

M. Crown

Forester
Coastal Seed Orchards
B.C. Forest Service
Victoria, B.C.

From 1963 to January 1979 some 25 seed orchards were established on the coast by Industry and Government (see Appendix 1). These orchards totalled 65.9 ha and were Douglas-fir[1] orchards, with the exception of a Sitka spruce orchard and a western hemlock orchard established by Tahsis Company. Based on experience gained by Pacific Logging Company Ltd. and Tahsis Company, who established orchards on the Saanich Peninsula, the importance of orchard location in relation to cone production soon became evident. Areas experiencing summer drought are now considered prime areas for seed orchard location.

The total production from all orchards to date is 149.750 kg of seed. Of this 126.168 kg or 84% has been produced from three orchards located in areas of summer drought. These are:

#10	Pacific	40.70 kg
#11	Tahsis	59.535 kg
#14	BCFS-Koksilah	25.923 kg
	TOTAL	126.168 kg seed or 9.5 million plantable seedlings

Many of the existing orchards were located in areas of high summer rainfall and lacked important criterion for success. In addition, there was considerable overlap of orchard components and objectives. Propagation facilities were also being duplicated. In 1973 a B.C. Forest Service directive stated that no new orchards should be established under the "forestry cost" system. (Expenditures by Industry for approved management activities on Crown lands were claimed as "Forestry Costs" and were recognized in the pricing of the timber).

It was not until January 1979 that a task force report on a Government/Industry Cooperative Tree Improvement Program was finally accepted by Industry and the Ministry of Forests, and a Coastal Tree Improvement Council (C.T.I.C.) was formed.

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[1] Scientific names and symbols on Page 35.

THE COASTAL TREE IMPROVEMENT PROGRAM

The program objective was stated as follows:

" I. to provide enough seed incorporating the first level of genetic improvement for all reforestation projects where site quality and accessibility will allow intensive forest management to be practised.

and II. to establish programs to increase these levels of gain through testing and breeding."

To meet the first objective it is estimated that it will be necessary to produce sufficient orchard seed to permit nursery production of 40 million seedlings by 1995.

The C.T.I.C. is comprised of Industrial Chief Foresters or their designates and Branch Directors and/or their designates from the Ministry of Forests.

The terms of reference of the Council are as follows.

TERMS OF REFERENCE APPROVED FEBRUARY 28, 1979

The Council shall act in an advisory capacity, with the responsibility of making recommendations to the Chief Forester with respect to the following matters:

1. Tree Improvement Program objectives, strategies and priorities, for both seed orchard and tree breeding operations, including progeny trials.

2. Plans, programs and budgets for individual orchards.

3. Standardization of seed orchard working plan format, progress reporting and costing.

4. Identification of research needs - at all levels (for submission to the Research Council).

5. Identification of the agency responsible for the establishment and operation of any given orchard.

6. Method of financing individual orchards.

7. Seed orchards for private lands or combination of private and Crown lands.

8. Seed extraction, registration, storage and ownership, including the sale and/or exchange of seed and allocation of improved seed between agencies.

9. Pollen extraction, registration and storage.

10. Production of orchard stock (propagation).

A technical planning committee with representation from all agencies is responsible for the technical aspects of program planning. The program coordinator at the technical level is also secretary to the Council.

PROGRESS TO DATE

1. Planting needs for the south coastal area by species for 1979 and 1994 have been derived (Figure 1). Planning data for the Prince Rupert region is expected shortly.

2. A program to modify six of the existing orchards, and establish 18 new orchards by all agencies has been adopted by Council and is now underway. These orchards will cover seven different species (F, Hw, Ss, Se, Ba, Cr and Cy)[2]. The impact of this program is best appreciated by reference to the maps showing orchard coverage by species, elevation and planning zone.

3. Working plans following a standard format have been prepared for each of the 24 orchards in the cooperative program. Four members of the technical planning committee for each individual orchard.

   These working plans are written as working documents, and will be revised annually. They are expected to be key documents and a letter of agreement or orchard management contract between the managing agency and the Ministry of Forests will formalize the management of the orchards. Expenditures by Industry are expected to be covered by credit to stumpage via Sec. 88 of the new Forest Act.

4. Propagation for coastal seed orchards and the breeding programs will be carried out at the Cowichan Lake Experimental Station at Mesachie Lake, and plans for the extension of the facilities are now on the drawing boards.

5. Clone banks will be a responsibility of the Research Branch and a plan for the management of these is now being prepared.

6. Seed allocation rules are currently under study and are expected to be finalized in the near future.

7. With such a surge in the development of seed orchards, the all important task of breeding and progeny testing is now under review and considerable expansion in this part of the program is anticipated.

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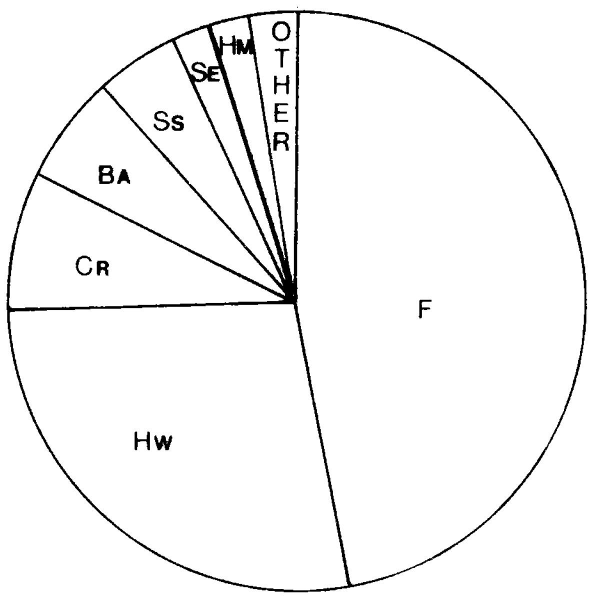
[2]F - Douglas-fir -- Pseudotsuga menziesii; Hw - western hemlock -- Tsuga heterophylla; Ss - Sitka spruce -- Picea sitchensis; Se - Engelmann spruce -- Picea engelmannii; Ba - Amabilis fir -- Abies amabilis; Cr - western red cedar -- Thuja plicata; Cy - Yellow cedar -- Chamaecyparis nootkatensis.

FIGURE 1: OVERALL COMPARISON OF ANNUAL PLANTING AREA (HA) BY SPECIES (1979 vs 1994)

BASIS– AGENCY RETURNS TO C.T.I.C. (AUG. 1979)

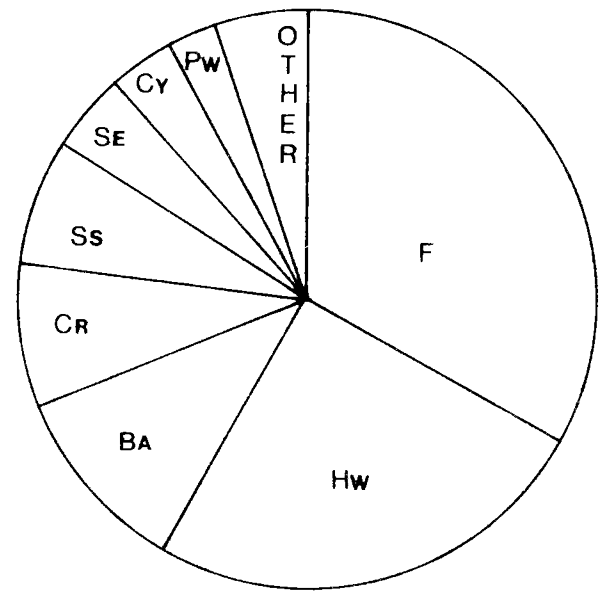
1979



OTHER – Cy, Bg, Pl, Pw, Bn

SPECIES	1979	1994
F	11,925	8,600
Hw	6,905	6,754
Cr	2,018	2,108
Ba	1,600	2,986
Ss	1,257	1,776
Se	579	1,196
Hm	438	692
Cy	223	892
Bg	116	253
Pl	94	104
Pw	20	751
Bn	--	50
TOTAL	25,175	26,162

15 YEAR PROJECTION (1994)



OTHER – Hm, Bg, Pl, Bn

SUMMARY

Seed orchard work in coastal B.C. has never been as challenging or exciting, and the breeding activity is now tied closely to orchard development plans. Through coordinated parent tree selection and propagation programs the C.T.I.C.'s priorities and a balanced program are maintained. Through the technical planning committee and its working plan review committees a knowledgeable "peer group" ensures that orchard management by any cooperator is up to standard. Orchard management practise will be maintained and improved by good communication between members and by pertinent technical workshops.

It is indeed good to see that the cooperative atmosphere that has now developed on the coast is reminiscent of the "plus tree" weeks and cooperative scion collection program (see Appendix 2) that marked the enthusiastic beginnings of tree improvement in B.C. in the 1960's. A similar cooperative program is just being developed for the B.C. Interior.

DISCUSSION

Bettle: How extensive do you expect summer drought? Have you found a certain time to be more effective to root prune?

Crown: We have a study underway now to see if there is an optimum time. At present we prune any time between October and spring but we don't have any data. Dr. Lorne Ebell is on contract with us and he has started to measure moisture stress in the orchards and to compare root pruned and non-root pruned trees and watered areas and non-watered areas. It's a whole area of applied research that we need because it is quite critical.

If we take Saanich, an ideal situation, we have moisture deficit in the 3 month period June, July and August of 25.9 whereas at Duncan we have 24.6. If we consider those marginal orchards where we root prune we're down to about 18 so you need areas with summer drought if you're going to get cone production.

Devitt: Can I add to what Mike said - at our seed orchards we found that by watering we could prevent a crop from developing the next year - so if we don't have a crop in the orchard we have to stress the orchard. We have two different types of watering regime depending on whether we have a crop. Normally we stress it in July to the point of wilting before we put the water on and we actually get the vegetative growth into a wilt condition before we start watering. Going back to some of Dr. John Owens' earlier work, I think the bud primordia are laid down sometime late June - early July and so that's why we stress it then.

APPENDIX 1

SUMMARY OF COASTAL ORCHARDS (August 1979)

#	Spp	Name	Managing agency	Seed orchard planning zone	Elev.	Estab. date
001*	F	Quinsam	BCFS	EVI	Mid	1963
002	F	Gold R. "A"	Tahsis	WVI	Low	1962-69
003	F	Caycuse	BCFP	WVI,EVI	Mid	1963-64
004	F	Courtenay	CZ	EVI,JS	Low	1964-65
005	F	Nanaimo Lks.	CZ	EVI	Mid	1964-65
006	F	Gordon River	Rayonier	WVI,EVI	Mid	1964-65
007	F	Gold R. "B"	Tahsis	WVI	Mid	1964-68
008	F	Gold R. Local	Tahsis	WVI	Low/Mid	1968-75
009	F	Saanich	Pacific Logging	EVI	Low	1966
010	F	Saanich	Pacific Logging	EVI	Mid	1966
011*	F	Saanich "C"	Tahsis	WVI	Low	1968-75
012	F	Jordan River	Rayonier	WVI,EVI		1968
013	F	Port McNeil	Rayonier	WVI,EVI		1969
014*	F	Koksilah	BCFS	SCM,CIT	Mid/Low	1970
015*	F	Snowdon	BCFS	JS	Low	1971
016*	F	Sechelt	CFP	EVI,JS	Mid	1971
017	Hw	Gold River	Tahsis	WVI	Low/Mid	1969-76
018*	Ss	Saanich	Tahsis	WVI	Low	1973
019	F	Harmac	MB		High	1978
020*	F	Dewdney	BCFS	CIT	High	1975
021	F	Saanich	Pacific Logging	EVI	Mid	1976
022	F	Harmac	MB	Dry	Mid	1976-78
023	F	Harmac	MB	Wet	Mid	1976-78
024	F	Harmac	MB	Dry	Low	1976
025	F	Harmac	MB	Wet	Low	1976
026*	Hw	Lost Lake	Rayonier	MVI,WCC	Low	(1979-84)
027*	Hw	Lost Lake	Rayonier	MVI,WCC	Mid	(1979-84)
028*	Cr	Lost Lake	Rayonier	MVI,WCC	Low	(1982-85)
029*	Ba	Mt.Newton Hts.	BCFP	(WVI),(JS)	Low	(1985)
030*	Hw	Mt.Newton Hts.	BCFP	WVI	Mid	(1983)
031*	Se	Cobble Hill	BCFS	CIT	High	(1984-85)
032*	Hw	Yellow Point	MB	WVI	Low	(1981)
033*	Hw	Sechelt	CFP	(JS),(SCM)	Low	(1983)
034*	F	Mt.Newton Hts.	CZ	JS	Low	(1983)
035*	Ba	Yellow Point	MB	EVI,SCM	High	?
036*	Hw	Saanich	Tahsis	WVI	Low	(1977-)
037*	Cy	Mt.Newton Hts.	CZ	SCM,CIT	Mid/High	(1985)
038*	Cy	Mt.Newton Hts.	CZ	WVI,EVI	Mid/High	(1985)
039*	Cr	Yellow Point	MB	WVI	Low	(1983-84)
040*	Cr	Yellow Point	MB	EVI,SCM	Low	(1983-84)
041*	Ba	Saanich	BCFS	SCM,EVI,JS	Mid	?
042*	Ss	Lost Lake	Rayonier	QCI	Low	(1979-84)
043*	Hw	S. Quinsam	BCFS	(JS),(SCM)	Mid	(1985-86)

*Orchards in C.T.I.C. Program

APPENDIX 2

SUMMARY OF PARENT AND/OR PLUS TREES REGISTERED FOR THE COASTAL TREE IMPROVEMENT PROGRAM (as of Aug. 15, 1979)

SPECIES	BCFS	BCFP	CFP	CZ	MB	RAY	TAH	WELD	PLC	MISC	TOTALS
Douglas Fir (Coastal) Pseudotsuga menziesii	471	21	39	24	21	3	48	4	14	10	655
Engelmann Spruce Picea engelmanii	136										136
Lodgepole Pine (Coastal) Pinus contorta					29						29
Western Hemlock Tsuga heterophylla	273	34	3	16	104	218	112			5	765
Mountain Hemlock Tsuga mertensiana						5					5
White Pine Pinus monticola	10				27						37
Sitka Spruce Picea sitchensis	13	2	1	6	23	184	123				352
Amabilis Fir Abies amabilis	53	4	2	3	17		83				162
Western Red Cedar Thuja plicata	9		1			138					148
Black Cottonwood Populus trichocarpa				1	12						13
Grand Fir Abies grandis	29	1									30
TOTALS	994	62	46	50	233	548	366	4	14	15	2332

BCFS = B.C. Forest Service, BCFP = B.C. Forest Products, CFP = Canadian Forestry Products, CZ = Crown Zellerbach Co., MB = MacMillan Gloedel, RAY = Rayonier Co., PLC = Pacific Logging Co., TAH = Tahsis Co., WELD = Weldwood Co.

THE ALBERTA TREE IMPROVEMENT PROGRAM

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HISTORY

The provincial tree improvement program in Alberta was conceptualized by the Alberta Forest Service in the early 1970's. In 1975 the Forest Service hired a geneticist, and under his guidance embarked on a tree improvement program jointly with the major Forest Management Agreement holders. Four participating companies are as follows:

North Canadian Forest Industries Ltd.
Procter & Gamble Cellulose, Ltd.
St. Regis (Alberta) Ltd.
Simpson Timber Co. (Alberta) Ltd.

Logging in Alberta is by no means a new industry, but until recent years, vast hectares of forest land remained intact as virgin forests. Even though most forests are now included in management plans, large areas remain in their virgin state. In this we are fortunate, because the provincial gene pool is largely intact.

Approximately 61% of Alberta is covered with forests. The 115 management units within the green zone are capable of yielding a coniferous annual allowable cut of 14.1 million cubic metres, but only 39% is presently allocated. Of this portion, 53% is allocated under several Forest Management Agreements.

North Canadian Forest Industries controls approximately 363 000 hectares in the region southeast and east of Grande Prairie. The company has been operating in this region since 1964, harvesting approximately 2 430 hectares per year.

The Procter & Gamble Cellulose' forest management agreement includes approximately 1 460 000 hectares to the north, south and southwest of Grande Prairie. The company has been harvesting approximately 4 100 hectares per year since 1973.

The management area of St. Regis covers approximately 770 000 hectares in an area virtually equidistant around Hinton. The majority of this area lies in the foothills. St. Regis (formerly North Western Pulp &

Power) has been harvesting approximately 4 400 hectares per year since 1956.

The management area of Simpson Timber Co. lies in the Whitecourt area in northwest central Alberta. Simpson's management area is approximately 457 500 hectares, and the company has been harvesting an area of approximately 1 620 hectares per year since 1975. The management units of these four companies do not coincide with the provincial forest boundaries, nor do they include all of the forested area. All of the provincial forests support a number of smaller companies under the quota system.

Breeding Regions

To properly organize and manage a tree improvement program of provincial magnitude, breeding regions (Figure 1) were established, based on physiographic data and topography. These regions contain approximately 90% of the present timber harvest in Alberta. The formation of these regions aided in priorizing the areas where the greatest efforts were to be spent, and the species of prime importance within each region.

Alberta does not have a wide diversity of commercial species. The two species predominantly utilized in reforestation within the province are white spruce (*Picea glauca* (Moench) Voss) and lodgepole pine (*Pinus contorta* (Dougl.) var. *latifolia* (Engelm.). The tree improvement program is mainly concerned with the improvement of these. Other species are commercially harvested, but not in large quantities.

LODGEPOLE PINE PROGRAM

Within the lodgepole pine program, our general method for improvement is as follows:

(1) make individual tree selections from wild stands

(2) from these selections, assemble a base population as open-pollinated single tree seedlots

(3) test the progeny performance through a series of field trials

(4) through these tests identify the best families (progenies) and use this information to rogue seed orchard(s)

To examine the workings of our program, let's examine Region B. Region B is listed as priority rating one, the major species being lodgepole pine. This area is one of the largest forested areas and contains portions of the management areas of North Canadian Forest Industries and Procter & Gamble Cellulose, and quota areas of Simpson Timber Co.

Within this region, we attempted to systematically sample suitable, pure, middle aged (60-80 years old) lodgepole pine stands from which the best lodgepole pine trees are selected. Selections were done by

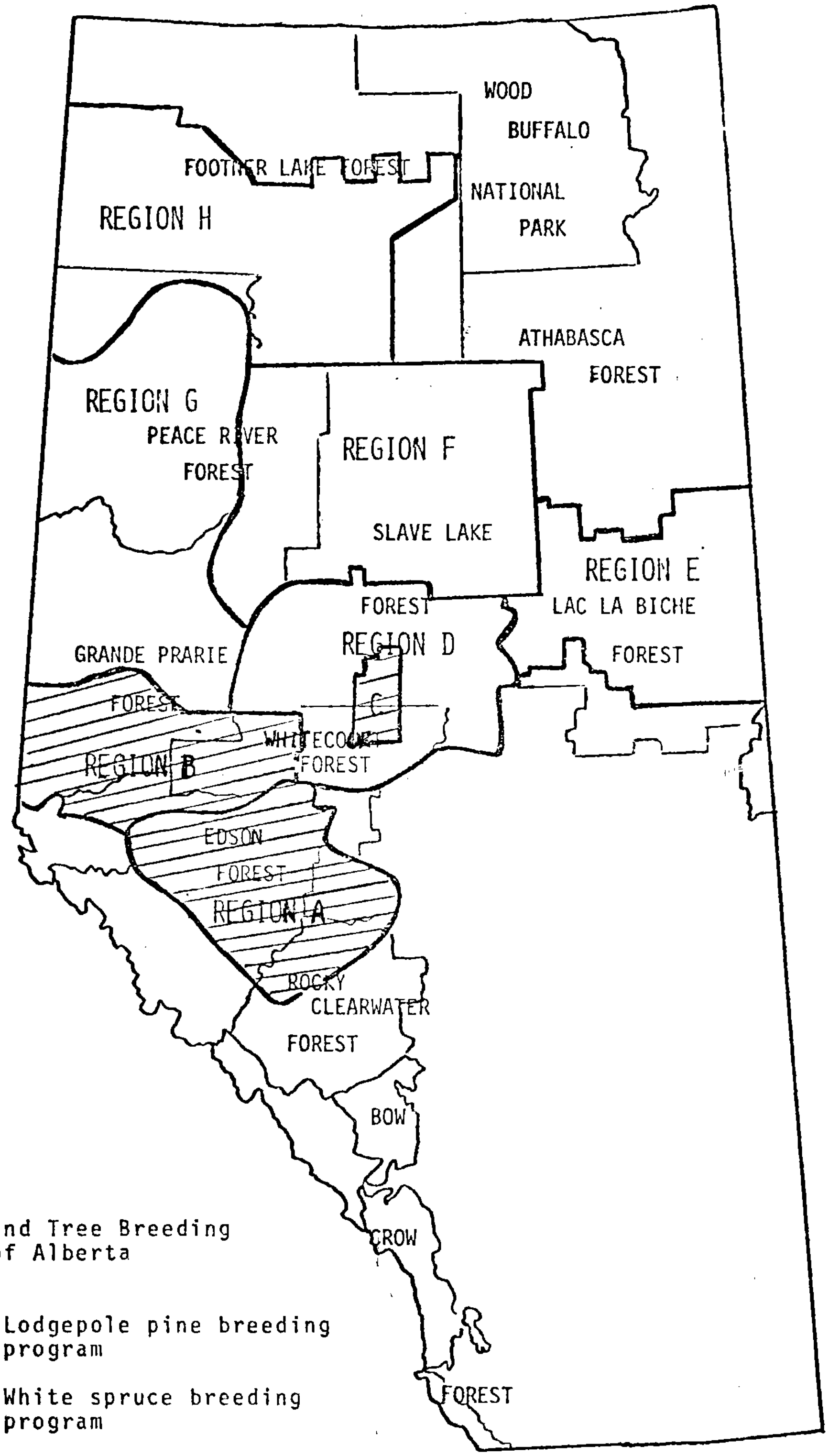

FIGURE 1

Forests and Tree Breeding Regions of Alberta

- Lodgepole pine breeding program
- White spruce breeding program

two-man crews consisting of one Company employee, and one Forest Service employee. Equipment such as helicopters (Bell 206B) and ATV's (Ferret) were supplied by the companies. Considerable selections were made along roadways. (We feel justified in this due to substantial new access to remote areas opened by booming oil activity.)

The selected trees were felled and the cones picked. The individual tree seedlots were extracted separately and stored in the seed bank maintained by the Alberta Forest Service along with a description of the parent trees, stands, and the area. We have attempted to collect seed by shooting tops of trees, but found that this method was not effective due to inadequate seed yields. Generally, 25 to 30 grams of seed are obtained per tree by harvesting all of the cones. Because we are actively building a seed inventory, and no reason prevailed to save parent trees, we decided to fell trees to satisfy our seed needs.

To date, 771 lodgepole pine have been selected within Region B based on the following selection criteria:

(1) excellent stem form
(2) narrow cylindrical crown
(3) superior natural pruning characteristics
(4) low taper
(5) short and thin branches attached to the stem at nearly 90 degree angle
(6) no visible signs of defect, damage or disease
(7) height superiority to any dominant tree growing within approximately 100 metre distance
(8) above average diameter
(9) above average cone production

Our effective selection intensity for field selection of superior trees is crudely estimated to be better than approximately 1:500. Selected trees on average have shown approximately 17% superior height and 13% superior diameter, when compared to better dominant trees within the same stand.

An excellent lodgepole pine tree selected for the program was described as follows. The selected tree was 69 years old (bh age) versus 73 to 77 years age for random trees within the same stand. Its height was 22 metres as opposed to 18 metres for other dominant trees growing in the close proximity. The diameter at breast height was 26 cm as opposed to 20 cm for these same dominants.

Our next step is to establish half-sib family tests within the region. Due to variability in elevation (800 m - 1 500 m) we feel six or more progeny tests will be necessary. The tests will be separated into two series, an upper elevation series and a lower elevation series. Each series will contain approximately 400 families per test site. Test sites of approximately 6 hectares will be planted in 1981 and 1982 with one year old stock reared in 60 cc containers. Measurement of field survival, height growth, and vigor is scheduled at 5 year intervals.

Three family test sites were selected last year. Two of the sites prepared by Procter & Gamble Cellulose were winter logged to minimize ground disturbance. No further site treatment is planned. The third site prepared by Simpson Timber Co. was lightly scarified to break up the residual logging slash which was then piled to produce a relatively clean site.

In conjunction with the progeny tests within Region B, Procter & Gamble Cellulose and the Alberta Forest Service are establishing a 12 ha seed orchard based on bulking portions of 206 individual tree seedlots collected from selected trees. This particular orchard is being established with the purpose of producing low cost genetically improved seed which would be mostly used for direct seeding. The seed orchard site was recently site-prepared. The planting would be done at 1 m spacing within rows and 3 m spacing between rows. At 5 year intervals the orchard will be progressively thinned to retain 20% of the best trees for seed production. These trees may eventually be felled for commercial cone collection when collection from the ground is no longer possible. Based on experience with this seed orchard planting, similar additional orchards may be established as part of an expanded program designed to specifically provide improved seed for direct seeding programs.

A second seedling seed orchard is to be established and will be fenced. We are now actively seeking a location for this orchard. We expect it will be located on suitable farm land near Grande Prairie. Families will be grouped in independent sets of 16 families each with spacing of approximately 1.5 m x 1.5 m among individual trees within sets. Each set will be successively rogued (based on family test results) to retain the following approximate complement of seed trees:

4 trees at age 10
2 trees at age 15
1 tree at age 20

The orchard will be managed to maximize cone production, and we expect sizeable quantities of improved seed to be available by the mid 1990's.

A second cycle orchard will be established about this time through vegetative propagation of the best trees in the best families to produce a clonal seed orchard. In the clonal orchard, controlled breeding will be carried out. Full-sib family tests will be conducted to determine the best matches for advanced breeding schemes. Our goal is to increase future productivity in the region by 20-30%.

WHITE SPRUCE PROGRAM

The white spruce portion of our program is somewhat different. Due to substantial site variability and unevenaged stands, the field evaluation and selection is very intensive. The selection intensity may be as high as 1 in 5,000. We are currently using the comparison tree method, but would like to develop a baseline approach for future work. In the baseline approach, the best candidate trees will be selected on the basis of acceptable relative superiority levels established for key traits. Our goal is to increase productivity by 20-25% in breeding Region D and 15-25% in Regions E through H. In these latter regions we expect to produce operational quantities of seed by the mid 1990's. In Region D the improvement strategy is to proceed as we did for lodgepole pine. We have collected open-pollinated seedlots from 83 selected trees. These will be used to establish half-sib family trials. Further collections are planned this year with the advent of good white spruce cone crops in Alberta.

In Regions E through H the improvement strategy is to collect scion material to develop clonal orchards. Seed is also collected for establishing open-pollinated progeny trials. With the aid of a 2 - 22 or a 25 - 06 rifle (using hollow-point or expanding point shell), scion material is shot from the distal ends of the top whorls. The scions are grafted to 3 year old potted rootstock which will spend approximately 1 year in the Alberta Forest Service greenhouse and 2 years in the nursery beds. Finally, it will be outplanted in respective seed orchards. Clone banks will also be established. We expect improved seed to be available approximately 8 to 10 years following planting of seed orchards. To date we have completed 49 individual tree selections in these regions.

A second cycle orchard will be established by using propagules from select clones of exceptional breeding value, as evaluated by open-pollinated progeny testing.

RELATED RESEARCH

In addition to our activities in the tree improvement program, the Alberta Forest Service is conducting a number of species trials. Presently we are testing sources of tamarack (*Larix laricina* (Du Roi) K. Koch), black spruce (*Picea mariana* (Mill.) B.S.P.), ponderosa pine (*Pinus ponderosa* Laws.), alpine larch (*L. lyallii* Parl.), whitebark pine (*P. albicaulis* Engelm.), Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco) and Siberian larch (*L. sibirica* Ledeb.).

Provenance Trials

Provenance trials are being established throughout the Province, for the purpose of determining tolerance limits for geographic movement of sources of major tree species such as white spruce, black spruce and tamarack. The information gained from these trials will:

(1) assist us in objectively establishing breeding region boundaries
(2) assist us with the final revision of the provincial seed zone map
(3) assist us in identifying superior seed sources that may be prescribed for reforestation, particularly in black spruce and tamarack (no breeding program is currently planned for these species)

Seed Production Tests

Because of the periodicity problem with white spruce, we are attempting to enhance seed production through three methods. The first involves the application of fertilizers to thinned stands. The second involves a number of physical stress treatments to trees such as topping, girdling, root pruning, etc. The third involves the movement of grafted stock to more stressful climates. At present we are surveying the warmer, drier areas of Alberta to locate possible sites to establish these tests. We already have some grafted material represented in interior B.C. through the kindness of Gyula Kiss of the B.C. Forest Service.

Cone Crop Protection

Another important aspect of white spruce seed production is the problem of yield. At present we can expect to loose out of any given crop 30-90% of our seed due to insect damage (spruce seed worm, spruce cone borer, and cone worms). Procter & Gamble Cellulose is presently conducting tests with the chemical furadan (a systemic insecticide) to attempt to reduce the seed loss. The chemical has been applied directly to mineral soil in two field trials, and is dissolved and leached into the soil by rain. Uptake of the chemical is being monitored by liquid - gas chromatography of cone and foliage samples. Results are expected to be available this fall.

Fertilization

Fertilization experiments in lodgepole pine and white spruce plantations have also been established by Procter & Gamble Cellulose. The pine have shown an excellent response to 100 lbs. per acre of 34-0-0 applied to 2 year old plantations.

SUMMARY

In summary, the first operational benefits from the tree improvement program will be realized in the mid 1990's with adequate quantities of seed expected to be available from most of the lodgepole pine and white spruce seed orchards. Our estimates of productivity gains are presumed to be conservative, but we expect they should be on the order of 15-25% in spruce and 20-25% in pine.

DISCUSSION

Crown: With the evidence you have from those shelterbelts in southern Alberta why would you even consider Grande Prairie as a location for seed orchards?

Holmes: Because of its proximity, it is useful to have your orchard close to where you're going to use the seed. For our main lodgepole pine program we're buying land for a seed orchard near Grande Prairie now. For white spruce, we are planning to establish tests in Grande Prairie as well as in southern Alberta to obtain information on seed production potential of grafted stock in both regions.

Stipanicic: Have you many provenances of Siberian larch?

Holmes: That particular stock illustrated is from an unknown source. The larch program is mainly undertaken by the Alberta Forest Service.

Dhir: Much of the Siberian larch growing in Alberta is found in small amenity plantings. Only recently we recognized potential usefulness of this species for reforestation. The earliest plantings of Siberian larch in Alberta date back to around 1925. We have considerable interest in this species and are trying to procure a collection of seedlots from the U.S.S.R. through the Petawawa National Seed Centre; it is almost 3 years since our request was passed on. Also, we have procured Siberian larch seed from a seed orchard in Finland.

GENETIC IMPROVEMENT OF JACK PINE IN NORTHWESTERN QUEBEC

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The latest objectives of the Quebec Department of Lands & Forests artificial regeneration program will require a total of about 1 900 kilograms of jack pine seeds annually, beginning in 1983. Of this amount, 94% will be used for direct seeding and the rest for planting. It is expected that improved seeds from seed orchards will be used only for plantations. With such a large amount of seed needed, it is imperative that the best stock be used to ensure the highest fibre yields in the future forests grown in short rotations.

The object of this paper is to present a practical program for the genetic improvement of a population of jack pine from Northwestern Quebec, the goal being to produce improved seed to meet a part of the needs of this region of the province.

STRATEGIES FOR THE IMPROVEMENT OF JACK PINE

Results of a provenance test conducted in western Quebec by the Petawawa Forest Experiment Station identified a superior stand of natural origin growing along the Côte Jaune Creek, to the west of Lake Baskatong (Fig. 1). Seeds from this source could be used roughly within the limits of forest section L.4B and the northern part of L.4C in Quebec (Yeatman 1976).

It was decided that about 120 hectares of this stand would be reserved as a seed production area. In this area, access strips 6 m wide were cut every 40 metres. Cones were collected during logging operations. The stand between the lanes was thinned to encourage crown development and cone production on the remaining dominant and co-dominant trees. When cones are required from this particular area, a portion of the stand will be cut and the site regenerated from this seed.

Selection of Trees

During the summer of 1974 and 1975, 325 plus trees were selected in the Côte Jaune area according to the guide prepared by the Quebec Department of Lands & Forests (Lamontagne 1973). For each plus tree, 3 comparison trees were identified in order to provide some measure of superiority of the selected tree to other dominant trees nearby. A total

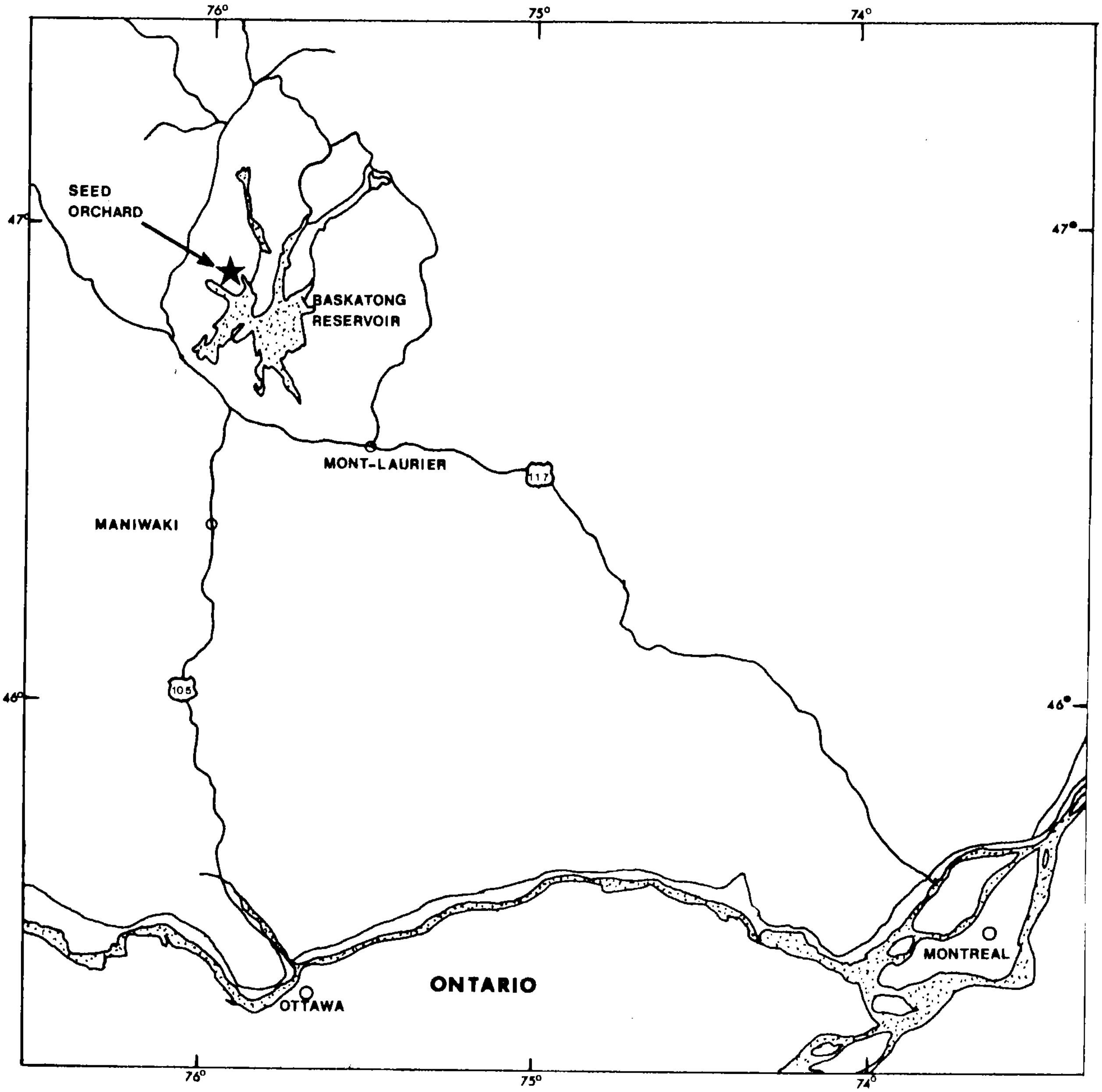

FIGURE 1 : LOCATION OF THE BASKATONG JACK PINE SEEDLING SEED ORCHARD

of 1 300 trees were then selected, marked, measured and recorded. The selection was made by students, both girls and boys, working in a crew of 3. They were trained and supervised by C.I.P.'s personnel under provincial government financing. Each crew was instructed to select the best individual tree per 0.4 hectare (acre). The whole stand was thus systematically surveyed except for some areas where the general quality of the stand was low.

Plan for Orchard and Progeny Tests

In order to further upgrade the genetic quality of the stand, a meeting was called with interested organizations to plan an improvement program in order to best utilize the trees already selected. Representatives of the Petawawa Forest Experiment Station, the Canadian International Paper Company and the Quebec Department of Lands & Forests then met in Maniwaki in the fall of 1975. The proposed scheme was further accepted by authorities of the Quebec Department of Lands & Forests. The program includes the creation of a 40 ha seedling seed orchard, the establishment of two progeny tests and two clone banks for further controlled breeding (Fig. 2).

Collection of Cones and Scions

The collection of cones and scions began in December 1975 with a crew composed of C.I.P. and Lands & Forests personnel. Each selected tree was felled in order to ease the job of collection. The cones (kept separate by trees) were shipped to the extraction plant located at Berthierville. The scions were placed in plastic bags with snow, identified by tree and shipped to the Research Branch of the Quebec Department of Lands & Forests and to Petawawa Forest Experiment Station where they were kept frozen until grafted.

Cone and Seed Characteristics

All the cones in each tree were collected. Upon their arrival at the extraction plant, they were separated into two groups: current year (yellow cones) and those more than one-year-old (grey cones). Seed was extracted separately for these two groups. The results are presented in Table 1. Seed extracted from current year cones is generally bigger than that from cones aged more than one year, as shown by the weight of 1,000 filled seeds and the number of filled seeds per kilogram. This information might be useful in planning future jack pine cone collections.

TABLE 1. Cone and seed characteristics of the selected jack pine trees.

Observations (mean of 325 trees)	Yellow cones	Grey cones	Total
Mean number of cones/tree	64	191	255
Mean number of filled seed per cone	20.7	18.4	19.5
Mean weight of 1,000 seed (gm)	281,000	301,000	291,000

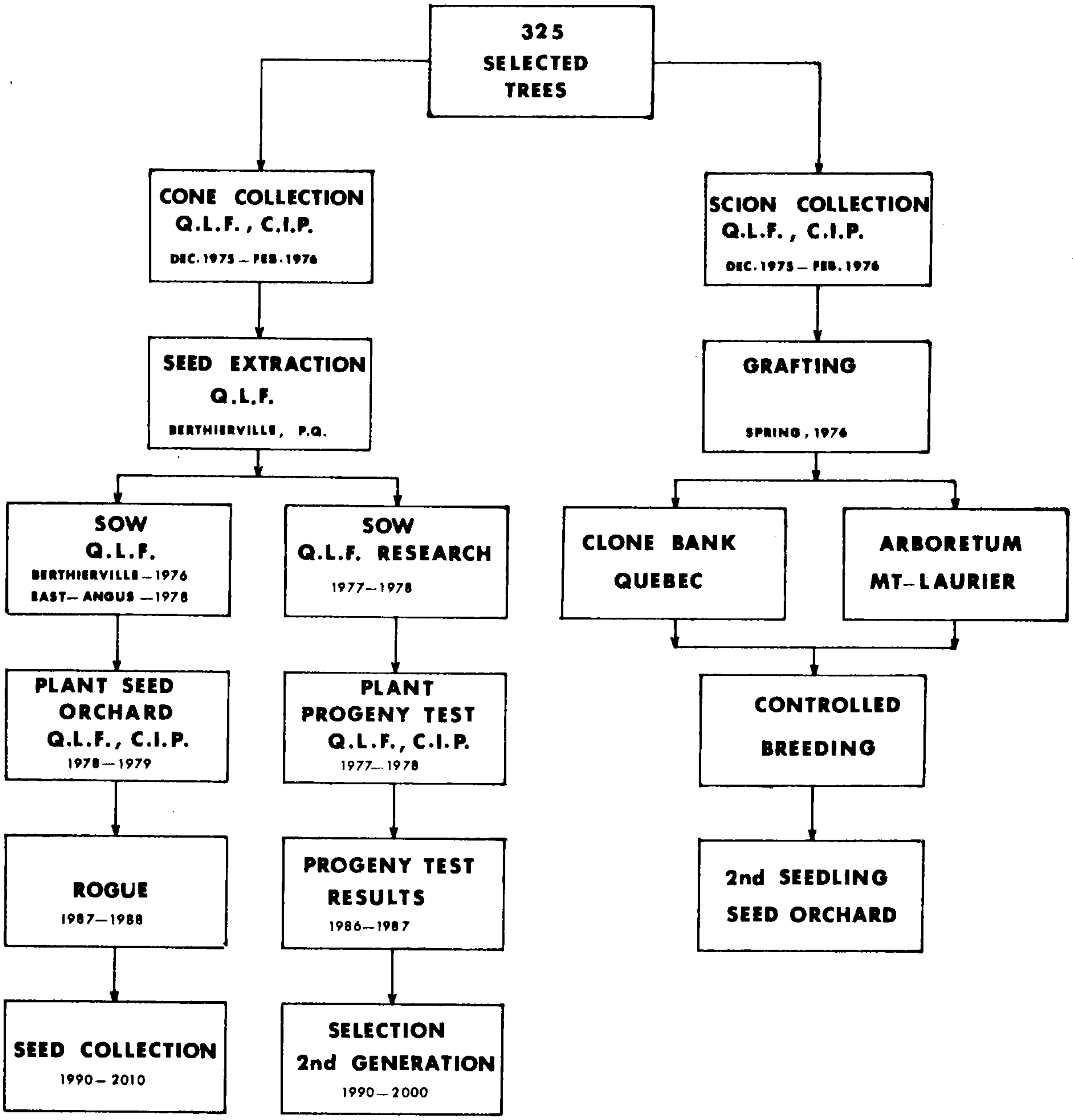

FIGURE 2: FLOW CHART FOR GENETIC IMPROVEMENT OF THE CÔTE JAUNE (QUEBEC) JACK PINE PROVENANCE

NOTE: Q.L.F. : QUEBEC DEPARTMENT OF LANDS AND FORESTS

C.I.P. : CANADIAN INTERNATIONAL PAPER COMPANY

Seedling Production

It was orginally planned to extend the plantation over four years at a rate of ten ha a year. Since the orchard site was ready earlier than expected and since a greenhouse was available for seedling production, it was decided to make two productions of seedlings to accelerate the program: one bareroot production at the Berthierville nursery and a container production at the East-Angus greenhouse complex.

At the Berthierville forest tree nursery, seed from 302 families was sown in the fall of 1976. Germination was very good but unfortunately, a number of seed from some 70 families was lost due to a partial flooding of one seedbed during the spring of 1977. At age 2-0 (1979), the seedlings were lifted, culled, packed in bundles of 30 and shipped to the planting site.

For the production in containers, seed of 272 families was sown during the winter 1977-78 in Japanese paperpots (FH 508) in order to get about 200 seedlings from each family. These seedlings were packed according to the orchard design before shipping and were ready for planting in the spring of 1978.

All the seedlings needed for the orchard were then produced within two years instead of four.

Planting Sites

The seed orchard is established on two large areas about 3.2 km apart in the same stand where the selection of trees was made. One area is about 30 ha and the other about 22 ha.

Both areas were cleared and seed was collected from felled trees. The sites are located on a sandy-loam soil with a good drainage. The original stand in which the selections were made surrounds the orchard providing an effective barrier to possible outside lower quality pollen which might contaminate the orchard.

The sites are accessible by a good forest road system and are located near a river which provides water for fire protection and for other uses like pesticide application.

Orchard Design and Plantation

One part of the orchard (Part 1) was planted in the spring of 1978 with the seedlings grown in containers. It was divided in three blocks. In block one, five seedlings of 261 families were planted in 20 replications for a total of 26 100 seedlings. In block two, four seedlings, 211 families replicated 20 times were used for a total of 16 880 seedlings. In block three, 5 976 seedlings were planted without any design and identification as to which family they belong. A total of 48 956 seedlings were planted in Part 1 of the orchard. Spacing was 1.5 m in the row and 3.0 m between rows. This spacing allows for further thinning and mechanical cultivation between rows. The distribution of families within each replication was done by a computer. During planting the seedlings were kept in their shipping boxes and watered every day. Each family is identified in the field and the whole plantation is mapped. Planting was done with planting guns and the paper around the roots was taken off before putting the seedlings into the ground.

The second part of the orchard (Part 2) was planted in the spring of 1979 using the bareroot stock. This area was also divided in three blocks. Thirty seedlings per family were used instead of five. This has proved to accelerate the planting time but permits some inbreeding among progenies of the same family left after thinning.

In block one, 179 families were replicated five times for a total of 26 850 seedlings used. Only two replications for each of the 179 families were used in block two. In block three, 13 060 non-identified seedlings were planted. A total of 50 650 seedlings were thus planted in orchard two. Spacing was identical to that in orchard one, i.e. 1.5 m on the row and 3.0 m between rows. The total number of seedlings in both orchards was close to the 100 000 that was previously planned.

Survival in Plantations

An evaluation of the plantation was done by officers of the Department of Lands & Forests according to a standard procedure in order to estimate survival percent. Four months after planting, survival in the 1978 plantation (container seedlings), was 72%. The other seedlings were either dead, missing or strongly deficient. Survival may have been higher if the seedlings had been bigger at time of planting. For the bareroot stock plantation in 1979, survival was close to 90%. Other survival data are to be collected next year.

Future Plans

According to the original plan, the seedling seed orchard will be rogued 10 years after establishment. It will be rogued following the results of the progeny test conducted on the same site by the Research Branch of the Department of Lands & Forests. Up to 50% of the poorest families could then be eliminated. The best individuals within the best families will be kept in the orchard.

Other Aspects of the Program

Five progeny tests were originally planned to be established by the Research Branch of the Department of Lands & Forests. Of these, only two have been established. One is adjacent to the orchard at Côte Jaune and was established in 1977. There are 282 progenies, 6 seedlings per progeny and 9 replications for a total of 15 228 seedlings in this test. First year survival was 66%. In the second test established near Mattawin (Lat. 47°07'40", Long. 73°12'45") in 1978, 242 progenies, 6 seedlings per progeny and 10 replications for a total of 14 520 seedlings are represented. Survival after one year is much better and is about 90%. The results of these tests, particularly from the one from Côte Jaune will provide valuable information for roguing the orchard.

Scions were also collected form the selected trees in order to retain them in clone banks. Both the Quebec, Lands & Forests Research Branch and Petawawa Forest Experiment Station agreed to establish these banks. Unfortunately, due to poor rootstock and the long period of scion storage, success was very poor by both organizations.

Of the two banks anticipated by the Quebec Lands & Forests Research Branch, one has been established near Quebec City and another small one is planned near Mont-Laurier when more material is available. They will serve future breeding purposes. The two clone banks anticipated by the P.F.E.S. had to be abandoned for the reasons mentioned above.

CONCLUSIONS

This seedling seed orchard is a good example of government-industry cooperation for the improvement of forest trees. It is also a good example of how research results can be applied for large scale seed production.

It is hoped that future improvement or other forestry work will be conducted the same way by all interested organizations.

I wish here to extend my sincere thanks to all cooperators in this program.

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DISCUSSION

A member: When you planted the orchard with container stock, you used five seedlings per family and so many replications and so on, using a computerized design; how many man-days did it take you to plant that orchard and what types of problems did you have arranging the families?

Lamontagne: When you're dealing with close to three hundred families with five trees per plot you get all sorts of problems - such as how to identify the plots, how to get the trees planted in a day and so on. Can someone from the Research Branch give us an idea how to plant so many seedlings and keep track of them?

Rauter: Our field people don't like to handle these complicated designs either. We're going to have to get into large volumes of jack pine and black spruce in the future.

Yeatman: The main approach that I've taken is to divide the orchard program into two parts. Firstly, an A-class orchard, relatively small and densely stocked when planted, but with families identified so it can be subjected to intensive family and individual tree selection. The seed from this orchard will be used to grow planting stock for prime sites and to establish the next generation of mass selection, or B-class orchard. The first generation B-class orchard is created from bulked open-pollinated seed of plus trees and on a relatively large scale. Close initial spacing will permit mass selection for growth, form and absence of disease. It should be designed to produce seed in quantities sufficient for direct seeding. Thus there are two levels of improvement carried on simultaneously and interdependently. The genetic gain from the intensively managed A-class orchard will be reflected within half a generation in the mass-production B-class orchard. In view of the difficulties related to size and numbers of seedlots and trees, I congratulate Mr. Lamontagne on the remarkable job of seedling orchard establishment at Côte Jaune.

Rauter: One alternative is to label it in the nursery instead of worrying about computer designs and trying to place them in the field. If they're packaged by replication you can randomize as the trees are planted in the field. The critical time is the amount of time it takes to plant in the field.

Lamontagne: We intend to do something similar to this next time.

Rauter: In a couple of years we'll be getting into large sizes of progeny tests consisting of thousands of trees. We plan to site prepare the land, to furrow it to give you one line so you wouldn't have to go in and pre-stake an area. With the small test plantings it was fine for us to go in and pre-stake because we didn't have many trees to deal with. With thousands of trees you can go in and line up, plant it randomly and map after planting. This is a quick way of getting around these massive planting problems.

Lamontagne: We have to do this in the future because the current way of doing the work causes tremendous problems.

Klein: We have established progeny test plantations with 216 entries and about 10 000 trees using Spencer-LeMaire trays and just labelling the trays with block numbers - they get planted in the order they're arranged in trays - so that all the arranging is done in the greenhouse.

THE NEW BRUNSWICK TREE IMPROVEMENT COUNCIL

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Keywords: Applied tree improvement, tree improvement cooperatives, black spruce, white spruce, jack pine, tamarack.

ABSTRACT

The New Brunswick Tree Improvement Council is composed of nine pulp and paper companies, the University and the provincial and federal governments. The Council's objectives are: (1) to provide well adapted seed initially, (2) to provide sufficient quantities of genetically improved seed. The organization and operation of the Council is discussed. The program and progress to date are outlined with reference to the objectives. Black spruce and jack pine are being improved through the seedling seed orchard and half-sib progeny test approach, while with white spruce and tamarack we use an intensive individual tree selection and clonal orchard approach. The problem of disparities in the tree improvement efforts of the individual agencies are discussed and possible solutions mentioned.

ORGANIZATION AND OPERATION

In response to requests for tree improvement information from individual agencies within New Brunswick during the early 1970's, the Maritimes Forest Research Centre suggested that a cooperative be formed to foster and undertake the improvement of stock used in reforestation programs within the Province. By the fall of 1976, nine pulp and paper companies and the provincial and federal governments had agreed to the principles of a cooperative effort to provide genetically improved seed. In January 1977, the first meeting of the New Brunswick Tree Improvement Council was held, terms of reference, objectives and species' priorities were established.

Member's participating in the Council are:

Acadia Forest Products Ltd.
Boise-Cascade Canada Ltd.
Consolidated Bathurst Ltd.
Fraser Companies Ltd.

Georgia-Pacific Corp.
J.D. Irving Ltd.
MacMillan Rothesay Ltd.
New Brunswick International Paper Co. Ltd.
Valley Forest Products Ltd.
Faculty of Forestry, University of New Brunswick
New Brunswick Department of Natural Resources (DNR)
Maritimes Forest Research Centre (MFRC)

Objectives

The two main objectives of the Council are:

1. to provide an adequate supply of seed of good quality from known local sources until such time as seed orchards satisfy demand;

2. to provide sufficient quantities of genetically improved seed to meet the demands of reforestation in the Province.

Initial emphasis will be placed on black spruce (*Picea mariana* (Mill.) B.S.P.), white spruce (*P. glauca* (Moench) Voss), jack pine (*Pinus banksiana* Lamb.) and tamarack (*Larix laricina* (Du Roi) K. Koch) with likely expansion to other species as the need arises.

Structure and Organization

The structure of the Council is informal and is not incorporated. It is organized and coordinated by a management committee chaired by the Department of Natural Resources. Each participating agency has one representative on this committee who, for industrial agencies, is usually at the chief forester level. Maritimes Forest Research Centre provides the technical planning and assistance through the services of a tree breeder who acts as technical coordinator and secretary to the management committee.

At present there are four separate projects, each dealing with a particular tree species (black and white spruce, jack pine, and tamarack). The Department of Natural Resources participates in all ventures while the industrial agencies take part in, or contribute to, those cooperative projects of direct concern to them. For each species project, the technical coordinator establishes and presents to the management committee, for approval, the work-, cost-, and benefit-sharing arrangements for each year.

Agencies are not required to make a financial contribution, *per se*, to the Council. Rather, each agency involved in a species project is asked to contribute to the pool from their respective landholdings, plus tree selections, cone and scion collections, and the outplanting of stand and progeny tests. Orchard establishment is an option if the individual agency's reforestation program warrants it. The Department of Natural Resources assumes the responsibility for producing the seedlings for the tests and orchards in their tree improvement complex. When this capacity is insufficient, as was the case in 1979, one or more of the industrial cooperators may assist in seedling production.

PROGRAM AND PROGRESS

Seed Production Areas

To meet the first objective, that of supplying an initial source of well-adapted seed, the Council has concentrated on black spruce and jack pine, the preferred species of the present reforestation program. Both species occur in large even-aged stands which lend themselves to development as seed collection areas. Forty-three good black spruce stands and 44 good jack pine stands have been selected and reserved by cooperators throughout the Province. In the fall of 1977, seeds were collected from 20 or more individual dominant trees well spaced throughout each stand. Greenhouse production of seedlings was completed in DNR facilities by mid-June. Six black spruce and eight jack pine stand tests were established by Fraser Co., Georgia-Pacific, J.D. Irving, MacMillan Rothesay, New Brunswick International Paper, Valley Forest Products, and DNR on their respective lands. Early results will indicate which of the original stands are the best sources of seed for particular areas of the province. These stands, if young enough to respond to treatment, may be thinned and fertilized for conversion to seed production areas and a portion will be cut during seed years. These seed production stands will provide quality seed which will be well adapted to local conditions. Limited genetic improvement is anticipated once the best stands have been identified in the stand tests.

Breeding

To meet the second objective of providing genetically improved seed we have employed breeding methods to match the species. For black spruce and jack pine we are using low-intensity selection, half-sib progeny tests, and seedling seed orchards. For white spruce and tamarack we employ high-intensity selection with clonal orchard establishment which will be followed by full-sib progeny tests.

Black Spruce and Jack Pine

Both black spruce and jack pine occur in fairly large, relatively even-aged stands often of fire origin and both species are capable of early cone production with proper management. Our selected individuals must exhibit superior height growth. Black spruce usually has an acceptably straight bole and compact efficient crown while in jack pine we are placing more emphasis on selecting for straight stem and fine branching habit. This necessitates a different selection method in the field for the two species. For black spruce we are evaluating height and diameter growth against other stand dominants while for jack pine we are comparing height growth, stem straightness, and crown form with five nearby comparison trees. To date we have selected approximately 200 individuals of each species for our progeny tests and orchards. Progress, particularly in black spruce, has been hampered by a lack of cone crops. Our black spruce plus trees have approximately a 12.8 percent height advantage over the stand dominants, while in jack pine we have found an 8.3 percent height advantage over the comparison trees. Four agencies have now established a total of 20 ha of black spruce seedling seed orchard and two agencies have established with 2 m spacing between the rows, 1 m spacing within the rows and every 10th row is left unplanted for road location. The Council has about 30 ha of half-sib progeny test in the ground. Design of the tests is 10 randomized-block replications of 4-tree row plots planted at 2 m spacing. We expect to expand our black spruce selections by about 400 individuals this fall as we have a reasonably good cone crop.

White Spruce and Tamarack

A different approach to improving white spruce and tamarack is desirable because of the suspected higher heritabilities of the most important selected traits. Emphasis is on locating a small number of phenotypically superior individuals followed by the establishment of clonal seed orchards. White spruce crown form and stem straightness vary considerably between individuals and can be improved through selection. Tamarack has a notoriously crooked bole, so great gains can be expected in stem straightness. The selected individuals must also exhibit excellent volume growth. We are employing the comparison tree selection method for white spruce and tamarack. Because of the scattered location of both species it is often difficult to find five comparison trees on a similar site and in a competitive situation. Our white spruce selections have averaged 9.7 percent height advantage over the comparison trees while for tamarack we have found only a 3.9 percent height advantage but many of our individuals are almost straight. To date, about 40 white spruce and 30 tamarack have been selected. Scions have been collected and grafted at MFRC's Acadia Forest Experiment Station. By 1982, small clonal orchards of both white spruce and tamarack should be established and will be expanded as new selections become available. Extensive controlled breeding programs within these orchards and the resulting progeny tests will provide information with which to rogue the orchard and will provide seedlings of known parentage for future generation orchards.

The consistently good performance of white spruce provenances from the Ottawa Valley region of Ontario over much of eastern Canada has prompted the establishment of "local" sources of Ottawa Valley seed. In 1978, DNR planted an 8-ha seedling seed orchard composed of approximately 75 individual tree families from the Ottawa Valley region. This was expanded this spring to include an additional 40 families. At the same time, we have outplanted four progeny tests of this material.

It appears from local plantations of Japanese and European larch and their hybrids that they may have a place in reforestation in the more temperate areas of New Brunswick. Therefore, the Maritimes Forest Research Centre is actively conducting a breeding, selection, and grafting program with the material that is available, and two small clonal seed orchards have been established.

An establishment report for each orchard test is published by the Maritimes Forest Research Centre for the cooperators under a New Brunswick Tree Improvement Council cover. The report contains information on seed sources, seedling production and test establishment and is in loose-leaf form so that results may be added as they become available.

COSTS

Council members keep a precise record of costs and time required for each specific task. From this, we are able to accurately establish a budget for the coming year which is distributed to the agencies for financial planning.

Plus tree selection costs which include wages, transporation, lodging, and equipment, vary with species. For black spruce and jack pine our cost per tree is between $175 and $225, while for white spruce and tamarack the cost is approximately $500 per tree. Costs of establishing seedling seed orchards and progeny tests are about $1500 per hectare. Progeny tests require a large proportion of time for the layout while for orchards considerable time is needed for tagging the individual seedlings and mapping.

PROBLEMS

There is a great diversity between the agencies in land control, both freehold and lease, and hence disparities in the reforestation and tree breeding efforts. This is unfortunate and is the cause for the Council's rather tenuous or fragile existence. The Province controls about 50 percent of the land and is very active in tree improvement. Among the three industrial agencies with substantial freehold land there is some variation in effort but two have now budgeted money for tree improvement. The three industrial agencies with smaller amounts of freehold land are contributing proportionately. The problem arises with the remaining three companies which have virtually no freehold land. As they operate solely on crown land, they feel that the Province should be responsible for tree improvement and therefore they contribute very little. Because tree improvement work in the Province is not tied to the terms of a crown license nor is there a contractual commitment to the Council, there is little that can be done. No one wields a big stick. Another disadvantage of an informal cooperative with no financial commitment is the lack of funds available for applied research projects such as specific gravity determinations and enhancing seed production. However, there are options for changing this situation and these are being discussed. The Council may perhaps become incorporated, with firm monetary commitments from each agency. Also, the system of tenure on crown lease is currently being reviewed and there is a possibility that intensive management will be a condition of receiving a crown license.

Efforts are currently being made to establish a New Brunswick Forest Research Committee, which would be composed of senior management of all major forestry agencies in the Province and which would function as a steering committee for the Tree Improvement Council as well as examining other forestry Resource and Development needs. Hopefully, this committee will be able to exert some influence on non-active members of the NBTIC.

An initial problem was lack of knowledge among the cooperators of even basic tree improvement techniques and terminology. This stems partially from the almost total lack of tree breeding courses offered by universities. This problem is being overcome as more forest genetics courses become available at the University of New Brunswick and agency personnel attend tree improvement workshops and conferences.

Despite these problems the Council has made excellent progress in planning a coordinated program and in initiating work on the first phases of that program. Cooperation and participation by member agencies have, in most cases, been good and we are now confident that this undertaking will benefit the reforestation effort in New Brunswick.

DISCUSSION

Burry: This Upper Ottawa Valley source of white spruce seed that you were using in New Brunswick to establish your seedling seed orchards; have they run out of that yet?

Fowler: It's always been rather difficult to get seed. The Ottawa Valley has been identified as a very promising seed source of white spruce for use over a very wide part of its range and in most tests it has shown up very well; in the northern Lake States, almost up to Manitoba, Ontario, the province of Quebec and in the Maritimes.

Burry: It has here as well (i.e. Newfoundland).

Fowler: Yes; and everyone wants seed of course and I think Lands and Forests (OMNR) is getting all the seed they can get.

Rauter: We aren't getting a lot because of budworm damage.

Fowler: It is difficult to get seed. We ended up with a hundred and seventy-five different families in an eight hectare orchard.

Swan: Can you tell me if that considerable sum of money, some four hundred thousand, was that all put up by Fraser?

Fowler: No, most of the companies in the region are contributors.

THE TREE IMPROVEMENT PROGRAM IN NEWFOUNDLAND AND LABRADOR

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Province of Newfoundland and Labrador

In 1979 the Forest Improvement Steering Committee approved the Terms of Reference for the Newfoundland and Labrador Tree Improvement Working Group (N.L.T.I.W.G.). Along with the formation of this group it is the first time that the Forest Service has been involved with tree improvement programs. All previous tree improvement work has been undertaken by the Canadian Forestry Service.

TERMS OF REFERENCE

Objectives

The Tree Improvement Working Group will plan, organize and conduct a research and development program in support of Provincial Programs to produce, at the earliest possible time, adequate quantities of genetically improved tree seed. As an interim step, the Group will also advise the Province on measures necessary to improve the source of seed used in current reforestation programs.

Program

Within the framework of the above, the Tree Improvement Working Group will:

1. Identify genetically superior individuals and populations of indigenous species.

2. Establish seed zones and seedlot registration systems.

3. Evaluate and advise on the potential of exotic species for reforestation in Newfoundland.

4. Develop criteria for the establishment and treatment of seed production areas.

5. Develop methods to enhance seed production.

6. Identify and advise on the research and technological development necessary for the establishment of seed orchards.

Organization

The Tree Improvement Working Group will report to the Forest Improvement Steering Committee and will consist of four members; two to be appointed by the Canadian Forestry Service for two year terms, and two to be appointed by the Department of Forestry and Agriculture for two year terms. The Steering Committee, from time to time, may appoint additional members. Since the implementation of the program is a Provincial responsibility, the Chairman of the Working Group will be one of the Province's representatives.

GENETICALLY UNIMPROVED SEED

Included in this categroy are all native species to be used in reforestation. Although it may be disputed, we have included seed production areas in this category of "unimproved" seed.

The main emphasis will be towards the selection of phenotypically superior stands of black spruce and white spruce in major commercial forest areas as seed production areas and seed collection areas.

As is the case across Canada, genetically unimproved seed from natural stands will provide the bulk of seed to be used in this Province's reforestation program in the immediate future.

Because of the difficulty of collecting cones from older stands of black spruce, it will be more economical to patch-cut a designated seed production area. As the original stands are felled for cone collection, the cleared areas will be replanted with progenies of local trees, thus maintaining the seed origin. Such a program will be spread over a decade or two by which time these stands will be producing seed in quantity.

Because of the scarcity of white spruce in certain regions of the island, it may be necessary in certain instances to reserve some mature stands indefinitely for systematic seed procurement. Normally, such stands would be reserved for cutting only until they produce a good seed crop.

GENETICALLY IMPROVED SEED

Black spruce will be the major species used in this Province's reforestation program and as such will require the bulk of tree improvement funding. The Department of Forestry and Agriculture has identified the black spruce forests as being in greatest need of regeneration assistance following logging.

The status of white spruce, in terms of being part of a Tree Improvement Program, has not as yet been clarified. It is generally felt that white spruce would out-perform black spruce on the very high capability sites. However, the fact that it is a favoured host of spruce budworm (*Choristoneura fumiferana* Clem.) seriously reduces its potential

4. Seed orchard location and site preparation will begin in 1980. We are suggesting, to minimize contamination from background pollen, to establish seed orchards in areas where the existing forest is comprised of a different species. It was considered that although physical isolation is often stressed, it would appear to be impractical for our purposes. The establishment of sites for clone and seedling banks will also begin in 1980.

There are two points of which I would appreciate further clarification:

a) What is the present status of the "superseedling" approach in the Nursery to establish seed orchards in black and white spruce?

b) We are recently informed that white spruce rootstock proved superior for grafting, even for black spruce. Is this statement accurate?

DISCUSSION

Gordon: It always excites me listening to the enthusiasm of the competing industries on the West Coast and it seems to me that it might be worthwhile for your working group to enquire into the possibility that industry may want to take a different look. It seems that in the long run forest industries will want their own nurseries and you should encourage their cooperation.

Burry: Well, the position of the Forest Improvement Steering Committee is that they had no objection to the idea of industry being involved - they just don't like the idea of a cooperative.

Gordon: Yes, but what you call it is semantic - you called it a working group for instance. It may be worthwhile in having someone go out West and see how things are being done there.

Fowler: Has anyone ever approached Bowater or Price to see if they are really interested in it?

Burry: Anything that involves a cooperative won't be a decision of our working group - it will be a decision of the Forest Improvement Steering Committee. If I report to them that a cooperative should be formed, they either say, yes or no, and in this case they said no.

Gordon: Well, I can think of many ways to put a so-called co-op together. It seems to me to be within the bounds of human imagination that one can get an organization, let's say call it a council, which doesn't act like a cooperative. It's apparent that in the West they have a march on the East in tree improvement and almost every company has a good record in it.

Devitt: Part of it grew from a restricted funding and the fact that there was just no way that two people could go out and survey all the fir stands that were available and select good plus trees. It was from the need for continuous funding that everybody got together and decided to act. I don't know how many species you're talking about here but even now the list of species that we have to deal with is large. Everybody puts priorities, and you can start listing them off - white pine, Abies grandis, Abies amabilis. From Mike Crown's presentation, including overlays, it's obvious that no one agency can cover it all.

Rauter: There's one thing that should be brought up and that's the Land Tenure System. If a company owns land then it's a lot easier to get into the system. You will have to have new laws instituted and some changes made if you want a company which is strictly on a tenure system and is leasing the land to cooperate. The companies will have to be reimbursed or an acceptable system must be set up so the program can be justified to the stockholders.

Devitt: It's not without its problems but these problems are being overcome.

Rauter: This is when you have to approach your administrators to overcome some of these problems.

Devitt: That is why I made the comment about the need for the team to be all working in the same direction. It's all very well for the research group and the management group to decide to have a seed orchard and get everybody involved and go out and do it. But then someone in a regulatory role says you can't do it.

Just one last comment; one of the big needs in my regeneration program is seed and I don't know how nature provides your seed crops here but 1966 was the last Douglas-fir seed crop that was really collectable and before that it was 1959 and before that, 1945. We have some huge gaps and you can't wait 15 years for a seed crop. Thus, a lot of the company effort is strictly seed supply so you can carry out reforestation programs and if you are successful in that area you can sell it and then the genetics part of it comes later.

Yeh: I think one of the problems is that as foresters we have been working backwards; the researcher has been going to the administrator and saying that we are predicting so much gain. They reply "how are you going to prove that". The case in B.C. has changed recently because the management has come to the researcher and said "we would like to have that much gain in the approximate year" and now we can make plans and state "that is the amount of gain we can obtain providing you fund us at that level". I think that's the case now and it's much easier for us to justify tree improvement that way.

Chairman: Yes, there is a very subtle change here in the approach taken but it's a very important one.

Kellison: One thing that Don Fowler said that would concern me and it was that with the selection and the progeny testing the correlation wasn't very good and if that's so then you may need a whole different breeding system. Because, if you're not getting that correlation then you're not operating on additive genetic variance and that creates problems.

Fowler: I think that was more for black spruce than the jack pine.

Kellison: It was black spruce.

Fowler: Yes, but the reason that we're not very effective is the type of landscape in which we're selecting black spruce, in the intermediate areas we're on this hummock/hollow topography so the environment forms a major component. On the basis of progeny tests we're getting good heritability estimates but we don't have the parent progeny correlation indicating that we're not very efficient in our selections in the wild.

Kellison: If environmental effect is that strong you're just as well going out collecting seed from trees at random.

Fowler: Just picking out a thousand trees, yes, I suppose it's a level of confidence you're willing to put in your selections. I'm sure we're making some gains but whether you're willing to put the effort into very high intensity selection, and I'm not, I think we're going to make more progress relying primarily on progeny tests to identify best growing families and go on from there.

Kellison: I would agree under your situation.

Fowler: In jack pine I think the main improvement one is going to make during the first cycle of selections is in stem form and crown form and branching rather than growth. Would you agree with that?

Yeatman: Yes, also there is some heritability for growth but this is best covered through the progeny test (family performance). I believe that the form characteristics do have quite a high heritability so that the selection you're exercising in the forest will be effective for these traits.

TREE IMPROVEMENT IN NEWFOUNDLAND 1977-1979

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I. TRIALS OF EXOTIC SPECIES (J.P. Hall)

1. Plantation Trial of Larix Species

Results three growing seasons after planting show that the indigenous L. laricina (Du Roi) K. Koch and two provenances of the exotic hybrid L. x eurolepis (Henry) had better survival than the other three exotic species tested - L. sibirica (Ledeb.), L. russica Endl. and L. kaempferi (Lam.) Carr. Vegetative competition from Ribes spp., Rubus spp., and various herbaceous plants is heavy on this typical site, and the seedlings have been able to overcome this competition during the first three years following planting. (Hall, J. Peter, 1978. Survival and growth of planted native and exotic Larix species after three growing seasons. NFRC File Report No. 3, Study 5-3, 4 pages.)

2. Plantation Trial of Exotic Abies Species

Veitch's silver fir (A. veitchii Lindl.) has been shown to be suitable for planting under Newfoundland conditions and is resistant to the balsam woolly aphid (Adelges piceae Ratz.) (Hall et al. 1971). The rate of height growth is approximately the same for both Veitch's fir and balsam fir (A. balsamea (L.) Mill). Since 1975 both species were damaged extensively by the spruce budworm (Choristoneura fumiferana Clem.) and the trees lost up to 90% of their total foliage. In general, damage was greater on balsam fir than on Veitch's fir and since the cessation of budworm attack in 1977, the Veitch's fir have recovered from the attack more rapidly than has the balsam fir (Hall, J. Peter, 1978. Plantation of exotic Abies species: Degree of recovery after spruce budworm attack. NFRC File Report No. 4, Study 5-5, 2 pages.) Work is continuing on this study to explain more fully this apparent greater resistance to budworm attack.

3. Plantation Trials of Exotic Picea Species

In 1970 and 1971 two plantations were established in central and western Newfoundland to compare survival and growth of local and exotic spruces. The following species were planted:

Picea mariana (Mill.) B.S.P.	Badger, Newfoundland
Picea sitchensis (Bong.) Carr.	Bella Coolla, B.C.
Picea sitchensis (Bong.) Carr.	Kitimat, B.C.
Picea abies (L.) Karst.	Vilppula, Finland
Picea abies (L.) Karst.	Region VIII/16, Germany
Picea omorika (Panc.) Purk.	Knuthenborg, Denmark
Picea omorika (Panc.) Purk.	Region VIII/16, Germany
Picea jezoensis Sieb. & Zucc.	Hokkaido, Japan
Picea orientalis (L.) Link.	Jutland, Denmark

Results five years after planting show that _P. mariana_ was most successful in both locations followed by _P. abies_ and _P. sitchensis_. The remaining species, at this stage, show little promise due largely to slow rates of growth (Hall, 1977(a)).

4. Plantation Trial of Exotic _Pinus_ Species

In 1966 a plantation of exotic _Pinus_ species was established in central Newfoundland, to test the suitability of a number of exotics for reforestation purposes. The following species were planted:

Pinus banksiana (Lamb)	Newcastle, New Brunswick
Pinus contorta (Dougl.)	Long Beach, Wash., U.S.A.
Pinus sylvestris (L.)	Morayshire, U.K.
Pinus syvlestris (L.)	Kuorevesi, Finland
Pinus resinosa (Ait.)	Petawawa F.E.S., Ontario
Pinus nigra (Arn.) v. _corsicana_ (Loud.)	Nottingham, U.K.
Pinus cembra (L.)	St. John's, Newfoundland
Pinus albicaulis (Engelm.)	Cranbrook, B.C.

Results 10 years after planting showed the following species to be suitable for planting: _P. sylvestris_ (both seed sources), _P. banksiana_, _P. contorta_ and _P. resinosa_. Best growth in the plantation was achieved by _P. banksiana_ followed by _P. sylvestris_ (U.K.)(Hall, 1977(b)). In 1976 _P. banksiana_ flowered and the cones were collected but only about one viable seed per cone was obtained.

II. THE GENETIC IMPROVEMENT OF LARCH IN NEWFOUNDLAND (J.P. Hall)

In 1977 the NFRC initiated a program for the genetic improvement of larch. Since then, several studies have been established under this program.

1. All-Range Provenance Trial of _Larix laricina_

The NFRC is cooperating with PNFI on an all-range provenance trial of _L. laricina_. Five locations in Newfoundland and Labrador have been selected in which to make collections of seed. Cone crops were poor during the 1977 and 1978 seasons and no collections were made; however, indications are that the 1979 crop is better. It is hoped to establish one or more of the all-range trials in Newfoundland and possibly to combine it with a Province-wide provenance trial.

2. Provenance Trial of *L. kaempferi*

The NFRC has received from PNFI 79 seedlots of *L. kaempferi* which are scheduled to be sown in a provenance trial in 1979. In 1977 and 1978 collections of *L. kaempferi* seed were made from plantations in Newfoundland and this seed will be used in the experiment. In addition, three provenances of *L. laricina* seed collected between 1976 and 1978 will form part of the study.

3. Development of Criteria for the Selection of Plus Trees

This study is aimed at the development of objective criteria for selection of plus trees which can be used to begin a seed orchard. The rate of growth of *L. laricina* varies on different forest sites on the island of Newfoundland and there is considerable variation in growth rate among and within sites, indicating the need for careful attention to selection procedures. The data collected on stem form, crown size and branching habit showed no relation between these phenotypic characters and growth rate. Any selection program at this stage will emphasize rapid growth rate and desirable stem and branch characteristics. Work is also beginning on the heritability of branch and stem characteristics in the species.

4. Yield of Seed in *L. laricina*

The yield of seed in *L. laricina* has been examined in planted and natural stands. Yields of seed vary annually among regions and among trees and indications are that, except in very good seed years (1976 was a good example), the proportion of sound seed in the cones will be very low. Total seed/cone is usually in the range 8-16; but full seed per cone is much less, 0-6 is common.

5. Relationship Between Temperature and Pollen Development

The relationship between pollen development and temperature is being studied in *L. laricina*. It is known that freezing temperatures during active stages of cell division may cause the formation of non-viable pollen and if this occurs on a large scale within a seed orchard, the seed crop can be adversely affected. In Newfoundland it has been shown that the active stages of pollen formation occur in late March to early April when below freezing temperatures are a common occurrence (Hall, 1979). Within that period, however, there is a wide tree to tree variation in date of occurrence of active cell division and, also, in the length of time that trees are in active stages of cell division. Detailed knowledge of these variables would enable selections to be made on the basis of stability of the pollen formation process and emphasize selection of trees which go through the pollen formation process later in the spring when freezing temperatures occur less frequently.

III. THE TREE IMPROVEMENT COOPERATIVE PROGRAM IN NEWFOUNDLAND
(J.P. Hall and M.A.K. Khalil)

In the proceedings of the sixteenth CTIA meeting, a description of the establishment of the Forest Improvement Steering Commitee was presented. The Committee was established to act as a policy advisory group between the two levels of government and industry. The Committee was also empowered to appoint sub-committees to achieve particular defined objectives. From one of these committees (the Regeneration and Tree Improvement Sub-Committee) eventually emerged the Newfoundland and Labrador Tree Improvement Working Group. It was felt by all interested parties that a working group would be the best vehicle to implement the policies in the tree improvement field which are necessary in the overall forest improvement plan for the Province. The working group held its first meeting in March 1979 in St. John's.

The Tree Improvement Working Group is to plan, organize and conduct a Research and Development Program in support of Provincial programs to produce, at the earliest possible time, adequate quantities of genetically improved tree seed. As an interim step, the Group will also advise the Province on measures necessary to improve the source of seed used in current reforestation programs. Within the framework the working group has several specific tasks. These are:

(i) To identify genetically superior individuals and populations of indigenous species.

(ii) To establish seed zones and seed lot registration systems.

(iii) To evaluate and advise on the potential of exotic species for reforestation in Newfoundland.

(iv) To develop criteria for the establishment and treatment of seed production areas.

(v) To develop methods to enhance seed production.

(vi) To identify and advise on the research and technological development necessary for the establishment of seed orchards.

The working group will report to the Forest Improvement Steering Committee and is to consist of four members; two appointed by the Canadian Forestry Service for two year terms and two appointed by the Newfoundland Department of Forestry and Agriculture for two year terms. The Steering Committee is expected to appoint additional members representing the forest industry in Newfoundland. Since the implementation of the program is a Provincial responsibility, the Chairman of the Working Group is a Provincial representative.

The working group had already begun work in some of the above topics prior to the actual formation of the group. Procedures have been established to select black spruce plus trees for use in seed orchards. These procedures are being refined by further experimental work but superior trees are being selected in the field at the same time. Work is still in progress on the introduction of exotic species to Newfoundland and several promising species have been identified. Several seed production areas have been identified and located and management methods are now being developed to treat these areas.

Cooperation among the participants has been excellent to date - an encouragement to the implementation of tree improvement programs in the Province.

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STUDIES ON THE GENETICS OF FIR, SPRUCE AND POPLARS IN NEWFOUNDLAND

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Key words: Black spruce, white spruce, red spruce, sitka spruce, poplars, balsam fir, auxins.

Forest genetics research had started in Newfoundland in a small way in 1964 in an era of complacency in forest management in the Province. The potential of forest genetics in improving forest productivity and in ameliorating forest and urban environments had not been appreciated. Even at the time of revision and expansion of this program by the writer in 1972 (Khalil 1972) the need for intensive forest management had not been fully realized and large scale afforestation or reforestation was neither in progress nor planned. Thus, the stage had not been set for extensive application of the results of forest genetics research to forest management. Consequently, only a modest program had been proposed. Even implementation of this program was seriously hampered by the growing financial restraints. However, as a result of the deliberations of the Forest Improvement Workshop at Gander in February 1976 (Richardson 1976), realization dawned that Newfoundland required bold new forest management strategies to effectively enable forest industry to compete in future world markets. An ambitious forest improvement program has now been initiated to increase fibre and wood production for lumber, pulp, cattle feed and energy. The program is funded by the Department of Regional Economic Expansion. Tree breeding is an essential element of this program. The Newfoundland Forest Research Centre has been urged by the provincial authorities, the Forest Improvement Steering Committee and by its Research Advisory Committee to expand research efforts in tree breeding. However, financial restraints are even increasing with consequent operational difficultures. The work summarized in this and the other report from Newfoundland has proceeded under these restraints. This report summarizes the last two years research on the genetic improvement of spruce and fir species and poplars.

BLACK SPRUCE [PICEA MARIANA (MILL.) B.S.P.]

Regional Provenance Studies

The data of the nursery phase were analysed by regression analysis to study the effect of selected environmental factors of the sites of the provenances on juvenile height growth in an attempt to identify those which contributed most to height growth and to assess the usefulness of the subset as a prediction. The four variables found statistically significant, out of the 54 tested, are: (1) square of the latitude, (2) interaction of the longitude and mean precipitation during the period May-September, (3) interaction of mean number of frost-free days and mean number of days during the growing period, and (4) interaction of the mean number of frost-free days during the annual growing period and the day length on June 21. The results have been published (Khalil and Douglas 1979). The seven field experiments have been maintained and will be measured this yeat at the age of 10 years from seed.

The All-Range Provenance Studies

The three field experiments have been maintained and will be measured next year at the age of 10 years from seed.

The Regional Progeny Studies

The data on the characters of cone morphology and seed weight have been collected and statistically analysed. A paper on the genetics of cone morphology and seed weight of black spruce in Newfoundland is under preparation. Anatomical and physical properties of wood of the parent trees have been determined and the data are being analysed. Chemical analysis of the wood and isozyme analysis of seed is planned for this year.

WHITE SPRUCE [*PICEA GLAUCA* (MOENCH) VOSS]

The Great Lakes-St. Lawrence Region Provenance Study

The results of the 20th year measurements of the experiment in the North Pond area have been published this year (Khalil 1979a). Eight best provenances have been identified on the basis of growth. They are 279-309 cm (105-117% of mean) in height and 35-42 cm (112-133% of mean) in D.B.H. They are similar to each other in taper and have not suffered from frost or winter damage. Consequently, they are being recommended for use in Newfoundland. There is a highly significant replication X provenances interaction which indicates the possibility of enhancing growth by combining good provenances and cultural treatments like fertilizers. Significant within provenances genetic variation exists, which can be used for obtaining additional genetic gains by individual tree selection within superior provenances. There is a strong juvenile-late correlation in growth which makes early identification of superior provenances possible. Further research to verify and use the above conclusions is in progress.

The All-Range Provenance Studies

These studies have been started in the provincial Forest Nursery at Wooddale in cooperation with the Newfoundland Department of Forestry and Agriculture. Seeds of 116 provenances (including 44 provenances with single tree seed) were sown in the greenhouse in April 1978 and transplanted into nursery beds in September of the same year. Three field provenances -

progeny experiments in the lattice design will be planted in the spring of 1980. A three-replicated greenhouse-cum-nursery experiment was also started simultaneously for collection of information on germination, infantile growth and phenology. Collection and analysis of data are in progress.

The Exploits Valley Progeny Studies

The paper referred to in the previous report has been published (Khalil 1979b). Results of progeny tests on plus trees conducted in growth chamber have been analysed and a publication is under preparation. Comprehensive research is planned on terpene and isozyme analyses of "plus", "ordinary" and "minus" trees.

BALSAM FIR [ABIES BALSAMEA (L.) MILL.]

Two experiments were laid out in 1961 to determine the relative role of genetic and environmental factors in the premature retardation of growth in balsam fir on the Avalon Peninsula and in the adjoining area of southeastern Newfoundland. These experiments were located in the Salmonier (lat. 47°14'N, long. 53°20'W) and Cormack regions (lat. 49°19'N, long. 57°23'W) in southeastern and western Newfoundland respecitvely. Both experiments were laid out in the four-replicated randomized complete block design with 144-tree square plots. Four provenances were used, one originating from the problem area on the Avalon Peninsula, and the rest from normal areas in central Newfoundland and New Brunswick. The Salmonier experiment was abandoned in 1970 due to extensive damage from squatters. Height and DBH measurements were made in the fall of 1976 in the Cormack experiment. Statistical analyses of these data did not show significant differences between any two provenances. The results have been published (Khalil 1977).

EXOTIC FIR AND SPRUCE PROVENANCES

The provenance experiment on red spruce (*Picea rubens* Sarg.) and the nine experiments sitka spruce [*Picea sitcheusis* (Bong.) Carr.] in insular Newfoundland were maintained. The former is due for 20th year and the latter for 15th year measurements this year. The results on the 10-year measurement of sitka spruce in 1974 were reported to the IUFRO Working Parties joint meeting at Vancouver, British Columbia in August-September 1978 (Khalil 1979c).

EXOTIC AND HYBRID POPLARS

Four replicated field experiments and the archive were planted again in June-July 1978. The competing vegetation was removed and the areas were scarified and limed at the rate of 7.4 metric tons/ha. Rooted cuttings were used in all cases. The four field experiments were located at Wooddale (lat. 49°09'N, long 55°36'W), Millertown Junction Road (lat. 48°58'N, long. 56°18'W), Goose Arm (lat. 49°09'N, long. 57°31'W) and Robinson River (lat. 48°14'N, long 58°38'W). The archive was located at

Wooddale. The results of the survival count made in September 1978 are summarized in Table 1.

Table 1. Results of survival count of poplars in field experiments in September 1978.

Location	Survival %	No. of clones lost
Goose Arm	53.2	Several in each replication.
Millertown Junction Road	98.6	None in any replication.
Robinson River	90.0	Three clones lost in one or two replications.
Wooddale	98.6	None in any replication.

The survival in the archive was almost complete. These results support the earlier indication that planting of rooted cuttings, removal of competing vegetation, and scarification and liming of the planting site are essential for success in field plantation of poplars under Newfoundland conditions. Casulties were replaced in June-July 1979. Results to date have been published (Khalil 1979d).

Thimann and Delisle (1939) found most conifers and many hardwoods unaffected by the root-promoting effects of auxins although these properties were recognized in 1934 and the technology had been steadily refined. Trembling aspen (Populus tremuloids Michx.) is one such species (Snow 1938; Afanasiev 1939). These negative results and the subsequent success in vegetative propagation from root sections (Farmer 1963; Zufa 1971) discouraged research on the use of auxins on branch cuttings. In recent years trials of exotic and hybrid poplars in Newfoundland necessitated vegetative propagation of the local trembling aspen. Discouraging results of vegetative propagation from root sections prompted the use of branch cuttings with auxin treatment. An exploratory test was conducted in 1975. The auxins used were "Turtox Hormone Powder" and "Turtox Hormone Salve" (α - naphthalene acetic acid 10 ppm and vitamins B_1 and C each 5 ppm in inert medium of talc and lanolin respectively), "Hormodin 3" (0.8% 3-indole butyric acid), 3-indole acetic acid, 3-indole butyric acid, 3-indole propionic acid and α - naphthalene acetic acid. The last four were used in four concentrations of 50, 100, 200 and 400 mg/1. The preliminary indications available from this exploratory experiment are that (1) rooting of branch cuttings of trembling aspen with auxins is possible, (2) "Turtox Hormone Powder" and 3-indole-acetic and α - naphthalene acetic acid in concentrations of 100 and 50 mg/1 respectively seem to offer most promise. The results have been published (Khalil 1979e).

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TREE BREEDING AT THE MARITIMES FOREST RESEARCH CENTRE, 1977 AND 1978

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Key words: Population studies, provenance tests, species hybrids, applied tree improvement, tissue and organ culture, Picea, Larix.

It is estimated that almost 100 million trees will be planted annually in the Maritimes by 1987. An opportunity exists to substantially increase forest growth in the Region by utilizing genetically superior seeds and seedlings in these reforestation programs. The objectives of the tree breeding work at the Maritimes Forest Research Centre (MFRC) are to determine the amount of genetic improvement attainable within promising tree genera and to provide resource managers of the region with the information and breeding materials required to obtain a realistic genetic improvement of trees used in reforestation.

H. G. MacGillivray retired from the Canadian Forestry Service in December 1976 after more than 20 years service in tree improvement research at MFRC. The vacant position was finally filled in June 1978 by Dr. Y. S. Park. Mr. R. F. Smith also joined the tree improvement group at MFRC in September 1978. The addition of these men to the MFRC staff has made it possible to reorganize the tree improvement program to serve better the expanding cooperative improvement programs of the Region and to maintain a strong research capability.

Dr. Park, a recent graduate of Pennsylvania State University, has a strong background in quantitative genetics and is providing much needed expertise in this field. He is responsible for population studies of important tree species, and with Dr. Fowler is responsible for the provenance studies established by H. G. MacGillivray. Mr. Smith, University of New Brunswick, 1978, will be assisting Mr. Coles with various aspects of the cooperative tree improvement program especially in relation to cone and seed production problems in seed orchards.

HYBRIDIZATION IN PICEA AND LARIX

The objectives of this program are to produce and test inter- and intraspecific hybrids, to develop methods of mass producing promising hybrids, and to provide information and breeding materials to forest managers.

Interspecific crossing work was continued in 1977 and 1978. In 1977, a total of 64 tree x pollen combinations was attempted using white, (Picea glauca (Moench) Voss.) black (P. mariana (Mill.) B.S.P.) and red spruce (P. rubens Sarg.) as female parents for crosses with white, black, red, and a Mexican spruce, P. chihuahuana Martinez. Of these, only the crosses with red x black and the reciprocal could be considered successful. A few putative hybrids were obtained from other crosses but as yet have not been verified. Crossing of white and black spruce has proven to be very difficult. However, attempts in 1974 to cross black spruce with Sitka (P. sitchensis (Bong.) Carr.) and Engelmann (P. engelmannii (Parry) Engelm.) spruces, both of which cross readily with white spruce, were reasonably successful. This suggests that barriers to crossing western "white" spruces with black spruce may be less well developed. In 1978, to test this hypothesis, local white, black, and red spruces were crossed with local white spruce, and white and Engelmann spruces from British Columbia. Some putative black x white and red x white hybrids were obtained but as yet have not been verified.

Two of the most promising hybrids to emerge from the crossing program in recent years are white x Sitka and black x Sitka. The cross black x Sitka is new and was successful on all three black spruces tested. These three trees crossed with a Sitka spruce pollen mix from Denmark, yielded 432 cones with 191 full seeds which produced 156 seedlings. In the winter of 1977-78, 10 cuttings from each of the 27 "best" white x Sitka hybrids and 31 "best" black x Sitka hybirds were struck. Of these, 85% rooted and survived transplanting to a nursery.

Flowering of Larix species in the Maritimes was poor in 1977 and 1978. Work on Larix was thus restricted to establishing tests with hybrids produced in 1975 and 1976 and to measuring existing trials. In addition, a small clonal orchard of selected Larix leptolepis (Sieb. and Zucc.) Gord. was field planted in cooperation with Valley Forest Products Ltd.

POPULATION STUDIES

Population work was consolidated under a single study in 1978 and is now the responsibility of Y. S. Park. The objectives of this work are to elucidate the genetic structure of populations of tree species used for reforestation in the Maritimes, to estimate and interpret genetic parameters of important growth and quality attributes, and to utilize this information to assist in the development of tree improvement strategies.

An understanding of relationships among trees within a stand is necessary to correctly estimate potential genetic gain and to determine the most effective selection practices for improving tree species. Studies designed to determine the amount of inbreeding in natural stands of white and black spruce and native larch were continued in 1977 and 1978.

A white spruce progeny test representing progenies from almost 150 trees in two natural stands was started in a greenhouse and transplanted into the nursery. Detailed information on the parent trees, including physical location within the stands, is available for each progeny. Seeds and individual tree data were collected in the fall of 1978 from 130 plantation-grown black spruce and will be used for progeny tests designed to provide estimates of important genetic parameters.

SPECIES AND PROVENANCE TRIALS

The objective of this work is to improve forest production in the Maritimes by determining the best adapted and productive species and the best provenances within these species for use in various locations in the Region.

Starting in the late 1950's, MFRC embarked as a long-term program of provenance testing of Norway spruce under the direction of H.G. MacGillivray. Between 1961 and 1972, 10 separate Norway spruce trials, including the 1100-source IUFRO 1964-68 test, were established. One complete planting of each trial was established at or near the Acadia Forest Experiment Station with other replicated trials and observation plots established throughout the Region. Native species were included as "controls" in all but one of the trials.

Results of this work are being prepared for publication. In summary, average survival of Norway spruce is the same as that of black spruce in 13 tests where comparisons can be made, and better than that of white spruce (15 comparisons) and red spruce (12 comparisons). Black spruce is taller than Norway spruce in all but one trial while Norway is taller than white or red spruce in most trials. With few exceptions, the best provenances of Norway spruce for use in the Region are from mid-elevations in the Sudetan and Carpathian Mountains of Poland and from eastern Poland. Provenances from east of the Baltic Sea in northeastern Poland, Latvia, Lithuania, White Russia and western Russia also do well and are recommended for northern New Brunswick.

TECHNICAL ASSISTANCE PROGRAM

The Nova Scotia Tree Improvement Working Group (NSTIWG) and the New Brunswick Tree Improvement Council (NBTIC) (Coles 1979), were formed in late 1976 to coordinate the tree improvement efforts of industry and the provincial governments. The Maritimes Forest Research Centre provides technical assistance for the operational programs of these cooperatives.

The NSTIWG is concentrating on the improvement of white, red, black, and Norway spruce and white pine. An intensive selection program for all species is well underway. Large grafting programs have been conducted for the past two years and a holding area was established at the Lawrencetown nursery. The cooperative is presently selecting and preparing sites for orchard establishment. Large acreages of red and white pine have been designated and treated as seed production areas. MFRC has had a substantial input in planning the new tree improvement complex at Debert funded by DREE.

To meet its first objective of supplying a source of well-adapted local seed, the NBTIC selected and reserved 43 black spruce (NBTIC 1978a) and 44 jack pine (NBTIC 1978b) stands. During 1978, seven stand tests of each species were established throughout the province to determine the best seed sources.

To improve black spruce and jack pine, a program of individual plus tree selection was begun in 1977. A 7-ha black spruce seedling seed orchard and three progeny tests (NBTIC 1978c) were established by Fraser Co. in 1978. In the summer of 1979, the cooperative will establish three 8-ha black spruce seedling seed orchards and seven progeny tests containing about 160 families along with two 8-ha jack pine seedling seed orchards and six progeny tests with 170 families.

The cooperative is practicing intensive selection on white spruce and tamarack, and a grafting program and holding area have been established at Acadia Forest Experiment Station. In 1978, an 8-ha seedling seed orchard and four progeny tests of Ottawa Valley white spruce were established; these will be expanded in 1979. This will provide New Brunswick with a "local" seed source of rapid growing Ottawa Valley provenance (Fowler and Coles 1977).

Tree improvement in the Maritimes is well underway, and MFRC input into these two cooperatives has expanded, such that two professional foresters are now employed full time providing the technical leadership and coordination.

TISSUE AND ORGAN CULTURE

Tissue Culture

The production of homozygous lines and the subsequent crossing of these lines to produce heterotic hybrids has been successfully used as a breeding technique with several agricultural crops (e.g. hybrid corn). The development of near homozygous lines requires several generations of inbreeding (usually self-fertilization). Because of the long period between generations, this technique has generally been avoided by tree breeders. If haploid plants could be located or produced, their chromosome complement could be doubled to produce homozygous diploids and the long period required to produce such trees by inbreeding could be avoided.

The gametophyte stage (haploid) in gymnosperms, although greatly reduced in comparison to the sporophyte, undergoes several cell divisions. If the gametophyte could be induced to undergo further divisions and subsequently to differentiate into a functional plant, the production of haploids and homozygous diploids would be feasible.

Recent developments in the culture of the gametophyte of *Ginkgo biloba* L., indicate that this approach is plausible. Male and female gametophytes and gametophyte pieces have been cultured *in vitro* and the effects of various nutrients, growth regulators, etc., on cell division and differentiation have been studied.

The studies at MFRC have been mainly with red pine gametophytes. This species has been selected because of its genetic uniformity and low frequency of deleterious genes. Once techniques have been successfully developed for red pine they will be used with other coniferous species.

To grow conifer tissues in culture requires about 20 different nutrient chemicals, each of which has to be present in specific amounts to assure growth. Similarly, the requirements for such physical factors as pH, light and temperature cycles, ion exchange capacity of the nutrient medium, gas exchange, etc., have to be correctly determined. Furthermore, once growth has been satisfactorily obtained, the chemical-physical environment has to be manipulated in such a manner that the growth pattern changes from an unorganized to an organized pattern. Each stage of organization generally requires adjustments in the environment (Bonga 1977a).

By manipulating the growth hormones in the media, embryo-like structures were induced in the initially unorganized callus tissue (Bonga 1977a). The tissues derived from the male gametophyte grow faster and generally form embryo-like structures more easily than the tissue derived from female gametophytes. However, in the tissues derived from the male gametophyte, there often is a high ratio of diploid over haploid cells. There are strong indications that these diploid cells have arisen from fusion of haploid cells within single pollen grains, and thus would be homozygous diploid, i.e. the desired condition, and did not originate from the heterozygous diploid cells of the anther walls or from fusion of different pollen grains.

It is important to have good cytological techniques to determine: (1) if cells are haploid or diploid; and (2) if diploid cells arise from fusion of haploid pollen cells or from the diploid anther wall cells. The techniques commonly used in conifer cytology were tested but none of them were satisfactory. Therefore, efforts were made to develop new techniques to (1) intensely stain chromosomes in callus and pollen tissues; (2) properly separate cells, so that large numbers of cells can be studied; (3) accumulate metaphases in the highest numbers possible; and (4) shorten and separate chromosomes, as much as possible, for easier counting. With regard to callus tissues, the first three of these objectives have now been achieved (Bonga 1978 a, b); the new stains for pollen are much better than the original ones, but the possibility of further improvement is still being investigated.

It is intended to continue the study along much the same lines over the next 2-3 years. To obtain haploid, and eventually homozygous plantlets, the interactions of the various physical-chemical factors that will induce haploid tissue proliferation and differentiation will have to be more precisely defined.

Organ Culture

Conifers are usually propagated sexually because vegetative propagation of trees old enough to have demonstrated their superior characteristics is often difficult. However, where vegetative clonal propagation is economically feasible, it is often preferred to sexual propagation because it allows fixing of selected genetic characteristics. Consequently, it is important to develop methods to vegetatively propagate older trees.

To date, the most common method of vegetative propagation of conifers has been rooting of cuttings. However, cuttings often fail to root properly and in these cases tissue and organ culture could be a more promising approach (Bonga 1977a). Complete or partial vegetative regeneration of conifers from tissue or organ cultures has been achieved by other researchers for several species using explants taken from either embyros or young seedlings, but not from explants from older trees.

In our attempts to obtain vegetative propagation from tissues of older trees of Abies balsamea L. (balsam fir), dormant buds minus bud scales were used as explants. Buds were chosen because they or their callus often form adventitious embryos or organs more easily than explants from other parts of the plant. In spite of extensive efforts, the balsam fir buds have, so far, failed to root. However, specific short-term hormone treatments were developed which induced the formation of adventitious embryos from tissues of the needles of the buds (Bonga 1977b). Some of these embryos germinated and formed small seedlings. Unfortunately, germination was abnormal and, consequently, the developing seedlings were severely stunted. Methods to obtain normal germination of the adventitious embryos remain to be developed.

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TREE IMPROVEMENT AT N.B. INTERNATIONAL PAPER CO.
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Keywords: plus tree selection, stand tests, progeny tests, seedling seed orchard.

Tree improvement work at New Brunswick International Paper Co. has been directed at fullfilling our commitment as a member agency in the New Brunswick Tree Improvement Council cooperative program. Since the summer of 1977, we have participated in the Council's recommended program for selection and testing of black spruce, white spruce and jack pine.

A brief summary of our activities follows.

PLUS TREE SELECTION AND BREEDING

To date we have selected 54 black spruce, 7 jack pine and 6 white spruce superior individuals from our lands in northern and central N.B. Plans call for 120 black spruce, 40 jack pine and 20 white spruce selections by 1982. Indications are that this year is a good cone crop year for black spruce and jack pine and we will be collecting seed this fall for expansion of our existing seedling seed orchards.

Last March, 50 scions collected from our white spruce selections were grafted at the provincial forest experiment station. We are looking into setting up our own grafting facility at the local company greenhouse.

STAND TESTS

Three good black spruce stands and two good jack pine stands have been selected and reserved on our crown lease for development as seed collection areas. A black spruce area is being thinned to remove species other than black spruce and red pine.

Forty three good black spruce stands and 44 jack pine stands have been selected by council members throughout the province. In the fall of 1977, seeds were collected from individual dominants within each stand. Five ha of replicated stand tests using progeny from the selected N.B. sources have been established by us, and by six other cooperators in

N.B. The best natural seed sources will be identified in the stand tests.

PROGENY TESTS

Last spring, two ha of Ottawa Valley white spruce progeny test, composed of 72 replicated families, was outplanted and will provide information towards rogueing of the 8 ha of provincial Ottawa Valley white spruce seed orchard.

Presently we are outplanting a black spruce progeny test composed of seedlings from 130 plus tree individuals selected by council cooperators which will also provide rogueing information for black spruce orchards established with the same material.

SEEDLING SEED ORCHARD

Last fall, we selected and prepared a black spruce seedling seed orchard site which appears to meet most of the requirements for good seed production despite a drainage problem which will require some ditching. Four ha composed of 16,000 individuals from the 130 plus tree selections has just been outplanted. The proposed 1980 program calls for an expansion of our present orchard site by an additional 10 ha, which we are working on now.

FOREST GENETICS AND RELATED WORK AT THE UNIVERSITY OF NEW BRUNSWICK 1977-1979

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All undergraduate students in the Department of Forest Resources take a series of common, or core, courses during their five-year B.Sc.F. program and elect other courses according to the students's area of concentration. Among the core courses are 'Tree Development and Variation' (formerly part of 'Forest Botany') in the second year and 'Silviculture I' in the fourth year. In the former, students are exposed to variation in, and between, trees -- the basis for forest tree improvement. They deal not only with within-tree variation and between-species variation, but also with between-tree, within-population (within-species) variation. Through this exposure they become aware of ecotypic and clinal variation, of provenance and seed-zone considerations, and also of problems and possibilities associated with hybridization. Introgressive hybridization is dealt with especially as it relates to Picea in the natural forests of the central New Brunswick area.

In the Silviculture course, about three weeks is spent in dealing with principles of forest tree improvement, both in the classroom and in the field. In the past two years this section of material has been taught by a forest geneticist, C.M. Harrison, who has been a member of the department as a Post Doctoral Assistant. He has also led small groups of students in field studies of forest genetics during Fall Camp, but more importantly, has given a course in Forest Genetics as an elective. Seventeen students took the course in 1977-78 and ten in 1978-79. As a course project, each student was required to seed and select a plus tree, and then to defend his selection. Selected trees which proved to meet the criteria used by the New Brunswick Tree Improvement Council (NBTIC) were added to the tree-improvement program within the province.

Students opting for concentration in the Tree Biology field have also had the opportunity to take a course in Genetics in the Department of Biology. Many also take a forestry course in their final year labelled 'Tree Development in Relation to Reproduction'. That course deals in depth with morphogenesis of the seed-producing process and with intrinsic and extrinsic factors affecting it and its outcome. All students engage in a project involving crown analysis, cone analysis and seed analysis. In the past two years, projects have involved jack pine (Pinus banksiana Lamb.) cones of different ages from the same trees and red pine (Pinus resinosa Ait.) cones from different crown positions. Students also have practice in strobilus-bud analysis using all North American genera of the Pinaceae.

All students are required to write a thesis in their final year. Undergraduate theses on topics related to forest genetics or tree improvement in the past two years were:

Loo, J. 1979. Geographic variation in specific gravity among Japanese larch provenances.

Manley, A.L. 1978. Seed yield of immature black spruce (Picea mariana (Mill.) B.S.P.) plantations in south-central New Brunswick.

White, B.F. 1979. Progeny, statistical ranking and genetic gain and heritability of Norway spruce.

There have been no graduate students working in forest genetics at the University of New Brunswick during the past two years. Mr. Harrison has been involved in completing his Ph.D. requirements for the University of Idaho. He has produced (Harrison, 1979) a paper on tree improvement in the Atlantic Provinces, has been heard on a CBC radio spot during Forestry Week and, with G.R. Powell, has been involved in the NBTIC.

Morphogenetic investigations relating to seed production of Pinaceae have continued at a low intensity, but results of some earlier work have been published (Powell 1977a, b, c, 1978). Work in this area is currently increasing with impetus from the needs of NBTIC in relation to stimulation of abundant and annual strobilus production in young trees of jack pine and black spruce.

Forest tree improvement activity is rapidly increasing in the Maritime Provinces. The University of New Brunswick is involved, and is seeking ways to foster this activity. It is, thus, good to be able to end this report on a note of optimism with a quotation, dated 12 June 1979, of the Dean of the Faculty of Forestry, Dr. J.W. Ker.

> "In the near future the Faculty of Forestry expects to receive confirmation of funding of an industry-sponsored chair in Forest Tree Improvement. A well-qualified and experienced forest scientist would thereby be added to the Department of Forest Resources to accelerate the application of advanced technology to reforestation and stand-improvement activities in order to assure a continuing and improving supply of economic roundwood for future harvesting".

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AMÉLIORATION DES ARBRES FORESTIERS AU SERVICE DE LA RECHERCHE DU MINISTÈRE DES TERRES ET FORÊTS DU QUÉBEC

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

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

Plantations Comparatives

Deux plantations comparatives de clones de peupliers ont été réalisées en 1977 et 1978 avec des plants ou plançons provenant d'éclaircies faites dans des tests clonaux réalisés en 1973 et 1974. L'arrachage de plants dans un dispositif clonal au populetum de Matane, a permis de constater une forte attaque d'une hépiale perceuse de racine dont le nom est Sthenopis quadriguttattus Gr.[1]. Cet insecte creuse des galeries dans la racine principale des peupliers ce qui peut favoriser le bris des plants et le développement d'une pourriture du pied. Quelque 24 p. cent des tiges étaient infestées et aucun des 12 hybrides ou espèces de peuplier présents dans le dispositif n'a montré une résistance complète.

Acquisitions

La collection de clones du Service s'est enrichie de 49 nouveaux clones dont 20 ont été expédiés par M. Franclet de l'AFOCEL, France, et 29 par le Dr. Zsuffa du Centre de recherche forestière du Gouvernement de l'Ontario. Avec les nouveaux clones exotiques reçus depuis 1975 et ceux sélectionnés au Québec, ainsi que les meilleurs clones déterminés par les tests clonaux de 2° génération réalisés en 1973 et 1974, un quartier de pieds-mères a été réalisé en 1977 pour la production de boutures destinées aux tests clonaux de 3° génération.

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[1] Vallée, G. et R. Béique, 1979. Dégâts d'une hépiale et susceptibilité des peupliers. Société de Protection des Plantes du Québec. Revue Phytoprotection 60 (1) (page 23-30).

Croisements

Les croisements réalisés en 1971 et 1973 ont permis de constater la grande sensibilité des hybrides P. × jackii Sarg. aux rouilles des feuilles. Cependant, les croisements P. balsamifera Duroi × P. nigra L. cv. italica ont donné des descendants très résistants aux rouilles comme c'est aussi le cas de la plupart des croisements où P. balsamifera est l'arbre mère. Les descendances pures de P. deltoides Marsh obtenues des croisements de 1971 ont montré un comportement exceptionnel sur le plan croissance, même dans des conditions de sols acides, et une assez bonne résistance aux maladies foliaires. Malheureusement l'aptitude au bouturage de P. deltoides est très variable et inférieure à celle des hybrides ayant du sang de P. balsamifera.

Dans les croisements réalisés en 1978 on a cherché à obtenir des descendances dont les sujets auraient une plus grande résistance aux rouilles des feuilles et une bonne aptitude au bouturage. Parmi les croisements réussis il y a:

P. deltoides × P. × jackii
(P. balsamifera × P. nigra cv. italica) × P. × euramericana (Dode) Guinier
P. × jackii × (P. balsamifera × P. nigra cv. italica)
P. × euramericana × P. balsamifera
P. × euramericana × P. × jackii (et le réciproque).

C'est durant l'été 1979 que l'on pourra constater si ces descendances présentent une bonne résistance aux rouilles des feuilles.

Quelques Résultats

Les hauteurs à l'âge de 5 ans, à partir de la bouture, des 15 meilleurs clones de trois tests clonaux réalisés en 1973 et 1974 à Trécesson, Lotbinière et Matane (tableau 1), et qui comprenaient respectivement 113, 180 et 140 clones, sont présentées au tableau 2.

Même si la fertilité des sols n'est pas identique aux trois endroits de plantation et compte tenu de la fertilisation réalisée lors de l'installation des dispositifs, il est permis de supposer que le principal facteur limitant pour le développement des clones est le climat. On peut d'ailleurs constater qu'aux deux endroits les plus nordiques ce sont les clones balsamifera, × jackii, et × berolinensis que l'on retrouve en majorité parmi les 15 premiers clones, tandis qu'au sud (Lotbinière), ce sont les × euramericana, deltoides et × interamericana (dont P. cv. Donk et P. cv. Rap). A Matane et Trécesson, les clones deltoides, euraméricains et certains interaméricains subissent des gels des pousses presque tous les ans.

Les clones n° 70, 1014, 3052 montrent un bon comportement aux trois endroits, ce qui signifie qu'ils possèdent une aptitude d'adaptation très étendue compte tenu des différences écologiques (tableau 1) entre les trois sites expérimentaux. Pour des conditions climatiques qui se rapprochent comme c'est le cas pour Trécesson et Matane, on retrouve des clones qui ressortent aux deux endroits comme les n° 45, 70, 1009, 1012, 1014, 1016, 3052 et 3176. Cela laisse présager une certaine amplitude d'adaptation de ces clones aux différences pédologiques.

Malgré leur potentiel de production, les *P. × jackii* montrent en général une très grande sensibilité aux rouilles ce qui les rend douteux à utiliser pour les plantations industrielles, même dans les régions boréales.

Tableau 1. Localisation et quelques facteurs climatiques des endroits de plantation des 3 tests.

Endroits	Trécesson	Lotbinière	Matane
Latitude	48°41'N	46°30'N	48°40'N
Longitude	78°30'O	71°55'O	67°15'O
Altitude	76 m	305 m	91 m
Température moyenne de juin-juillet-août, °C	15	17	14
Saison sans gel, jours	80-100	120-140	80-100

PROJET G 69-5. TESTS DE PROVENANCES SUR L'ÉPINETTE DE NORVÈGE (*PICEA ABIES* KARST.), PAR D. ROBERT

Mots-clés: sélection, essais et amélioration des arbres forestiers, tests de descendances et de provenances, introduction d'espèces.

L'expérience débuta en 1969 avec l'installation des premiers dispositifs sur le terrain. Au cours des années qui suivirent, d'autres dispositifs furent également installés; maintenant, les premiers résultats sont obtenus quant à l'évolution des provenances introduites dans les principales régions climatiques du Québec susceptibles d'être favorables à l'épinette de Norvège.

Buts de l'Expérience

Les principaux buts à atteindre sont les suivants:

1- déterminer parmi les provenances expérimentées, celles qui sont les plus aptes au reboisement des régions concernées;

2- étudier les variations phénologiques de cette espèce;

3- sélectionner des arbres de belle venue parmi les meilleures provenances pour le développement de variétés multiclonales et de vergers à graines;

4- créer des hybrides infraspécifiques présentant des caractères propres à différentes fins.

Tableau 2. Hauteur des 15 meilleurs clones de trois dispositifs de comparaison de clones comprenant de 113 à 180 clones.

N° clone	Trécesson Hauteur (cm)	Lotbinière Hauteur (cm)	Matane Hauteur (cm)	R[1]	Hybride ou espèce
2			315	6	P. × jackii
14	201			4	P. balsamifera
22			313	5	P. × jackii
36		502	332	3	P. × euramericana
45	215		325	5	P. × jackii
70	236	459	337	6	P. × jackii
201	197			2	P. × interamericana Van Brock.
205		510		3	P. × euramericana cv. Robusta
206		446		2	P. nigra × P. trichocarpa
1009	235		333	5	P. × jackii
1012	209		346	5	P. × jackii
1015	216	432	312	6	P. × jackii
1016	205		368	6	P. × jackii
1017			344	6	P. × jackii
1036	218			5	P. × jackii
1079	206			5	P. × jackii
1080			342	5	P. × jackii
1083			268	5	P. × jackii
2002		432		5	P. deltoides
2045	207			5	P. × jackii
2068		439		5	P. deltoides
3021		530		2	P. × euramericana cv. Dorskamp
3026		500		4	P. × interamericana cv. Donk
3027		516		5	P. × interamericana cv. Rap
3031		432	276	3	P. tacamahaca
3050	198			3	P. × interamericana
3051		463		4	P. × interamericana
3052	230	464	315	4	P. × interamericana
3053	210			3	P. × interamericana
3055		470		4	P. × interamericana
3116		462		5	P. deltoides
3176	212		304	3	P. × berolinensis

[1] Sensibilité aux rouilles à la pépinière de Duchesnay à la mi-août lors d'une année de forte infestation.
0: aucune tache, 6: très sensible avec nécrose des feuilles

Méthode

Outre les 19 dispositifs déjà établis, le tableau 3 présente les six nouveaux dispositifs installés au printemps de 1978.

Tableau 3. Dispositifs établis en 1978.

Arboretum	Expérience*	Dispositif	Nombre et origine des provenances
Iles-de-la-Madeleine	384-B-6	D519-78	19 Pologne
Labrieville	550	D521-78	3 Finlande
La Patrie	384-B-4	D524-78	17 Pologne
Lotbinière	384-B-5	D527-78	17 Pologne
Mont-Laurier	384-B-2	D532-78	19 Pologne
Verchères	384-B-3	D535-78	19 Pologne

* N° d'expérience du Service canadien des forêts.

La collecte des données fut complétée au cours de l'été 1977 pour les dispositifs indiqués au tableau 4, afin de procéder à leur analyse:

Tableau 4. Dispositifs faisant l'objet d'une analyse complète

Arboretum	Dispositifs
Duchesnay	D77-72
Gaspé	D43-71, D110-72, D113-72
Guigues	D6-69, D1-69
Lac-Saint-Ignace	D8-69, D14-69, D31-71, D98-72
Parke	D35-71
Trécesson	D4-69

Toutes les données recueillies sur ces dispositifs depuis leur installation ont donc été entrées en mémoire pour être ensuite traitées à l'aide d'ordinateur.

Résultats

Quelques résultats préliminaires sont disponibles actuellement; bien que l'analyse comme telle de ces résultats n'ait pas encore été complétée, les tableaux 5 et 6 présentent un classement cumulatif sur les pousses moyennes de 1972 à 1976 et un autre sur la pousse de 1976 et ce, respectivement pour les dispositifs D8-69 et D14-69 de l'arboretum de Lac-Saint-Ignace.

Le tableau 5 permet d'observer que parmi les provenances de Pologne, ce sont celles de Sadlowo et de Kowary qui se distinguent par leurs accroissements supérieurs. Bien que les résultats de ces deux provenances soient comparables, leurs origines sont toutefois différentes, Kowary étant davantage une provenance de l'intérieur et de moyenne altitude (50°48' lat. N., 15°52' long. E, 625 m) que Sadlowo qui est plutôt de basse altitude et près de la côte de la mer Baltique (53°55' lat. N., 21°06' long. E., 140 m).

Tableau 5. Classement des provenances quant à l'accroissement moyen de 1972 à 1976 et quant à la pousse de 1976.

ARBORETUM DE LAC ST-IGNACE
Dispositif 8-69
Épinette de Norvège (provenances de Pologne)

Provenance		Accroissement moyen, de 1972 à 1976 en cm		Pousse de 1976 en cm	
Numéro	Origine	Valeur	Rang	Valeur	Rang
5420	Sadlowo	81,68	1	24,01	2
5410	Kowary	81,63	2	24,85	1
5431	Stronie	73,88	3	22,64	3
5412	Wisla	73,68	4	19,54	8
5417	Kanstancjewo	71,58	5	19,19	10
5425	Goldap	69,65	6	22,20	4
5413	Rycerka	69,23	7	19,81	7
5430	Miedzyrzec	68,95	8	18,51	13
5414	Wetlina	67,95	9	20,72	5
5426	Suwalki	67,50	10	18,01	14
5411	Istebna	67,25	11	19,87	6
5422	Slaski	67,23	12	16,94	17
5424	Przerwanki	66,35	13	19,18	11
5419	Nowe Ramuki	65,48	14	18,53	12
5416	Blizyn	63,58	15	17,17	16
5418	Ilowa	63,15	16	19,25	9
5423	Borki	62,50	17	16,89	18
5428	Bialowieza	62,50	18	16,14	22
5427	Augustow	61,60	19	17,32	15
5409	Brody	59,80	20	16,45	19
5429	Zwierzyniec	59,38	21	16,23	21
5421	Myszyniec	57,00	22	16,32	20

La moyenne de l'accroissement de ces deux meilleures provenances présente un écart de 21 pour-cent avec la moyenne générale de toutes les provenances. S'il est tenu compte des quatre meilleures provenances, le même écart est de 15 pour-cent.

Le tableau 6 permet également de voir que les deux premières provenances du dispositif 14-69 se détachent passablement de l'ensemble des autres provenances. Dans ce cas, en tenant compte de la moyenne de l'accroissement moyen de 1972 à 1976 de ces deux provenances par rapport à celle de l'ensemble du dispositif, l'écart correspond à un gain de 25 pour-cent; cet écart passe à 15 pour-cent s'il est tenu compte de la moyenne des quatres meilleures provenances.

Tableau 6. Classement des provenances quant à l'accroissement moyen de 1972 à 1976 et quant à la pousse de 1976.

ARBORETUM DE LAC ST-IGNACE
Dispositif 14-69
Épinette de Norvège (provenances d'Europe)

Provenance		Accroissement moyen, de 1972 à 1976 en cm		Pousse moyenne de 1976 en cm	
Numéro	Origine	Valeur	Rang	Valeur	Rang
5400	Latvie R.S.S. (Skede)	108,2	1	34,12	1
5404	Russie blanche (Gorodokski)	106,3	2	31,43	2
5399	Latvie R.S.S. (Jelgava)	99,3	3	29,41	4
5401	Latvie R.S.S. (Tukums)	93,6	4	27,18	8
4027	Québec (plantation, Proulx)	93,3	5	29,94	3
4076	Québec (plantation, Proulx)	93,0	6	28,91	5
4028	Québec (plantation, Proulx)	92,7	7	28,19	6
5394	Roumanie (Turda)	89,9	8	27,27	7
5407	Allemagne de l'Est (Carlsfeld)	89,0	9	24,53	12
5398	Latvie R.S.S. (Daugavpils)	84,1	10	26,34	9
5408	Allemagne (Frankenwald)	83,4	11	24,86	10
5390	Roumanie (Marginea)	82,6	12	23,19	16
5403	Lithuanie R.S.S. (Wilno)	82,5	13	24,73	11
5391	Roumanie (Dorna cindreni)	80,7	14	23,03	17
5395	Roumanie (Cimpeni)	79,5	15	23,96	14
5393	Roumanie (Comanesti)	77,6	16	22,72	19
5397	Latvie R.S.S. (Auce)	77,3	17	24,50	13
3154	Pologne (Rycerka)	77,1	18	22,91	18
3153	Allemagne (Tannesberg)	76,2	19	21,37	21
5405	Russie blanche (Glubokski)	74,6	20	23,25	15
5406	Russie blanche (Minsk)	72,1	21	21,16	22
5392	Roumanie (Bicaz)	68,0	22	21,80	20

Pour ce même dispositif, le comportement de certaines provenances d'une même région est passablement différent; c'est le cas qui se présente entre Gorodokski de Russie blanche (55°30' lat. N., 30°10' long. E., 200 m) et Glubokski (55°15' lat. N., 30°10' long. E., 200 m). Quant à l'accroissement moyen de 1972 à 1976, leur rang respectif est le deuxième et le vingtième.

La variation est donc importante à l'intérieur des deux dispositifs au niveau de la croissance et l'analyse des autres variables observées permettra de mieux juger la valeur générale de chacune des provenances.

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

Durant les deux dernières années nous avons poursuivi les travaux prévus dans notre projet d'amélioration du mélèze. L'accent a été mis surtout sur l'espèce indigène - *L. laricina* (Du Roi) K. Koch, mais en même temps nous avons mis en marche quelques expériences avec les espèces exotiques, tel que *L. decidua* Mill., *L. leptolepis* Gord. et *L. sibirica* Lebed., avec le matériel que nous possédions déjà ou que nous avons récolté nous-mêmes ou reçu des autres organismes.

Plantations Expérimentales

Au mois de février 1977 nous avons semé dans la serre, 87 provenances de *L. laricina* ce qui nous a permis de former deux tests de provenances, représentant une assez grande partie du sud-est de l'aire de distribution du mélèze laricin. La germination des semences n'était pas homogène et certains lots n'ont pas germé du tout, ainsi les deux tests ne sont pas exactement pareils. Le plus grand, comprenant 79 provenances, a été installé dans l'arboretum de Lotbinière et l'autre avec 66 provenances, sur le terrain d'un secteur expérimental situé à environ 60 km au nord de New Richmond en Gaspésie. Les premières observations sur la mortalité et la hauteur de la première année ont été faites, mais il est encore trop tôt pour donner une appréciation plus exacte sur les provenances.

Au printemps 1977 et 1978, nous avons installé sur le terrain 10 tests de provenances avec 22 provenances de *L. × eurolepis*, 13 provenances de *L. decidua*, 10 provenances de *L. leptolepis* et 12 provenances de *L. sibirica* et des hybrides *L. sibirica* × *L. leptolepis* et × *L. decidua*. Ce matériel fait partie des expériences n° 377 et n° 378 de la Station forestière expérimentale de Petawawa. Nous l'avons réparti dans 10 arboretums à travers la province, en essayant de couvrir le plus possible les différentes régions écologiques du Québec.

Présentement, nous possédons dans la pépinière des semis 2-0 de 3 provenances de mélèze d'Europe et 9 provenances de mélèze du Japon. Ce matériel provient de plantations connues au Québec et fournira des informations sur la valeur de ces plantations comme source de graines.

Récolte des Graines

Dans nos régions, 1977 et 1978 n'étaient pas des années de bonne fructification. Cependant, dans deux jeunes plantations de L. laricina âgées de 7 ans (un test de provenances et un test de descendances) installées dans l'arboretum de Lotbinière, les arbres ont commencé à produire en 1978. Étant donné que ces plantations seront éventuellement transformées en verger à graines, nous avons récolté tous les cônes, arbre par arbre, en vue d'une évaluation de la qualité des graines. Ainsi nous avons présentement une collection de 175 descendances de L. laricina, et un test de descendances sera mis en marche vraisemblablement l'année prochaine.

A l'automne 1978, en collaboration avec la compagnie CIP ltée, nous avons effectué une récolte de cônes sur tous les arbres en production dans la plantation «Avoca» de la Ferme forestière de Harrington. De cette plantation, nous possédons maintenant 100 descendances de L. decidua. Comme dans le cas précédent, cette collection servira à faire une évaluation de la qualité des graines que cette plantation peut produire.

Propagation Végétative: Greffage

En janvier 1979, en collaboration avec PFES et la compagnie CIP ltée, nous avons récolté des greffons sur 76 arbres sélectionnés dans la plantation de L. leptolepis à Harrington. A la même époque, nous avons reçu de PFES des greffons de 60 arbres sélectionnés dans les plantations de L. decidua (provenances de Pologne et des Sudètes). Une partie de ce matériel a été greffé au mois de mars de cette année dans la serre et le reste est présentement en cours de greffage dans la pépinière. Les résultats obtenus, jusqu'à maintenant sont satisfaisants et les greffes réussies seront utilisées pour la formation de vergers à graines clonaux. Le schéma de ces vergers prévoit l'introduction d'un clone de L. decidua entre plusieurs clones de L. leptolepis de façon à pouvoir récolter les graines provenant des arbres sélectionnés de L. leptolepis et les graines produites par L. decidua sur lesquels nous espérons obtenir des croisements L. × eurolepis. Il est bien évident qu'un test de descendances sera nécessaire pour vérifier la qualité de ces hybrides.

En vue des travaux sur la pollinisation contrôlée de mélèzes, nous sommes en train de former un parc à clones dans lequel nous possédons présentement 175 clones différents provenant des arbres sélectionnés de L. laricina, L. decidua, L. leptolepis et autres. Quelques floraisons ont déjà été remarquées l'année dernière et ce printemps.

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

Mots-clés: test de descendances, test de provenances-descendances, verger à graines.

Un programme d'amélioration du pin gris a débuté en 1974 au Service de la recherche. La phase de l'établissement des tests de descendances pour l'amélioration de la provenance Baskatong a été complétée en 1978. Deux tests de provenances-descendances seront installés au printemps 1979 dans le nord-ouest afin de trouver les meilleures sources de graines et poursuivre l'amélioration de cette espèce. L'installation des vergers à graines de production dans la province demeure la responsabilité du Service de la restauration du M.T.F.

Amélioration de la Provenance Baskatong

Un test de descendances a été établi en 1978 dans le canton Normand aux coordonnées suivantes: 73°12'45'' de longitude ouest et 47°08'40'' de latitude nord. Ce test comprend 242 familles de la provenance Baskatong issues des arbres sélectionnés en 1976 et 18 familles provenant d'arbres sélectionnés d'une très bonne provenance près du canton Normand. Les 2 provenances sont sensiblement situées à la même latitude sauf que la provenance Baskatong va être déplacée d'environ 2° de longitude vers l'est. La provenance Baskatong ayant été classée comme une des meilleures au Québec, il sera intéressant de la comparer à celle du canton Normand sur le plan rendement en volume et qualité des tiges.

Le verger à graines de 40 hectares établi à partir des descendances de Baskatong va être complété en 1979 par le Service de la restauration. Le test de descendances du canton Normand fournira des informations sur le transfert des semences de la provenance Baskatong.

Test de Provenances-Descendances dans le Nord-Ouest

A l'automne de 1974 et 1978, 530 arbres ont été échantillonnés dans le Nord-ouest en vue de trouver les meilleures sources de graines pour les reboisements de cette région. Le Nord-ouest est une région prioritaire pour l'amélioration du pin gris puisque 43 pourcent du volume total de cette essence coupé à travers la province provient de cette région et qu'une grande partie de ces bois est destinée au sciage.

Afin de faire un échantillonnage complet et mieux distribué de tous les peuplements de pin gris, chacun d'eux a été délimité sur une carte forestière à l'échelle 1/50 000 puis retranscrit sur une carte 1/500 000 pour visualiser l'ensemble des peuplements. Les tests de descendances sont conçus de façon à être convertis en vergers à graines aussitôt qu'on aura les informations nécessaires sur la qualité des familles.

A chaque année, de nouveaux tests seront implantés dans d'autres secteurs par ordre de priorité pour trouver les meilleures sources de graines et constituer des vergers à graines de semis. Le choix des secteurs à améliorer est établi avec la participation du Service de la restauration.

AMÉLIORATION DES ARBRES FORESTIERS AU SERVICE DE LA RESTAURATION DU MINISTÈRE DES TERRES ET FORÊTS

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

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

Environ 10 mille hectolitres de cônes sont requis annuellement pour répondre aux besoins du programme de régénération artificielle. Le service de la Restauration du ministère des Terres et Forêts a mis sur pied un programme d'amélioration des arbres forestiers qui devrait permettre dans le futur, l'utilisation de semences améliorées génétiquement dans la régénération artificielle.

RECOLTE DE CONES

Au cours de 1977, 3,475.7 hl de cônes furent cueillis alors qu'en 1978, ce volume a été porté à 6715.2 hl (tableau 1). Des variations naturelles sont notées entre les régions dues à la fructification et la distribution des essences. L'année 1978 fut très bonne pour le pin gris, le pin rouge et moyenne pour le pin blanc et le pin sylvestre. La récolte chez les autres essences fut pratiquement nulle.

AMELIORATION DES ARBRES

Peuplements semenciers

Durant les deux dernières années, des travaux ont été réalisés sur une superficie moyenne de 285 ha. Les travaux ont surtout consisté à nettoyer les peuplements déjà établis, à dégager les arbres choisis comme semenciers, à tailler quelques flèches terminales et à arroser certains peuplements contre la tordeuse des bourgeons de l'épinette.

Tableau 1. Quantité de cônes récoltés, par essence, en 1977 et 1978 au Québec.

Essence	Cônes récoltés en	
	1977	1978
	. . . . hl	
Larix decidua	--	8.1
Larix laricina	--	1.6
Larix leptolepis	--	9.4
Picea abies	677.9	8.2
Picea glauca	--	0.6
Picea mariana	--	22.6
Pinus banksiana	1006.7	4652.8
Pinus resinosa	233.4	1210.1
Pinus strobus	1489.7	375.7
Pinus sylvestris	53.4	422.1
Autres essences	14.6	4.0
Total	3475.7	6715.2

Un programme d'établissement de peuplements semenciers a été préparé pour chacune des régions mais n'a pu être réalisé au cours de la dernière année. Seulement deux nouveaux peuplements ont été ajoutés au réseau déjà existant. Une amplification marquée de ce programme est à prévoir pour les prochaines années.

Vergers à graines

L'établissement de vergers à graines avec des semis-plus sélectionnés en pépinières s'est poursuivi au cours des deux dernières années avec la sélection et la plantation d'environ 2,900 semis sélectionnés dans les pépinières du Québec. Les essences impliquées étaient surtout _Picea glauca_, _Picea mariana_, _Picea abies_, _Pinus banksiana_ et _Larix laricina_. Dès que les installations nécessaires seront en place, nous procéderons à la multiplication végétative des plants à floraison précoce et des plants à croissance exceptionnelle mais à floraison plus tardive.

Un verger à graines de semis de _Pinus banksiana_ a été mis sur pied dans la région du Lac Baskatong, dans l'Ouest du Québec, avec la collaboration du service canadien des forêts, de la Compagnie Internationale de Papier du Canada et du ministère des Terres et Forêts du Québec. Au printemps de 1978, 47,500 semis produits dans des Paperpots ont été mis en terre. La plantation des autres semis est prévue pour le printemps 1979 afin de compléter les 40 ha suggérés dans ce programme d'amélioration du pin gris. Il est à noter qu'environ 300 familles sont représentées dans ce verger.

Sélection d'arbres

Le programme de sélection d'arbres-plus a démarré lentement au cours des deux dernières années. Un grand total de 334 arbres ont été sélectionnés dans la province en 1977 et 1978. Les principales essences impliquées étaient Picea glauca, Picea abies, Picea rubens, Larix laricina, Pinus strobus, Pinus banksiana et Pinus sylvestris.

Ces arbres seront reproduits dans des vergers à graines clonaux ou de semis dépendant des espèces.

Au cours des prochaines années, ce programme de sélection d'arbres prendra de l'ampleur et sera conduit dans les unités de gestion où les besoins en régénération artificielle sont les plus urgents.

FOREST GENETICS AND BREEDING AT THE LAURENTIAN FOREST RESEARCH CENTRE, 1977-1978

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Key words: genetics, tree breeding, provenance research, white spruce, black spruce, Norway spruce, eastern white pine.

The increasing demand for forest products and by-products results in growing pressure on the wood resources. World needs will have increased by 30 and 60 percent for the years 1985 and 2000 respectively.

In Québec the global productive potential of the forest has not yet been reached, however some regions in the southern portion of the province are already over exploited. The overall softwood potential of fiber production is depleting. Two million hectares of forest are inadequately regenerated after cutting and/or fire on public lands and more than eighty thousand hectares are added each year. At the actual rhythm of harvesting a shortage is expected before the turn of the century, in both public and private lands.

Québec needs to intensify its reforestation programme. The present objective is to plant 30 million seedlings annually starting in 1979 increasing to 70 million in 1984. Beginning in 1980, direct seeding is expected to be done on twelve thousand hectares of public lands each year. Management of seed production areas and establishment of seed orchards are urgent. Gene conservation and seed movement criteria are mandatory. Important gains are possible through breeding of selected trees. Additional knowledge of genetic population structures of our main forest species is necessary. More research is needed.

RESEARCH OF PROVENANCES OF CONIFEROUS SPECIES

The first experiments set up to search for the most suitable seed sources of indigenous and exotic trees species for reforestation in Québec were established in 1955 by the Canadian Forestry Service. From 1967 to 1977, some fifty additional tests were established in different forest sections of Québec. They included more than five hundred geographic souces and 350 individual trees (spruces, pines, larch, fir and Douglas). During the last two years trials of Polish, Russian and Finish provenances of Norway spruce were initiated concluding the expansion of our provenance research programme.

From 1976 to 1978, all observations collected in the trials since the beginning of the studies were punched on cards, verified, and mounted on a magnetic tape according to a Fortran subfile system. Some 325,000 card-like-records are now readily available for reference or analysis. Last summer, a student in programming was hired to work on programmes suitable for the statistical and genetic analysis of the data. Analyses have been performed on more than ninety percent of the bank content. New information is entered into the bank every year.

Our efforts to contribute to the formation of future forest engineers were continued during the last two years by providing directives, experimental material or data for undergraduate thesis of Laval University students. Research subjects were related to the production of accelerated growth seedlings in containers for genetic improvement purposes and to the study of geographically correlated genetic variations of black spruce. Early variation in growth and phenology of black spruce appeared to be clinal throughout its natural range. Nursery results indicate that the best growing sources are from the southeastern portion of the range.

GENETICS AND BREEDING OF WHITE SPRUCE

Initiated in 1976, the combined research and breeding programme of white spruce is partly based on results obtained from provenance trials conducted in the Great Lakes-St. Lawrence Forest Region. From those tests, seven populations superior for their growth performance and adaptability were identified. Fifty superior trees were selected within the original wild stands or on the provenance test sites for growth and form characteristics. When the selection was made in the provenance trials only one tree per provenance and site was selected in order to avoid possible loss of vigor in the succeeding generations due to inbreeding. Selected trees were grafted in the winters of 1977 and 1978 to constitute the basic material for a breeding arboretum and a seed orchard that will be established with the collaboration of the Ministère des Terres et Forêts of Québec. By using genotypes from populations separated by large geographical distances additional gains are expected due to the reconstitution of the heterogeneity lost within each small and homogeneous subpopulation.

To increase our knowledge of the genetic variation of white spruce and to constitute a second generation for further selection and breeding, in 1976, two hundred and fifty open pollinated families were sown and raised in Japanese paper pots. Seedlings were transplanted in the Valcartier Research Nursery to allow additional growth before field planting scheduled for the spring 1979. Observations of early development were taken each year. Partitioning of total variance for growth showed that populations and families are equally important sources of variation. Narrow sense heritability, on an individual seedling basis, was estimated to 0.22 and 0.19 at 4 months and 19 months respectively.

Seeds were exchanged with the Petawawa National Forestry Institute, Chalk River, and the wide range genecological study of white spruce was initiated last year. The study includes a total of 446 seedlots representing 100 provenances or populations and 420 mother trees.

The distribution of the seed sources between the provinces is as follows:

British Columbia	2	Québec	45
Alberta	2	New Brunswick	2
Saskatchewan	2	Nova Scotia	2
Manitoba	2	Newfoundland	2
Ontario	40	Prince Edward Island	1

In Québec, the early phase of the study is being conducted over two consecutive years because of the work load and of the restriction in staff and the physical facilities available. Seventy percent of the seedlots are sown each year under a plastic greenhouse in Spencer-Lemaire containers. Seedlings are grown in the greenhouse during six months and field planted the next spring in six different forest sections of Québec. In addition to providing information on the genetic structures of white spruce through its range the experimental stock will be used as basic material for population, family, and individual tree selection for producing improved white spruce varieties for Québec's reforestation needs.

GENETICS AND BREEDING OF WHITE PINE

At the beginning of the 20th century eastern white pine stands occupied over 95,000 km^2 of Québec territory. Because of intensive cuttings and lack of adequate natural regeneration, important populations are restricted to the valleys of the Ottawa River and its main tributaries. Whatever its economical importance white pine has not been planted as much as it should have been in the past because of the risk of blister rust infection and the difficulty in obtaining necessary seeds.

A recent re-evaluation of the situation of blister rust in Québec revealed that the natural range of eastern white pine could be divided into four susceptibility zones. In two of these zones, white pine can be grown with less than fifteen percent loss due to *Cronartium ribicola* (Lavallée, 1974). These zones cover the most favorable climatic and edaphic regions for fast growth. With site selection and minimum silvicultural practices to reduce weevil damages quality white pine can be grown in Québec.

It was urgent that genetic sampling of white pine populations be initiated before a too severe depletion of the gene pool occurred. Much progress has been done in the combined research and breeding programme of white pine initiated in 1976. In 1977 and 1978, more than one hundred populations were sampled and seeds were collected on 265 trees selected for apparent phenotypic resistance to blister rust, superior growth and form. During the fall of 1978, scions were collected on thirty plus-trees and grafted to establish one breeding clone park and clonal seed orchards.

White pine seeds were exchanged with Dr. L. Zsuffa of the Ontario Ministry of Natural Resources and Mr. C.M. Hunt of the U.S.D.A. Seeds of Eurasian white pines from the Working Party on Breeding White Pines collection were obtained from Dr. H.B. Kriebel of the Ohio Agricultural Research and Development Centre. This material will be tested for rust resistance in Québec and could be used as a gene source for hybridization and transfer of resistant genes within the eastern white pine genome. Scions from blister rust resistant *Pinus strobus* x *P. griffithii* hybrid clones were obtained from Dr. L. Zsuffa and grafted on eastern white pine seedlings.

Genetic sampling, plus-tree selection and grafting will be continued this year. Testing will be started in 1980 according to the established programme.

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PROGRESS IN HARD PINE BREEDING AT MAPLE

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Keywords: Breeding, interspecific hybridization, Pinus banksiana, P. rigida, P. nigra.

JACK PINE

Research in the genetics and breeding of jack pine (Pinus banksiana Lamb.) in Ontario is guided by the need for large quantities of genetically sound seed for direct seeding and planting in Ontario's reforestation program. To this end, studies are underway to ascertain the type and amount of genetic variation in natural jack pine populations, and to determine the effectiveness of selecting superior phenotypes from native stands and designated seed collection areas. Results of these studies are summarized below.

In a pilot project, satellite imagery was used to map the distribution of jack pine in a portion of northern Ontario (Buchert 1979a). Delineation of jack pine concentrations was quick and accurate, and four major jack pine areas were identified, as well as several smaller groupings. Subsequent sampling and testing will determine whether or not these groups are genetically distinct, and will yield valuable information on the extent and pattern of population structure in jack pine.

Early measurements from 2- and 3-year-old test plantations in the Kirkland Lake District seem to indicate that stand-to-stand variation in height growth may be minimal within a given jack pine breeding population. In these tests, open-pollinated families from trees with good, average and poor stem and branch characters were planted with bulk collections from local seed collection areas within the Engelhart Management Unit, bulk management unit collections, bulk samples from the local site region, bulk samples from a more southerly site region, and a bulk sample from a non-local seed collection area. Statistically significant differences were found among open-pollinated progenies, but not among general collections. However, such short-term data may not accurately reflect the differential fitness of different bulk collections, differences which may become more strongly expressed as time passes.

In another study involving selected jack pine clones from a seed collection area included in the above-mentioned tests, highly significant height differences were found among clones, indicating that much variation exists, and may be exploited by clonal and progeny testing and selective breeding.

PITCH PINE AND HYBRIDS

Experimental work with hybrids of pitch (*P. rigida* Mill) x loblolly pine (*P. taeda* L.), pitch x shortleaf pine (*P. echinata* Mill), pitch x slash pine (*P. elliottii* Engelm.) and pitch x Monterrey pine (*P. radiata* D. Don) continues (Zsuffa 1976, Buchert 1978). This work is aimed at defining the site and climatic tolerance of pitch pine hybrids, and testing parental combinations for hardy, fast-growing offspring.

Open-pollinated progenies of pitch pine and of hybrid trees were planted in five areas in 1977, ranging from North Bay District in central Ontario, to Brockville District in southeastern Ontario. The hybrids survived and grew significantly better than the pitch pine progenies. However, winter hardiness, especially of second-flush shoots was highly variable within hybrid materials, and stem form and height increment were related to winter hardiness of the previous season's growth.

Efforts to obtain hardy hybrid combinations are underway. Pitch pine trees were selected from Ontario sources and crossed with loblolly pine pollen supplyed by Dr. Silas Little[1], from a plantation in southern New Jersey (Zsuffa 1976). In spring, 1979 these full-sib hybrid families were planted on three different sites in southern Ontario.

A series of backcrosses between selected hybrid trees and hardy pitch pines of Canadian origin was begun in 1978 to obtain advanced generations for testing (Buchert 1979b).

A further series of controlled pollinations was carried out in spring 1979 using selected Ontario and Quebec pitch pine clones and pollen from selected Maryland and Delaware loblolly pine supplied by Dr. Peter Garrett[2] and Mr. Fred Trew[3]. This latest series of crosses combines a number of northern pitch pine clones with superior loblolly pine from the northernmost area of its range, and should give hybrid progenies which are more cold-hardy and better resistant to ice damage - a problem encountered in hybrids with one or more parents from the southeastern United States.

Further collections of hardy pitch pine seedlots are planned. Several cooperators in the United States will collect open-pollinated seeds from climatically rigorous areas within the range of pitch pine, which, along with a special collection of northern pitch pine sources will greatly expand the materials already available for future breeding.

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EXOTIC HARD PINES AND HYBRIDS

Provenance tests of P. nigra Arnold and P. sylvestris L. in southern Ontario indicate that selection and more extensive testing over a variety of sites will develop fast-growing trees with excellent form, which could be significant alternatives to red pine on many sites in southern Ontario. In particular, P. nigra from central Europe and P. sylvestris from eastern U.S.S.R. have shown very good growth, and preparations for more extensive testing are underway. Seedlots of P. nigra of the Louveigne and Koekelaer provenances from Dr. A. deJamblinne[4] and P. nigra var. laricio from Dr. F. Patolas[5] are growing in greenhouse and nursery beds, and will be outplanted over several sites in southern Ontario. In addition, Russian P. sylvestris provenance collections from Dr. Read[6] and provenances of P. densiflora Sieb. and Zucc. and P. thunbergiana Franco, from Dr. Peter Garrett are being grown for outplanting.

Hybrids of P. nigra x densiflora have shown very good growth in southern Ontario (Zsuffa 1975). Results with P. sylvestris hybrid, trihybrid and hybrid backcross combinations have been quite variable, indicating much heterogeneity. In one test, measured seven years after planting, P. (densiflora x sylvestris) x sylvestris progenies exhibited extreme variability among families, both in form and growth rate. However, the best hybrid families outgrew the red pine control by 25%. Other tests indicated a) no differences among P. nigra x densiflora families and red pine controls at 6 years; b) red and jack pine controls grew taller than P. (densiflora x sylvestris) x nigra trihybrids in two out of three plantings (no difference in the third planting), although the tallest individual trees in each plantation were hybrids; c) P. nigra x densiflora open-pollinated progenies were shorter than P. sylvestris as well as P. rigida hybrid combinations after 2 years in the field.

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SPRUCE GENETICS, SAULT STE. MARIE IN 1977 AND 1978

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

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

The objectives are (1) to elucidate the contribution of species, forms provenances and hybrids in productivity systems; (2) to collect and interpret information on genetic variability, crossability, heritability and other genetic parameters particularly genotype x environment interaction, in regard to genecology and phylogeny of the genus Picea and (3) to evaluate the effect of provenances, seed zones (site regions) in productivity systems, and confirm the validity of the limits of movement of spruce stock between regions etc. as compared with local sources.

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

HYBRIDIZATION

In 1977 extremely hot weather telescoped the flowering period in spruce forcing rapid development of pistillate strobili. Anthesis of staminate strobili was brief and the subsequent pollen flight very short. Controlled pollination work had to be restricted primarily to one breeding area only, Sault Ste. Marie, and was markedly truncated. Heat extremes may also have depressed results by raising the temperature in the pollination bags.

It is interesting to note that open-pollinated flowers on white spruce only yielded from 6 to 9% viable seed presumably because of the short length of time flowers were receptive, as well as the possible lack of exact synchrony with the shortened duration of pollen flight.

Controlled intraspecific pollination on white spruce, by comparison, resulted in up to 37% viable seed.

A number of crosses were carried out - some of which were for confirmatory purposes of earlier crosses, and to build up our stocks of hybrid material for subsequent selection and further experimental work. Others were new. Crosses were attempted using three morphologically differing clones from different sources of Picea glauca with P. glauca, P. pungens, P. sitchensis, P. shrenkiana, P. koyamai, P. asperata, P. abies, P. chihuahuana, P. omorika, P. orientalis, two P. rubens provenances and P. mariana. Three clones of P. omorika, were crossed with P. rubens, P. engelmannii, P. glauca and P. pungens and one clone of P. sitchensis with P. glauca. Of these all were successful except P. glauca x P. koyamai, P. asperata, P. abies and P. orientalis, and P. omorika x P. pungens.

The P. glauca x shrenkiana cross only yielded one seedling despite the fact that a substantial number of crosses were made on all three clones. This pattern seems to indicate that these species are rather reluctant crossers. The seedling is as yet unconfirmed.

P. glauca x P. pungens have been crossed successfully by several workers, but it is a difficult cross and has a consistently low crossability. As is the case with P. pungens x P. engelmannii (Kossuth and Fechner, 1973), there is probably considerable incompatibility. All clones of P. glauca pollinated by P. pungens yielded small numbers of viable seed.

For the second consecutive year a very few seedlings were obtained from P. glauca x P. rubens crosses. This occurred on only two of the three clones and curiously with different pollen parents. This cross, and that of P. glauca x mariana, has been attempted without success by many workers including ourselves, with monotonous regularity for many years.

In 1975 Hanover in Michigan first successfully accomplished the P. glauca x P. rubens cross and astonishingly the following year we met with success with the reciprocal, P. rubens x P. glauca, Gordon (1978). These seedlings have now been confirmed. Seedlings from these crosses exhibit some physiological disruptions e.g. resin ruptures on the foliage at least in the early stages. Crossability is extremely low.

Single unconfirmed P. glauca x P. mariana seedlings were obtained on each of two different P. glauca clones one of these died at about 1 year old. The remaining seedling is as yet unconfirmed, but exhibits some intermediate characteristics. Confirmed success with artificial crossing of these species is scarcely known. A single seedling, as yet unconfirmed was also obtained from several P. glauca x P. chihuahuana crosses.

Large numbers of seedlings were obtained from the P. glauca x P. sitchensis crosses. While interspecific crossability of these species is high, and seedlings can easily be obtained, such progeny are usually not particularly resistant to Ontario's continental climates (cf. Ying 1978). Through studies conducted on P. sitchensis provenances in our Piceta, we were able to make selections of this species sufficiently acclimatized to reach flowering size. Initial crosses of the reciprocal, P. sitchensis x P. glauca, were successful in 1977. To our knowledge this is the first time P. sitchensis has survived to flowering size in Ontario. P. omorika x P. engelmannii crosses first made successfully in 1971 were repeated. Results of this and P. omorika x P. glauca exhibit differing cross-compatability responses using different parents.

In 1978 flowering was light over much of Ontario Site Region 5 and we were unable to use some of our breeding areas. Breeding work was carried out primarily to the south in Site Region 6. Crosses were carried out using several clones of P. sitchensis x P. glauca and P. rubens, hybrid P. sitchensis x P. glauca x P. glauca, P. glauca x P. mariana (Rosendahl spruce) x P. glauca, and P. mexicana x P. engelmannii, P. glauca, P. pungens, P. rubens and P. orientalis. With three exceptions all of these were successful.

P. mexicana bears affinity to P. engelmannii and P. pungens and as a consequence we have thought it could possibly be usefully crossed with P. glauca. It is very fast growing. The attempted crosses with P. pungens were unsuccessful (unexpected), as were those with P. orientalis (expected) with which it is not related. The crossability of P. mexicana with P. glauca and P. engelmannii were disappointingly low, but a few distinctively hybrid seedlings were produced.

The surprise, by comparison, was the relatively moderate crossability of P. mexicana x P. rubens. Several vigorous and confirmed hybrid seedlings were produced. These species are scarcely alike and by most criteria belong to different groupings in the genus.

The failure of intermediate progeny of the Rosendahl spruce to backcross with P. glauca was also surprising. Hybrid P. sitchensis x P. glauca backcrossed easily with P. glauca as well as P. sitchensis with P. glauca.

After many years of repeated failures using P. rubens as the female parent, we had reported the first successful P. rubens x P. sitchensis (Gordon '78) cross in 1976. Crossability was low. However in 1978 P. sitchensis, used as the female parent crossed well with P. rubens. These seedlings are as yet unconfirmed.

APPLICATION OF INTERSPECIFIC HYBRIDS

Examples of marked positive heterosis providing sustained genetic gain resulting from interspecific hybridization alone are not common (cf. Wright *et al*. 1969, Jeffers 1971). After 8 growing seasons from seed the performance of our *P. omorika* x *P. rubens* and reciprocal crosses is truly astonishing. One experiment was partly ravaged by local citizenry stealing the fast growing individuals! Mean heights of the hybrids are 38% superior to the *P. rubens* parent and 24% to the *P. omorika* in Ontario Site region 5 and 52% superior to the *P. rubens* and 20% to the *P. omorika* in Site Region 6.

Our *P. omorika* x *P. mariana* reciprocal crosses are doing well, but do not at this point show quite the same promise as they do in some areas (cf. Nienstaedt 1975) or as the *P. omorika* x *P. rubens* reciprocal crosses do in these areas. We feel this cross will be of great importance in areas of man-made forests where silvicultural practices will diminish natural selection pressures. A new population of seedlings is being produced from seed from the original cross and will be turned over to tree production for mass propagation.

PICETA

The relationship of genetic variation on the nutrition, growth and efficiency in spruce are being investigated on a large number of spruce species and provenances on the same and different sites. An array of Ontario *P. mariana* and *P. glauca* provenances are included. The experimental plantations, called "Piceta", cover a complete range of plant hardiness zones and site regions in Ontario.

The Piceta are commencing to be utilized as breeding centres. Measurements and sampling have also begun in some of them.

The work of this Unit is otherwise largely occupied with productivity and nutrient cycling studies in spruce forest ecosystem research (Gordon, in press).

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GENETIC IMPROVEMENT OF SPRUCE AND LARCH FOR ONTARIO, 1977-78

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The spruce breeding program at the Ontario Forest Research Centre (OFRC), formerly the Southern Research Station, was started in the 1960's by Fowler and Heimburger. Various approaches in obtaining genetically improved material have been implemented through the years and described in previous reports to this Association (Rauter 1971, 1976). The larch improvement program was initiated in the mid-1970's and is quickly gaining impetus. The greatest interest originated with field staff in the southeastern part of Ontario, but has now spread across the province. A few trials have been field planted, although most are still in the nursery stage.

This paper will highlight results from a few of the spruce breeding experiments and identify some of the changes that have or will be instituted in the program; progress of the larch work to date will also be discussed.

SPRUCE IMPROVEMENT

Interspecific Hybridization

When the spruce improvement program first started, much of the emphasis was directed towards interspecific hybridization of native and exotic spruces. The original purpose was to determine crossability patterns of the genus Picea A. Dietr. and to find hybrids that showed heterotic vigour and/or greater tolerance to some of the site conditions, particularly in southern Ontario, than our native species. Field trials are now providing information on the performance of many of these hybrids.

Although some hybrids show heterosis, others do not. For example, even though Fowler (1965) reported on the hybrid vigour of Picea schrenkiana (Fisch. & Mey.) x glauca (Moench) Voss in the seedling stage, measurement of this experiment after 11 field growing seasons shows that the hybrid has lost its superiority and is now intermediate to the two parent species (Table 1). In another hybrid experiment, P. omorika

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(Panic) Purkyne x *mariana* (Mill.) B.S.P. has continued to outgrow both of its parent species after 12 field growing seasons (Table 2). In both experiments, survival has been good, but the introduced species have grown more slowly and the selfed populations have been the poorest.

Table 1. Mean total height growth of *P. schrenkiana*, *P. glauca* and *P. schrenkiana* x *glauca* after 11 field growing seasons.

Species	Mean total height growth (cm)
P. glauca x *glauca* (#1)	502
P. glauca x *glauca* (#2)	485
P. glauca x *glauca* (#3)	476
P. schrenkiana x *glauca*	381
P. schrenkiana x *wind*	109
P. schrenkiana x *self*	104

Table 2. Mean total height growth of *P. omorika*, *P. mariana* and *P. omorika* x *mariana* after 12 field growing seasons.

Species	Mean total height growth (cm)
P. omorika (S29) x *mariana* (mix)	459
P. omorika (S31) x *mariana* (mix)	457
P. mariana (Ontario mix)	424
P. mariana (New Brunswick mix)	369
P. omorika (S29) x *omorika* (S31)	330
P. omorika (S31) x self	299
P. omorika (S29) x self	284

A more recent trial of *P. omorika* and *P. mariana* shows similar results to the older trial; but in this experiment, differences in survival are considerable (Table 3). For the first two field growing seasons, survival was high in all populations. During the third year, the trees in the experiment were subjected to a summer drought. Mortality of the *P. mariana* populations was minimal, that of the *P. omorika* populations extremely high and that of the hybrids intermediate.

Table 3. Mean total height growth and survival of P. omorika, P. mariana and their hybrids after 3 field growing seasons.

Species	Number of populations	Mean total height growth (cm)	Survival
P. omorika x mariana	1	40	76
P. mariana x omorika	3	40	71
P. mariana x mariana	6	38	96
P. omorika x omorika	5	25	23

In other trials, hybrids such as P. glauca x sitchensis (Bong.) Carr. and P. abies (L.) Karst. x koyamai Shir. are performing well, whereas others such as P. glauca x jezoensis (Sieb. and Zucc.) Carr. are doing poorly.

Selection and Improvement of White and Black Spruce

The interspecific hybridization work continued until the early 1970's when the emphasis shifted towards the genetic improvement of our native white (P. glauca) and black spruce (P. mariana). Since that time the testing of seed production areas and seed orchards has been underway. For example, in the fall of 1977, nursery height measurements were taken for two trials to evaluate a black and white spruce seed production area. The variation in total height among half-sib families was considerable. In the black spruce trial, the mean total height for 20 families ranged from 24 to 35 cm, a difference of 45%; and in white spruce the height for 20 families ranged from 16 to 29 cm, a difference of 80%. These differences lend support to the necessity of progeny testing in any plus tree selection program.

Field staff within the Ministry have continued to select plus trees and to collect scions for the establishment of clonal seed orchards. In white spruce, greater emphasis is being placed on increasing the number of annual plus tree selections so that the orchards can be completed within a reasonable period of time. Discussion between research and management staff has resulted in a change of design for the orchards. Starting in 1979, the number of clones planted within a 144-tree block will increase from 12 to a minimum of 36 and preferably 48. This would reduce considerably the dangers of inbreeding that exist with the original design. The change in design will not affect the pattern for controlled pollinations (Rauter 1976) that are underway in the 3E (Hills 1960) white spruce orchard and that have started in the 3W orchard. With a field training program and the increased interest and support from the field staff, it is anticipated that controlled pollinations will be carried out in all of the clonal orchards as they reach flowering maturity.

Black spruce continues to be the number one species planted in Ontario and there is a crucial need for obtaining large quantities of genetically improved seed within a few years. In attempts to meet this need, emphasis is being reduced on the clonal orchard approach and directed instead towards the seedling seed orchard, a program first started with the cooperation of the field staff from the northwestern part of the province.

During the fall-winter of 1976-77 and 1977-78 cones were collected from approximately 2,300 selected trees. Some of the seed obtained was bulked into gene pool collections. The seed was germinated at the regional nursery in Dryden and will be shipped back to the collection area. Some seed was kept separate and will be germinated on an individual tree basis starting in the spring of 1980, upon completion of new greenhouse facilities at Dryden. Selected seedlings will then be placed in a seedling seed orchard (Rauter 1979), others will be used for progeny trials and the remainder will be available for the reforestation program in the northwest. It is anticipated that about 20 ha of seedling seed orchard can be established from these 2,300 trees; this is greater than the entire area of black spruce clonal orchard now planted for the entire province. Plus trees will then be selected from the progeny trials for advanced generation clonal orchard development.

Flower Initiation

The long periodicity between good cone crops is a problem in the white spruce orchards. Female flower initiation through the use of gibberellin $GA_{4}/_{7}$, particularly in combination with napthalene acetic acid (NAA), appears promising. In cooperation with Pharis of the University of Calgary, gibberellins were applied to several clones in the 3E white spruce orchard. In the spring of 1976, a foliar spray containing either $GA_{4}/_{7}$ or $GA_{4}/_{7}$ in combination with NAA was applied to the trees at periodic intervals from early May to the end of June. Three trees from four clones were selected for each of the two treatments as well as three from each clone as controls. In the spring of 1977, there was a 5.5-fold increase in female flower production between the control trees and those treated with $GA_{4}/_{7}$ and a 12-fold increase between the controls and the combination of $GA_{4}/_{7}$ and NAA (Table 4). This trial will be repeated to confirm these results. If the second trial also reveals increased female flower production, the use of GA and NAA will become part of the management system for white spruce clonal orchards.

Table 4. Summary of flowering results in trial using gibberellin $GA_{4}/_{7}$ and napthalene acetic acid.

Clone	$GA_{4}/_{7}$		$GA_{4}/_{7}$ & NAA		Control	
Number	Male	Female	Male	Female	Male	Female
353	14	143	4	1034	0	65
594	58	199	2	160	17	47
626	0	50	22	40	8	2
663	0	246	1	159	2	1
TOTAL	72	638	29	1393	27	115

Vegetative Propagation

Vegetative propagation of white and black spruce through rooting cuttings (Rauter 1976) has continued on a minor scale at the OFRC and on a larger scale at the Orono Nursery. New facilities were built at Orono in 1977 and used for the 1978 trials. Some of the better rooting clones have been established in stools and will be managed for future cutting production. Some of the material has been field planted to determine the potential in growth and form. More emphasis is now being placed on the collection of greenwood cuttings taken in late June or early July as these appear to root more readily and have better subsequent growth and form than dormant spring cuttings. It is anticipated that this program will increase substantially during the next few years.

LARCH IMPROVEMENT

Species within the genus _Larix_ Mill. have a great capacity for rapid growth. Although the first trials were established by Mark Holst of the Petawawa Forest Experiment Station in 1950 (Calvert and Rauter 1979), there was little interest throughout the province to undertake a sizable planting program for any of the larch species. However, during the past 5 years awareness of the potential shortage of future wood supplies has increased, resulting in greater support for the utilization of fast-growing, short-rotation species and for more intensive silvicultural management practices. The larches appear to have the greatest potential of the coniferous species to provide fast growth and suitable wood for fibre, pulp and lumber.

Several trials are currently being initiated to determine not only the best species, but also the best sources of these species for the site available. The first trial established by OFRC consisted of material provided by Holst to Rauter. Several populations of _Larix leptolepis_ (Sieb. and Zucc.) Gord., _L. decidua_ Mill., _L. eurolepis_ Henry and _L. laricina_ (Du Roi) K. Koch. were field planted on three sites across southern Ontario during the spring of 1977. Table 5 shows the mean total height growth by species after two field growing seasons. _L. eurolepis_ performed well on all sites, particularly East German sources. For example, the latter provided the tallest tree (224 cm, Brockville plantation). I believe that some of the growth rates in this experiment are as good or better than those of any other conifer planted on a similar site.

The early indications of the above trial lend support to the establishment of an orchard of select European (_L. decidua_) and Japanese larch (_L. leptolepis_) clones for the production of hybrid seed. This cooperative program was initiated in 1978 with the Petawawa Forest Experiment Station and the Quebec Department of Lands and Forests to obtain scions from selected individuals growing in Ontario and Quebec for grafting and the subsequent establishment of a hybrid, clonal orchard.

Since tamarack (_L. laricina_) is an extremely variable species, considerable genetic gain should result from a selection program. Many

Table 5. Mean total height growth of *Larix* after 2 field growing seasons.

Species	Number of populations	Location: Brockville (cm)	Niagara Falls (cm)	Melancthon (cm)	Species average (cm)
L. leptolepis	3	102.3	88.7	77.3	89.4
L. eurolepis	7	99.5	92.0	88.0	93.2
L. decidua	4	87.2	83.7	76.6	82.5
L. laricina	2	83.7	75.3	72.9	77.3
Plantation average		95.0	87.2	81.2	

good stands throughout southern Ontario have already been identified. Cones have been collected from some stands and a stand trial established from the seed available. Several plus trees have also been chosen. When seed is available from these selections, it will be germinated and a seedling seed orchard program similar to black spruce will be started.

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FOREST TREE SEED RESEARCH IN ONTARIO

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The provincial seed research program was initiated in 1968. One of the problems identified was reduction of variability in nursery stock for various production systems. The goal was to reduce culling costs, ensure uniform quality of trees and increase stock yield through improved seed programs.

Each of the three sets of factors considered influenced total germination, rate of germination and/or early seedling growth. Physical seed characteristics were investigated first. Studies of stock variation due to source of seed followed. Finally a development program was initiated based on modified germination conditions.

VARIABILITY DUE TO PHYSICAL SEED CHARACTERISTICS

Separation of bulk jack pine (*Pinus banksiana* Lamb.), black spruce (*Picea mariana* (Mill) B.S.P.) and white spruce (*Picea glauca* (Moench) Voss) seed lots resulted in strong seedling growth/seed weight correlations for trees grown under controlled greenhouse conditions (Skeates 1972). Contrary to the work of many authors, the growth advantage exhibited by trees from heavier seed increased with age of trees for the duration of the study, i.e. 16, 24, and 25 weeks for white spruce, jack pine and black spruce respectively. Similar results were obtained in two year nursery studies in white spruce though correlations were not as strong. Statistical significance of growth correlations with either seed size or density though both are components of seed weight, disappeared after a few weeks.

The general term, mean seed weight, has been used in different ways by various authors. The mean weight of a class of seed having a narrow range in individual weights is quite different from the mean weight of seed from a tree having a two to three fold range in individual seed weights.

Sorting of seed undoubtedly leads to some separation of population due to differences in the range of seed weights between trees (Hellum 1976). However this is minimized when the technique is used primarily as a stock production tool and most of each seed lot is shipped as nursery stock. Where large quantities of seed are collected for direct seeding, sorting of a fast growing fraction for nursery stock production would still represent several thousand mother trees and could be highly beneficial in production of improved quality stock.

Separation of seed lots, primarily on a seed size basis, is current practice in Ontario, available to provincial nurseries on request.

VARIABILITY DUE TO SEED SOURCE

Seed source variation was considered as a second probable source of stock variability. A review of older jack pine provincial provenance trials (Skeates 1979b) indicated population variability independent of the seed zone system in use in Ontario (Hills 1960). Though sampling distribution for the study was limited, stand to stand variability also appeared an important aspect of population variation.

In cooperative white spruce trials of Great Lakes/St. Lawrence region sources planted in several Ontario locations, it was also apparent that there was considerable variation between sources even with the same site region (Teich *et al*. 1975). Subsequent regional trials have been initiated. To date nursery results of 3-year-old trees grown at Dryden Ontario have provided growth performance patterns which contribute to our knowledge of population structure amongst Northwestern Ontario sources.

The new registration system adopted in 1978 in Ontario (Skeates 1979a) appears a very important advancement in light of exhibited stand to stand variation. Seed is currently identified first by administrative district for the five northern regions and by administrative region in the south, and secondly by site region for bulk collections. The numbering system allows for identification of registered stands selected as permanent seed sources. Differences between stands even within these new and much smaller zones suggest the need for identification, registration and preservation of potentially faster growing sources for each major reforestation species within each administrative district.

Seed source is a significant source of variation in production of nursery stock.

MODIFIED STOCK PRODUCTION SYSTEMS

Environmental factors such as seed bed densities, fertilization, irrigation etc. appear to be even stronger factors in quality of stock. A review of existing nursery data indicated low seed efficiency defined as yield of seedlings relative to viable seed sown in bare-root production on provincial nurseries. Expected losses average 60% in jack pine, 75% in white pine (*Pinus strobus* L.), red pine (*Pinus resinosa* Ait.) and white spruce, and 85-90% in black spruce (Skeates and Williamson 1979b). Unpublished growth data has indicated variation in rate of height development relative to time of sowing in container systems. Other data have shown black spruce germination over the duration of the summer in seed beds of a northern nursery. Resultant differences in rate of height development and duration of growth in the first season are probable major factors in stock variability. Effort therefore has been directed toward development of stock production systems which encourage full and uniform early germination. These developments have included pregermination techniques, greenhouse transplants and containers, primarily with black spruce and seed bed and seed drill shelters for all major conifers.

Pregermination techniques

Sphagnum moss 'cigarette' plugs were developed as a means of handling pregerminated seed. Seed was sown on the ends of 5/8" long 'cigarettes' and germinated under optimum conditions. Potentially large numbers of seed can be germinated in a relatively small space thus saving on costly greenhouse operation early in the season. High seed efficiency is achieved through germination under optimum conditions. Expensive greenhouse facilities are fully stocked initially and plants leaving the greenhouse tend to be uniform in size having started at a uniform stage of development.

Greenhouse transplants

A system of peat cubes was adapted from an agricultural system. Cubes were cut leaving fault lines in the peat instead of costly containers. The cubes were seeded or planted with cotyledenous seedlings. After initial greenhouse growth, seedlings were transplanted in cubes into nursery beds in mid-summer at a time of low work load. As the cubes were basically containers, little root disturbance was experienced by the plant. The system has potential for complete automation from pregermination to transplanting (Skeates and Williamson 1979a). Two-year-old transplants grown at Orono in 1975 (Skeates and Williamson 1979b), started in April, were shown to reach a standard comparable in height and root collar diameter to small, heavy grade 1+2 stock grown under normal nursery regimes (Reese and Sadreika 1979).

Container production

Peat cube 'containers' were developed using larger cubes than above, for direct planting in the field. Container walls, consisting only of fault lines in the peat, easily broken apart by hand at time of planting, significantly reduced production costs.

'Cigarettes' of 3/4" diameter are currently under investigation using a variety of coverings around screened sphagnum moss. Gauze covered sphagnum 'cigarettes' allow normal root formation with air preventing extension of root tips much beyond the container surface. Other container systems, even those that are biodegradable, initially direct all or most roots to the bottom allowing only a small surface for immediate rooting into the surrounding soil.

Bare-root seedlings

Germination and early performance of field sown seedlings have been improved by providing protection over seed beds. Continuous corrugated plastic shelters (Williamson 1978) were built in 4' sections to cover the width of the bed during the early stages of plant development. After two seasons, plants were up to 45-60% heavier with well balanced root systems suggesting the possibility of reducing production time by a year for some species. Similar gains were achieved using 6" drill covers of the same material, providing a greenhouse atmosphere for germination and early plant performance.

Each of the stock production systems developed gives a seed efficiency advantage providing a high yield of seedlings relative to viable seed sown. Each provides improved germination conditions contributing to more uniform stock development and reduced loss due to culling. For genetically improved seed lots it is essential to apply the fruits of tree improvement effort in the form of uniformly high quality nursery stock over as large an area as possible.

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POPLAR, WHITE PINE AND ORNAMENTAL TREE BREEDING AT ONTARIO FOREST RESEARCH CENTRE, MAPLE IN 1977 AND 1978

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Keywords: Poplar breeding, white pine breeding, clonal testing, vegetative propagation.

INTRODUCTION

Poplar and white pine breeding at Maple was initiated in the mid 1940's. Both programs have been active since that time. Some good results have been achieved and the programs gained in importance.

The present objective of the poplar program is to produce clonal stock for a variety of needs in an intensive poplar plantation programme. In white pine breeding, the current work concentrates on progeny testing of eastern white pine (P. strobus L.) plus trees, breeding and field testing of eastern white pine x Himalayan white pine (P. griffithii McClelland) hybrids and developing and testing clonal varieties. In ornamental tree breeding, the goal is to preserve ornamental types which result from various breeding programs.

In this report, the work and accomplishments of 1977 and 1978 are outlined.

POPLAR BREEDING

During the last two years, work concentrated on eastern cottonwood (P. deltoides Marsh) and its hybrids with black poplar (P. nigra L.) and various balsam poplar species (such as P. balsamifera L., P. trichocarpa Hook., and P. maximowiczii Henry). These hybrids are generally easy to clone and propagate by rooting of stem cuttings. They are easily established in plantations, grow vigorously, and respond to intensive management. Their biomass is valued for various uses.

There is less emphasis on the genetic improvement of trembling aspen (P. tremuloides Michx.). It is believed that on good aspen sites, stand improvement can usually be achieved by proper regeneration and management, so new stock for forest type poplar plantings will rarely be needed.

To satisfy the needs of developing intensively managed poplar plantations in northern Ontario, clones of selected plains cottonwood (P. sargentii Dode) and of balsam poplar hybrids are being developed. The hybrids are being created by crossing balsam poplar (P. balsamifera) selections from northern Ontario with either cottonwood, black poplar, or another balsam poplar species of good timber quality.

Methodology

The breeding and clonal development follows the same general outline: (1) selections of native species are made, seed collected and gene pools of progenies established; (2) scions and seeds of desired exotic species are obtained and established in gene-pool plantations; (3) parent trees with desired traits are selected and hybridized; (4) the hybrid progenies are established in gene-pool plantations; (5) specimens possessing desired traits are selected from gene-pool plantations and cloned; (6) initial clonal trials are established (with a large number of clones and small plots) in important planting areas; and (7) the best clones in the initial trials are studied further and recommended for plantation trials (Zsuffa 1979a).

The criteria of clonal selection are manifold and changing. They include good rooting ability, resistance to frost, resistance to diseases and insects, fast growth, desired site tolerance, positive reaction to intensive management, tolerance to certain management techniques, and desired biomass quality (Zsuffa 1979b).

Studies in Native Poplar Species

Little is known of the genetic variation in native poplar species, and gene-pool collections are almost non-existent. In 1977 a study and collection of eastern cottonwood genetic material was started. Eastern cottonwood was chosen because of its importance in poplar breeding for intensive management, and its scarcity in Ontario.

In the first stage, the occurrence and range of eastern cottonwood in Ontario was described and mapped. Specimens were systematically selected and described, and herbarium material was collected.

In 1978 the collection of seeds and scions from selected specimens was initiated. Parent trees have been vegetatively propagated and their open pollinated progenies raised.

Pollination

Several crosses were made between balsam poplar (northern Ontario selections), eastern cottonwood and P. Maximowiczii. Almost all of the crosses with eastern cottonwood as female parent resulted in good seed, while most of the crosses with balsam poplar as female parent failed.

In cooperation with the West German Forest Tree Breeding Institute[1] several crosses were made between trembling aspen selections from Ontario and P. tremula L. selections from Germany. Reciprocal crosses (with the native species as female parent) were made in the respective countries and the seeds exchanged for testing and studying.

Gene-pool Plantations of Hybrid Progenies

Several plantations of full-sibs produced at Maple were established in areas important for poplar culture. These plantations will be important sources of new clones. The breeder can draw from these sources continuously, as the need arises for clones of new and different qualities (for example, resistance to pests or different biomass qualities).

Clonal Testing

Most of the clonal evaluation is done on the basis of performance in initial trials and management trials. These are nursery and field plantations with replicated clonal plots.

The initial trials are established with large sets of clones (30 or more) and are of relatively short term (1-5 years). Although most of the clones planted in the different site regions and in subsequent years vary, a set of identical control clones is incorporated into each trial. Information on early performance allows the screening of a large number of clones for important traits. Initial field trials have been established in almost every area. Sites have been set aside and trials established annually on various soil types within blocks of regular plantings. Exploratory trials have been established in areas which may become important for poplar culture in the future, such as in northern Ontario. The initial trials are managed in the same way as the regular plantings in the area.

The management trials are established with clones screened in initial trials. Additional variables such as soil types, methods of site tending, weed control, type of stock and spacing are considered. These trials have been established in the areas of important poplar culture activities. Depending on the aim of the trial they are either of short-term or long-term character. The management trials are mainly in cooperation with the breeders, poplar culturists and researchers in other disciplines.

Clonal Propagation

There is a need for fast initial propagation of promising new clones, in order to multiply these in larger quantities for various studies and plantation trials. Small (2-8 cm long) stem cuttings and leaf-cuttings

1 Dr. H. Weisgerber, Hessische Forstliche Versuchsanstalt, Institut fur Forstpflanzenzuchtung, Postfach 231, 3510 Hann. Munden, West Germany.

were planted in small containers and kept in a greenhouse environment for this purpose. Rooting occurred within 2 weeks, growth was fast, and new green cuttings could be taken immediately from the rooted plants for further propagation. In this way, a single tree could produce several hundred individual plants within five months.

Cutting propagules are mass-produced in clonal stools. The clonal stools of poplars, which easily recoppice, are managed for the growth of juvenile, vigorous whips, suitable for cuttings. Three types of stools are developed and maintained at Maple and several forestry nurseries. The basic pool contains all clones which have been selected, propagated, hybridized and studied. The stools at Maple contain approximately 1000 clones. The clonal collection stools contain the clones which have potential for large scale planting. The collections at three forestry nurseries contain approximately 250 clones. Production stools provide large quantities of cuttings of certified clones for regular plantings. Presently, there are approximately 40 certified clones.

WHITE PINE BREEDING

The program on eastern white pine plus tree selection and progeny testing has continued. In 1978, 28 new eastern white pine plus trees were selected in 4 forest regions, and scions from 24 of these were grafted making a total of 97 plus trees, 66 of which were cloned. Progeny testing is in progress to establish the ability of the selected trees to produce improved offspring and to single out the best parents for seed orchards. The early (1 to 7 years) figures show large variation (up to 100%) in survival and height growth of the progenies and the unselected controls, suggesting a significant potential for genetic improvement.

Scions are collected from selected trees for propagation by grafting in the winter and cones are collected in the fall for progeny testing. Both of these collections can be difficult because of inaccessibility of the trees. It would be desirable, therefore, to combine the scion and cone collection. A simultaneous collection in the fall is the answer if the scions can be grafted at that time. Trials conducted over two years showed that the grafting of scions collected in the fall, at the time of cone collection, was feasible (Zsuffa and Eng 1979).

The Himalayan white pine produces vigorous, blister rust resistant hybrids when crossed with eastern white pine. Only restricted genetic material of this exotic was available in Canada. Range-wide samples have been obtained through IUFRO from India and Pakistan in the form of seeds collected from plus trees (153 open pollinated progenies). The seeds have been germinated and over 12 000 seedlings established in the nursery. These will be outplanted and the best trees used in future breeding programmes.

Several field trials of eastern white pine x Himalayan white pine hybrids have been established on a variety of sites. In the oldest trial, at 6 years of age, the hybrid white pine outgrew the eastern white pine control by 61%.

Clonal propagation of the selected blister-rust resistant, good-rooting white pine clones has continued. An orchard of such clones has been established in the Midhurst nursery. It is managed for the massive production of cutting-propagules. The trees are top-pruned to hold them in a juvenile stage. It is hoped that the hedging and trimming technique can provide a convenient way to produce and harvest many cuttings from a tree. In the stools the trees are relatively widely spaced (3 x 3 m) and the area is cultivated, fertilized and irrigated when necessary to maintain vegetative growth (Zsuffa 1979c).

ORNAMENTAL TREE BREEDING

Pine, spruce, elm, poplar and willow tree varieties of ornamental value are being selected among native species, exotics and hybrids and vegetatively reproduced. An "ornamental tree show" containing such varieties has been established near the St. Williams Nursery.

A collection of Dutch-elm-disease resistant American elm (*Ulmus americana* L.) and various hybrid elm trees is maintained, propagated and tested in disease-infected areas. A new method for cloning of elms by vegetative propagation of green-cuttings was successfully developed (Saul and Zsuffa 1978).

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RESEARCH ON TREE GENETICS AND BREEDING AT PETAWAWA 1977-1979

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Keywords: tree genetics; tree seed; selection.

The purpose of this report is to give an outline of research on tree improvement and tree seed at Petawawa National Forestry Institute for the period January, 1977 to July, 1979. Detailed reports on individual topics are given elsewhere in these proceedings by E.K. Morgenstern, C.W. Yeatman, C.C. Ying, W.H. Fogal, B.S.P. Wang, D.A. Winston and B.D. Haddon.

PROGRAM DEVELOPMENT AND STAFF MOVEMENT

The period 1977-79 was a crucial one for the tree improvement and seed programs. Before 1977 the programs were already feeling the cold winds of government austerity. Labor for the nursery and field trials became scarce and programs concerned with Scots pine (Pinus sylvestris L.), Norway spruce (Picea abies [L.] Karst.) and red pine (Pinus resinosa Ait.) were placed on care and maintenance. Scarcity of funds for travel also affected liaison with operational foresters and technology transfer. The programs were exposed to a Zero-A base analysis in 1977, and emerged unscathed. During this period Dr. D.F.W. Pollard, the physiologist working with the geneticists, transferred to the Pacific Forest Research Centre at Victoria, B.C.

In the fall of 1978 a major government austerity program was announced, with severe cuts throughout the government science sector. Petawawa Forest Experiment Station, as it was called then, was designated for closure and most of the staff were to be laid-off, placing the long-term genetics and silviculture trials in jeopardy. The decision to close the Station was reversed and the Station was amalgamated with the Canadian Forestry Service's Forest Management Institute and Forest Fire Research Institute to form the Petawawa National Forestry Institute. This amalgamation involved considerable cuts in the staff and budgets of the three amalgamated units.

These changes directly affected the tree improvement program. Mr. Ken Logan, the remaining tree physiologist, retired, leaving the program with no continuing plant physiology input.

Fortunately, in the fall of 1978 Dr. Nikhil Bhattacharya, a Natural Science and Engineering Research Council Visiting Fellow, came to work for two years at the Institute on isoenzymes in spruce and pine populations, thereby maintaining a temporary Institute physiology capability. During this period of uncertainty, Mr. R.F. Calvert, responsible for research on improvement of hardwoods and larch, resigned and joined the Ontario Ministry of Natural Resources as a Unit Forester at Thunder Bay. Dr. C.C. Ying, who was responsible for the major white spruce improvement program, also resigned and went to assist the B.C. Forest Service with their tree improvement program. In July 1979 the two remaining Petawawa geneticists were joined by Dr. Gordon Murray, who is on sabbatical leave from Lakehead University. He is working on the white spruce improvement and isoenzyme analysis of tree populations.

The Institute's two vacancies for geneticists, have been excluded from the government recruitement freeze.

In June 1979, the author, who had been Program Manager of tree improvement and tree seed research programs for eleven years, relinquished these responsibilities to concentrate on a program concerned with short-rotation forestry and the allied topics of environmental impact and use of nitrogen fixation in forestry. Dr. E.K. Morgenstern is now Project Leader for tree genetics and breeding, and Mr. B.S.P. Wang is Project Leader of the National Tree Seed Unit. The Program Manager responsible for both these projects is Mr. R.F. Ackerman.

The National Tree Seed Centre's staffing was less affected by the year's disturbances than the tree improvement program. Mr. Dave Winston transferred to Petawawa from the federal Great Lakes Forest Research Centre to develop a research program on seed production and collection.

The programs have emerged from these difficulties somewhat battered but nevertheless viable. Tree improvement and tree seed research and development are regarded as high priority programs, and the future for this work appears to be relatively bright.

The upsets of the past year have focussed attention upon the vital issue of security of long-term research programs. Without security there can be no continuity, and continuity is vital to the success of tree improvement research and development. The problem of how to protect good long-term research from the effects of changing political climate is a matter which managers and scientists should give serious consideration.

RESEARCH PROGRAMS

In spite of the year's disturbances, productive tree improvement and tree seed research programs were maintained.

White Spruce

During the 1977-79 period the emphasis of the white spruce (*Picea glauca* [Moench] Voss) improvement program was on completing the seed collection for the all-range provenance study and establishment of plots throughout Canada. Existing trials were all remeasured. In Ontario, the whole strategy for white spruce improvement was reviewed. Twenty-two-year-old progeny tests were measured, and the effects of selfing examined. Dr. Ying's departure has brought this work to a halt for the time being (see C.C. Ying *ibid*.).

Black and Red Spruce

Measurement and analysis of the cooperative red spruce (*Picea rubens* Sarg.) experiments in Quebec, New Brunswick and Ontario were completed and the effects of introgression examined. Open pollinated progeny of black spruce (*Picea mariana* [Mill.] B.S.P.) were planted in Ontario in 1977, and survival is excellent.

Jack Pine

The 1977-79 period was spent remeasuring all-range and other jack pine (*Pinus banksiana* Lamb.) experiments and analyzing the data, together with carrying the results into the development stage in cooperation with the governments of Ontario and Quebec, by assisting with the design and establishment of seed production areas, the selection of plus trees, initiating progeny tests and preparing grafts for seed orchard use.

The previous research on genetic differences in resistance to scleroderris canker has taken on a new significance now that the virulent European strain has begun to take such a toll of young and mature pines in New York and adjacent states. Cooperative work has been developed with the U.S.A. on the effects of this virulent strain on Canadian jack pine genotypes that appear to be resistant or susceptible to the North American strain of scleroderris (see C.W. Yeatman *ibid*.).

Larch

During the 1977-79 period the larch (*Larix* sp.) program was affected by a surge of interest in the use of larch species and hybrids in intensive forestry. Examination of existing trials of introduced larches indicated spectacular growth rates on some sites, and attention was focussed on the possible use of tamarack (*Larix laricina* [Du Roi] K. Koch). Experiments to examine larch performance were established in eastern Ontario in cooperation with the Ontario Ministry of Natural Resources and early results appear promising. The possible use of larch for energy production in "Energy Forests" is being examined by Petawawa scientists supported by ENFOR funds. At present seed supply is a major problem (see E.K. Morgenstern *ibid*.).

Hardwoods

A collection of black walnut (*Juglans nigra* L.) was made throughout the species range in Canada. In spite of delayed germination, it was possible to establish progeny tests in Ontario, Quebec and Wisconsin. Wide ranging collections of white ash (*Fraxinus americana* L.) and green ash (*F. pennsylvanica* Marsh.) were made in Ontario, Quebec and the Maritimes.

There is increasing interest in these two species for use in short rotation forestry. Experiments on effects of site, spacing, weed control, etc., have been established in cooperation with the Ontario Ministry of Natural Resources in eastern Ontario, funded by the federal ENFOR (Energy from the Forest) program. There is also an increase in interest in the use of alders (Alnus) to increase yield in short-rotation forestry and experiments are being established (see E.K. Morgenstern ibid.).

Physiology

The programs on development of early screening systems, growth acceleration techniques and bud morphogenesis have been terminated due to the loss of physiology positions. Dr. Bhattacharya, the Visiting Fellow is, however, working on development of techniques to identify isoenzyme patterns in different tree genotypes.

Economics

At present there is no one in Canada devoting a major part of their time to the economics of tree improvement programs. The author received several requests for reports on this topic in 1977-79 (see References).

The trend seems to be away from justificatory exercises -- although these will still be necessary if the Zero-A Base techniques continue to be used as a program appraisal tool -- towards optimization techniques involving linear programming. The author is no longer working in this field and there is a need for increased effort in this area.

Nursery and Plantations

Table 1 summarizes nursery (Mr. Z. Zdrazil) and plantation (Mr. Paul Viidik) activity for 1977 and 1978. The grafting program was reduced from 9,000 in 1977 to 4,000 in 1978 due to manpower shortages.

Table 1. Nursery and plantation activities.

Nursery	1977	1978	Total
Seedlots sown	600	900	1,500
Tree propagated vegetatively	9,000	4,000	13,000
Trees transplanted	23,000	35,000	58,000
Trees shipped for planting	31,000	12,000	43,000
Seedlots sent to research cooperators	1,400	600	2,000
Plantations			
Planted at PNFI	3.4 ha	3.0 ha	6.4 ha
Planted by cooperators outside PNFI	9.0 ha	7.2 ha	16.2 ha
	12.4 ha	10.2 ha	22.6 ha

Genetic Variation in Resistance/Susceptibility

This research program began in 1977. The relationships between larch sawfly and tamarack, white pine blister rust and eastern white pine (*Pinus strobus* L.), spruce budworm and white spruce, *Armillaria* and black spruce, white pine weevil and Norway spruce, *Gremmeniella* and jack pine and gall rust and Scots pine have been selected for study. In the larch sawfly-larch study it was found that the tall, fast growing genotypes were most heavily attacked, but that there were exceptions. An examination of chemical feeding deterrents for spruce budworm is in progress (see W.H. Fogal *ibid*.).

Tree Seed Insect Pests and Diseases

Work has been carried out on the impact of seed and cone insects on seed production in commercial tree species and on ways of controlling them. Spruce seed and cones are attacked by a wide range of insects and diseases, and these greatly hinder seed production by important spruce species. The effects of stand conditions, systemic insecticides and entomopathogenic fungi are being examined (see W.H. Fogal *ibid*.).

National Tree Seed Centre

The Centre continued to provide information and testing services, and has been involved with the development of the new Seeds Act in cooperation with the Canada Department of Agriculture. A wide range of research topics have been addressed and these are reported by B.S.P. Wang (*ibid*.).

Conferences

In 1978 Petawawa geneticists and seed scientists were involved in two major conferences: (a) a workshop on "Tree Seed Production and Tree Improvement in Canada. Research and Development Needs" held at Petawawa; and (b) a "Tree Improvement Symposium" sponsored by COJFRC, which was held in Toronto. The papers of these symposia have been published and are available.

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INSECT AND DISEASE RESEARCH IN TREE IMPROVEMENT AND SEED PRODUCTION - PETAWAWA

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Keywords: resistance; susceptibility; feeding deterrents; antifungal chemicals; vegetative propagation, control of seed and cone insects and fungi; seed quality.

INTRODUCTION

Two studies in tree improvement were initiated in 1977 at Petawawa National Forestry Institute (PNFI) to deal with problem insects and diseases threatening trees and tree seed in expanding forest regeneration programs in Canada. One is concerned with controlling insects by using knowledge of genetic variation in host trees either to develop resistant types or to prevent planting of susceptible types in forest regeneration. The other deals with identification and control of insect and disease problems in seed production, collection, storage and germination. One research scientist (W.H. Fogal), and one technical assistant (S.M. Lopushanski), devote half-time to each study.

GENETIC VARIATION IN RESISTANCE/SUSCEPTIBILITY

Objective

The objective of this study is to reduce economic impact of insects and diseases by identifying pest-resistant trees and providing information to prevent utilization of susceptible trees in forest regeneration.

Problem

Insects and parasitic fungi cause enormous losses in wood quality and increment and death of trees over widespread areas of Canadian forests. Management of destructive insects and diseases has relied heavily on chemical pesticides because there are few other effective alternatives for control of some of the most destructive species. However, the directed use of insect parasites and predators and parasitic microorganisms as biological control agents has provided effective control of a few major forest insect pests. In a broad sense, biological control involves human manipulation of the biological environment of the pest. Since the tree is the focus of activity of the pest there is a need to concentrate on manipulating this component of the pest environment. The wide range of genetic variability in most forest trees provides an excellent opportunity to develop trees with relatively high degrees of resistance; to develop trees with the ability to produce maximum fibre in the presence of insects or parasitic fungi.

Employment of resistant trees in pest management strategies will likely have significant economic benefits if one accepts the experience in agriculture. For example, time and money spent on research to develop rust resistant varieties of wheat have saved millions of dollars for Canadian wheat growers. Money is saved even though the resistance has a limited duration of usefulness because of development of strains of the pest which overcome resistance. This is largely the result of breeding programs designed to select for one or few genes for high degrees of resistance. The duration of useful resistance can be increased, by selecting for several or many genes, if one is willing to accept a smaller degree of resistance. This is likely to be the more practical approach in forest tree breeding because of the long life of the host relative to the pest.

Variation, Inheritance and Selection of Resistance

Investigations will be conducted on host-pest-environment relationships for some important pests attacking commercial tree species in Canada in cooperation with tree breeders at PNFI. Resistance and susceptibility have already been considered in tree improvement studies at PNFI in a number of host-pest complexes. Background information has been collected on variation of insect or disease attack in provenance trials of black spruce, jack pine and Norway spruce. The following host-pest complexes have been selected for further study: larch sawfly - larch (tamarack); white pine blister rust - eastern white pine; spruce budworm - white spruce; Armellaria - black spruce; white pine weevil - Norway spruce; Gremmeniella - jack pine; and gall rust - Scots pine.

Work will entail examination of: provenance material to determine degrees of variation in resistance at the population level; progeny material to determine degree and patterns of inheritance of resistance/ susceptibility; and individual trees and clones exhibiting exceptional resistance.

Sawfly in Exotic Larch Provenances

An outbreak of larch sawfly in provenance trials of exotic larches at PNFI during the summer of 1977 provided an opportunity to assess variation in resistance to this pest. A subjective method of rating for defoliation was devised and tested for statistical validity and among-provenance differences analyzed. Analysis of variance indicates that the rating system is valid and that there are significant differences in defoliation among provenances. There appears to be a tendency for tall, fast growing seed sources to be most heavily defoliated suggesting a correlation between height and sawfly attack. However one seed source S.2502 from Rundforbi, Denmark, is relatively tall but suffers modest defoliation. Thus, height alone does not appear to be the only factor predisposing the larch to heavy defoliation in this plantation. This work was undertaken in cooperation with Mr. R. Calvert.

Insect Deterrent and Antifungal Compounds

When superior pest resistant trees are identified, efforts will be devoted to learning the basis for resistance in terms of phenological, morphological and chemical attributes of the tree. These attributes will be used as criteria to aid in selection of insect- and disease-resistant trees. Because trees possess a wide array of potential chemical defence capabilities, efforts will be aimed at identifying plant secondary metabolites which play an important role in the tree-pest interaction. The ultimate aim of this work is to discover and develop trees which contain insect deterrent and antifungal compounds.

Budworm Feeding Deterrent

A chemical feeding deterrent has been identified for one of Canada's most destructive forest insects - the spruce budworm. The chemical is a glycoside of 3-4 dihydroxy acetophenone, otherwise known as pungenin; it occurs naturally at low levels in preferred species and tissues and high levels in species and tissues which are less susceptible. A rigorous and systematic evaluation of the relationship between budworm attack and pungenin levels in host tissues has not been undertaken because a rapid method for assaying pungenin content is not available. Thus methods of isolation and separation are being tested and an analytical method of measurement is being developed.

Vegetative Propagation

Difficulties in propagating cuttings from aged trees and incompatibility in grafts limits application of vegetative propagules in insect and disease resistance studies. A review outlining the uses of vegetative propagation and difficulties encountered in traditional methods was undertaken (Lopushanski and Fogal 1979). It provides background information on biological characteristics of the parent tree which influence the success in rooting of cuttings. This information provided guidelines for establishing an experimental study on rooting of buds on chemically defined media under aseptic conditions. Buds of white spruce, black spruce and jack pine and two hardwoods - yellow birch and sugar maple were tested to determine their response to chemically defined media. Spring or fall buds responded favorably to the media initially, breaking dormancy and increasing in size over the first four weeks; roots were initiated in a very small proportion of samples. The experiments have been terminated because of commitments to other higher priority work.

INSECTS AND DISEASES IN TREE SEED PRODUCTION AND SEED QUALITY CONTROL

Objectives

The first objective of this study is to optimize tree seed yields and quality by collecting and providing information and advice on the biology, impact and control of insect and fungal pests in seed production. Second, to develop and apply precautionary measures to prevent dissemination of insect and fungal pests through national and international trade of seed.

Problem

Tree seed yields are often disappointingly low because of damage from insect and fungal pests. Insects are the most destructive agents. When cone crops are poor most cones are attacked and even in moderate crop years the cones may not be worth collecting. To ensure an adequate supply of seed, methods of insect control are required. Contact insecticides cannot kill the pests except during a limited portion of their life cycle; experiments with some systemic insecticides have been successful but because of economic costs and environmental damage they may only be useful to protect seed of very high genetic or economic value. There is very little information on the control of seed and cone insects by biological control agents such as viruses, bacteria and fungi. These agents have proven to be successful for control of some forest defoliating insects and may prove effective as a management strategy for seed and cone insects as well.

In addition to their impact on yield of seed prior to collecting, insect and fungal pests are a problem in cone procurement, seed processing, testing, storage and stratification. Some insects overwinter within seeds and cones and may be disseminated in cone and seed trade. Mold growth frequently develops on insect damaged or improperly stored cones, and may reduce seed yield or in extreme instances invade the seedcoat and grow on deteriorating endosperm. During seed processing, mechanical injury facilitates invasion by molds which inhibit germination. Fungal contamination can affect accuracy of germination tests. Molds grow on seed of high moisture content stored at low temperatures and may be responsible for unaccountable losses during and after storage. During stratification, excessive moisture favours growth of some molds which may alter germination rates and capacity.

Distribution of seed for regeneration of intensively managed commercial forests is increasing. Trade occurs internationally, interprovincially and within provinces; distribution of insect and fungal pests should be limited as much as possible by means of inspection of seeds and cones. In addition there is a need to develop precautionary measures to prevent introduction of harmful exotic pests with imported seed and cones and to ensure that various seed-borne insects and fungal pests are not exported. This will ensure that Canada maintains an image as a supplier of unadulterated seed.

Seed and Cone Insects

Investigations are being conducted to determine the impact of seed and cone insects on seed production in commercial tree species and to develop effective means of control by chemical, biological or cultural means. First efforts were devoted to consolidating information in the literature on seed and cone insect pests in forest trees. A literature survey of pests of spruce, pine, larch, hemlock, small-seed hardwoods and nut trees in northcentral and eastern Canada was undertaken and a report published (Fogal 1979). It summarizes information for each pest on geographic distribution, life cycle, damage and possible means of control in short bionomic sketches. The sketches provide background information for identifying problem pests and determining areas where research is needed to discover means of limiting impact of problem species. They will also be useful for management foresters in collection, handling, production and management of tree seed.

The review indicates that spruces have the largest complement of insects attacking seeds and cones. Black and white spruce are major commercial tree species used in reforestation programs in central and eastern Canada. But, seed requirements cannot be met in some years because of insect attack. Because of the importance of white spruce in reforestation in eastern Canada and the large complement of insects attacking it, efforts are devoted entirely to attempts to find ways to manage its insect pests. Studies have been initiated on the effect of stand conditions on insect attack, use of systemic insecticides and entomopathogenic fungi as possible control agents. These investigations are closely integrated with studies on seed production management being undertaken by Mr. D. Winston.

Factors Influencing Abundance of Seed and Cone Insects

Little is known about environmental factors likely to influence abundance of the several insect species attacking white spruce cones. However evidence does suggest that open grown trees are more prone to attack by some of the insect pests. To clarify this relationship a survey was undertaken in three stand types: open-grown, widely-spaced old-field trees; widely-spaced trees in a spruce-fir-hardwood stand; and closely-spaced trees in a white and black spruce stand. Cone attack by the following insects was assessed: budworm; seedworm; cone maggot; cone midge; and coneworm. The results indicate that abundance of insects varies with stand conditions (Fogal et al. 1977). Open-grown trees are heavily attacked by seedworms and closely-grown trees by the cone maggot. This survey was repeated in 1978 and again this year because such differences have to be considered in developing strategies to prevent damage from particular insects.

Systemic Insecticides for Control of Seed and Cone Insects

Experimental trials to control seed and cone insects of white spruce with systemic insecticides were initiated in 1978 and are continuing. The following insecticides are included in the tests: foliar applications of Dimethoate, Lannate and Orthene; soil applications of Furadan, Disyston and Metasystox R.

One test with soil applications of Furadan has been initiated in cooperation with the Ontario Ministry of Natural Resources at the Bonner Tree Improvement Centre, Kapuskasing. It is a combined insecticide-fertilizer trial to determine if fertilizer nitrogen can stimulate a cone crop in white spruce and if soil-applied insecticides can control cone and seed insects.

Biological Control of Seed and Cone Insects

A study on biological control of spruce seedworms and cone maggots with entomopathogenic fungi has been initiated. This work is being conducted by Dr. M.I. Timonin under a special agreement between PNFI and Carleton University. The objectives for 1979-80 include: conducting a survey of the seedworm and cone maggot for evidence of natural infection with pathogenic fungi, bacteria and viruses; testing pathogenicity of *Beauveria bassiana*, *Beauveria tenella* and *Metarrhizium anisopliae*.

Seed Quality Control

Insects and diseases affect quality of seed as well as quantity collected. Seeds and cones may be infested with overwintering insects and exposed to damaging fungal parasites during harvesting, processing, storage or treatment prior to sowing. Such fungal infections can cause regeneration failures in the field. Thus there is a need to develop measures to achieve quality control in seed procurement. Entomological and pathological factors which affect yield and quality of forest tree seed were outlined along with other factors influencing quality in a joint report with B.S.P. Wang (Wang and Fogal 1978). To achieve a high degree of quality in tree seed, guidelines and precautionary measures are required to prevent indiscriminate transfer of seed-borne insects and diseases and to control trade of diseased seed. To protect seed users, a system of inspection guided by regulations under the Canada Seeds Act is currently being discussed with officials in the Canada Department of Agriculture and among the recently designated tree seed inspectors and seed analysts of the Canadian Forestry Service.

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GENETICS OF DECIDUOUS SPECIES AND SPRUCES, PETAWAWA, 1977-1978

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This report covers the work of R.F. Calvert with the genera Larix Mill., Acer L., Fraxinus L. and Juglans L. before he resigned to assume a position with the Ontario Ministry of Natural Resources at Thunder Bay in December 1978. It also describes studies of the writer in red spruce (Picea rubens Sarg.), black spruce (P. mariana [Mill.] B.S.P.), and Norway spruce (P. abies [L.] Karst.). The objective of all studies is to develop an information basis for the development of breeding strategy, to initiate pilot programs, and guide forest managers involved in operational breeding.

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

LARCHES

Exotic larches

Emphasis was on the measurement and evaluation of the Larix decidua Mill. and Larix eurolepis Henry (hybrid) experiments established in the 1950-75 period by Mark Holst at Petawawa. Diameters and heights were measured and defoliation by the larch sawfly (Pristiphora erichsonii Htg.) assessed in nine experiments. The results will be published.

A new series of experiments with L. eurolepis together with L. decidua and L. leptolepis (Sieb. and Zucc. Gord.) controls was established at Petawawa and by the Ontario Ministry of Natural Resources (OMNR) and Consolidated Bathurst Ltd. The Québec Ministère des Terres et Forêts and Maritimes Forest Research Centre received seed of the same material.

In response to growing interest in Japanese larch, 80 sources of this species were provided to J.S. Lucas, Eastern Region of OMNR, for testing and eventual establishment of seedling seed orchards. Plans for the development of clonal orchards to produce hybrid seed were made jointly with Maritimes, Quebec and Ontario organizations (Dr. D.P. Fowler, Dr. G. Vallée, Miss R.M. Rauter, Mr. J.S. Lucas).

Native larch

A range-wide provenance study of tamarack (Larix laricina [Du Roi] K. Koch) was initiated with seed collections in 1977 and 1978 and these collections need to be completed. The short period available for collections between ripening and seed fall is a major problem. The high priority of this study was recognized by the delegates to the national workshop on seed production and tree improvement held at Petawawa in April 1978 (Fowler 1969).

The status of larch improvement was reviewed during the Ontario Tree Improvement Symposium held at Toronto in September 1978 (Calvert and Rauter 1979).

HARDWOODS

Hardwood studies were begun in 1975 and the highest priority was assigned to black walnut (Juglans nigra L.). A nursery sowing of stratified nuts from the Canadian range of the species was made at Petawawa in the spring of 1977. Only about 40% of the nuts germinated the first year and seedlings were planted in 1978 in two progeny tests in southern Ontario and distributed to cooperators in Quebec and Wisconsin. Most of the remaining nuts germinated during the second year.

As mentioned in the previous CTIA report (Calvert 1978b), hardy eastern seed sources of the European maples Acer pseudoplatanus L. and Acer platanoides L. have been imported from the Soviet Union. They were distributed to cooperators in Ontario, Quebec, Manitoba and Alberta, and also sown in the Petawawa nursery in 1977. Because of the uncertainty of previous seed storage and treatment, and lack of experience with these species, germination and early growth were relatively poor.

In 1977 and 1978 seed collections were made from many stands of white ash and green ash (Fraxinus americana L. and F. pennsylvanica Marsh.) in Ontario, Quebec and the Maritimes Provinces in cooperation with the provincial forest services, Université Laval and the Maritimes Forest Research Centre. Still more collections are needed for all-range experiments. A white ash provenance experiment initiated by Calvin Bey of the U.S. Forest Service was planted in 1977 at Petawawa. Seed for an Ontario white ash progeny test was sown in 1978 at the OMNR Orono nursery.

SPRUCES

Red spruce

Dr. A.G. Corriveau, Dr. D.P. Fowler and the writer have completed the measurement and analysis of the nine red spruce provenance experiments established in the 1958-60 period in Quebec, New Brunswick and Ontario. The effects of introgressive hybridization with black spruce are quite evident. A paper is in preparation.

Black spruce

The westernmost set of the Ontario open pollinated progeny test series was planted in Region 4S in the spring of 1977. There is one test in each of the Districts Ignace, Sioux Lookout, Dryden, Red Lake, Kenora and Fort Frances. One additional test was planted in the eastern part of Ignace District (Region 3W) to re-establish the test lost in a forest fire the previous year. The year 1977 was moist and survival in all tests was excellent. The cooperating districts continued maintenance in the central and eastern tests planted 1976 and 1975 as well as the provenance experiments established in 1973-74 throughout northern Ontario. Inspections of all experiments in 1977 and 1978 indicated that competition by jack pine (*Pinus banksiana* Lamb.) constituted the major problem and required attention on nearly all test sites. Competition by aspens (*Populus tremuloides* Michx., *P. grandidentata* Michx.) and various shrub species and grasses was important on some sites. The shoestring root rot (*Armillaria mellea* [Vahl ex Fr.] Kummer) was present on many sites but has not yet caused any noticeable mortality. Damage by insects was insignificant.

A detailed analysis of the 100 provenances in a range-wide nursery experiment largely confirmed the presence of clinal variation in growth and phenology (Morgenstern 1978b).

Norway spruce

There has been relatively little activity in this species following the retirement of Mark Holst in 1976. However a number of younger provenance experiments will be reaching measurement age within a few years and will then be analyzed. Another possibility of capitalizing on the potential of this species is to survey the many plantations now found in eastern Canada and to select the best material. I suggested this during the OMNR Eastern Region Plantation Conference, held at Ottawa in September 1978.

WORKSHOPS AND CONFERENCES

During the past two years I was involved in the preparation of the national workshop "Tree seed production and tree improvement in Canada - research and development needs 1977-1987". This was held at Petawawa in April 1978 and the proceedings have been published (Morgenstern and Carlson 1979). The overview paper, summarizing the activities of all provinces, indicated that reforestation programs are expanding very rapidly. One of the consequences is that many current breeding programs, conceived at a time of much lower seed requirements, will have little impact on the quantity of improved seed available in the near future. It was estimated that only about 3% of the seed used in 10 years time will come from seed orchards and about 55% from seed production areas. The provincial forest services and forest industries must step up their activities to benefit from the economic advantages of tree breeding (Morgenstern 1979c).

A symposium on tree improvement, sponsored by the Canada-Ontario Joint Forestry Research Committee, was held in Toronto in September 1978.

The status of black spruce tree improvement in Ontario was reviewed for this occasion (Morgenstern 1979b).

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NATIONAL TREE SEED CENTRE, 1977-1978

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Since the 1977 progress report, the National Tree Seed Centre has expanded its program by the new addition of two scientists and two technicians. Dr. Willard Fogal and Mr. Stan Lopushanski are working on the identification of problem pests in cones and seeds, determination of their impact on seed production, distribution and storage, and development of effective control measures; while Messrs. David Winston and Moe Anderson are involved in improving seed yield and quality for reforestation through studying major factors affecting seed production, harvesting and handling. Dr. Fogal and Mr. Winston came to the Petawawa National Forestry Institute from the Great Lakes Forest Research Centre, while Messrs. Lopushanski and Anderson were transferred from Ottawa.

The new studies have been initiated since the 1977-78 fiscal year and a report of progress in seed production is included in this paper. The study on cone and seed insect and disease problems is reported separately by Dr. Fogal.

INFORMATION SERVICE AND SEED DISTRIBUTION

Demand for these services continues to increase. In response to 270 requests for material and information in 1977 and 1978, about 1,500 seed samples comprising about 100 species were sent to correspondents in Canada and 28 other countries. In addition to seed samples, the Seed Centre prepared hundreds of cone sample packages in response to specific requests from educational institutions and for distribution as part of the CFS genetics exhibit displayed at meetings and public occasions. The Seed Centre collected and supplied one quarter of a million red maple (<u>Acer rubrum</u> L.) seeds for the Department of the Environment's very popular exhibit at the Canadian National Exhibition in 1978. Cones and nuts were procured from across North America for inclusion in a display to be set up at the Ontario Science Centre. Assistance was given to prepare an exhibit of cones and seed for permanent display in the offices of a Canadian paper company.

A computer record system has been developed for all reproductive material at the Petawawa National Forestry Institute. An updated seedlist was published in 1977 (Haddon 1977). It is anticipated that a new list will be prepared in 1979.

SEED PROCUREMENT

The Seed Bank is now stocked with more than 4,000 seedlots of over 100 species, and continues to expand to include single tree collections from different geographic sources which are especially valuable to geneticists and other researchers, and collections of seed from species or sources which may be considered endangered.

The established world-wide network of contacts has enabled the Seed Centre to procure valuable collections of seed from eastern Europe and other parts of the world for the Seed Bank and other programs and organizations. In response to the recent considerable interest in Alnus and Larix, for example, the Seed Bank now contains collections of several species from both natural stands and seed orchards around the Northern Hemisphere.

Several collections of seed have been obtained from the U.S.S.R. and the People's Republic of China in recent months and ties in these countries are being strengthened for continued seed exchange.

SEED PROCESSING

About 2,800 seedlots were processed in the Seed Centre's extraction plant in 1977 and 1978. The majority of these lots were processed as a service to other programs and organizations. Again, white spruce (Picea glauca [Moench] Voss) was a large component of this work, but considerable effort was spent on lodgepole pine (Pinus contorta var. latifolia Engelm.) as part of a project with the Alberta Forest Service described below.

SEED TESTING AND RESEARCH

The number of service, routine and regulatory testing of tree seed for moisture content determination, purity, germination, tetrazolium staining, excised embryo, x-radiography, assessment of processing injury and evaluation of causes of seed deterioration has increased from few hundreds in the 1960's to 1,700 in 1978. About five per cent of these tests were for official testing of tree seed of western species for export.

The Seed Centre actively participated in an International Seed Testing Association sponsored referee testing of Scots pine (Pinus sylvestris L.) seed to compare the standard method of germination with alternative methods and to test the reliability of replicate sampling which is notoriously difficult for tree seeds.

A study on dormancy and germination requirements of red maple seed from six Ontario sources was completed and published. Results from this study indicated that dormancy in freshly collected seeds seems to vary with seed source: dormancy was absent from seeds of southern Ontario but present in seeds of northern Ontario; and that dormancy in the freshly collected seeds of southern sources appears to be induced when the seeds are air-dried and stored (Wang and Haddon 1978). The best pretreatment and germination conditions were found to be 6-8 weeks moist, cold stratification and followed by germinating the seeds at 20°/30°C alternating temperature with an 8-hour photoperiod during the high temperature regime.

Ten international provenances of Sitka spruce (Picea sitchensis [Bong.] Carr.) seeds were procured, and their 1000-seed weights and germination behaviour were assessed. Findings demonstrated that 1000-seed weight varied with geographic sources from 2.28 g of Oregon to 2.68 g of Alaska origin, and that seeds of all ten provenances showed various degrees of dormancy and required moist, cold stratification pretreatment for maximum germination. Within the range of seed sources tested, from 45°49'N to 58°22'N latitudes and 0 to 150 m in elevation, no clinal or altitudinal patterns in seed dormancy were noted. One interesting observation was the presence of the least dormancy in a seedlot collected from a known transitional area with Engelmann spruce (Picea engelmannii Parry). Further work is planned to verify this observation.

Cooperative research with the Alberta Forest Service on seed yields and germination requirements of white spruce and lodgepole pine seeds was partially completed, and a report was prepared and distributed within the Alberta Forest Service. The research results suggested that since seed yield of white spruce from dry sites was 26% and 40% higher than that from mesic and wet sites respectively, dry sites should be favoured for locating future seed production areas and seed orchards, and that both white spruce and lodgepole pine seeds from Alberta showed various degrees of dormancy and required 3-4 weeks of moist, cold stratification pretreatment for maximum germination (Wang 1978). The cooperative research is continuing and another report on lodgepole pine seed germination requirements and effects of seed weight on germination and early seedling development will be prepared.

Experiments with western white pine (Pinus monticola Dougl.) seed have shown that treatment of partially moist, cold stratified seeds with a hormone mixture (Kinetin, gibberellic acid and indole acetic acid) and hydrogen peroxide can improve both the rate and total germination (Pitel and Wang 1978). A biochemical analysis of gel electrophoretic characterization of the soluble and chromosomal proteins at different stages of prechilled western white pine seeds revealed that some alterations of the chromatin composition occurs during prechilling and supports a current theory that genome activation is one of the key steps in dormancy release. The histones are involved in the non-specific repression of DNA-dependent RNA synthesis, while some of the non-histone chromosomal proteins are believed to be involved in the activation of specific genes (Pitel 1977; Pitel and Durzan 1977a, b).

A preliminary study of the seed of whitebark pine (Pinus albicaulis Engelm.), which is an important species for reclamation in the west, revealed that the seedcoat is at least one key factor responsible for the imposition of dormancy and that the generally low germinability of the seeds appears to be due to the low number of seeds with fully developed embryos and endosperm (24-42%). Further work on seeds of this species is planned.

Results from studies on basswood (Tilia americana L.) seeds have shown that treatment of seeds with sulphuric acid scarification followed with a mixture of Kinetin and gibberellic acid improved total germination. More work on basswood seed dormancy and pretreatment is in progress.

To determine the best enzymes, tissues and germination stages for optimum resolution of isozyme banding suitable for seed source identification, an investigation into the characterization of the isozymes in four enzyme systems of germinated lodgepole pine seed was made. Results showed that for the four enzymes, the number of isozymes varied with the stage of seed germination and also with the tissue examined, e.g. roots or shoots. A report has been prepared.

Work on determination of the chemical composition of a number of hardwood and softwood seed species needed for studying optimum seed storage requirements has also been initiated.

SEED PRODUCTION, HARVESTING AND HANDLING

The objectives of this research study include the following broad subject areas related to improving the supply and economic use of high-quality tree seed in Canada: (1) to determine optimum methods of crop forecasting, production, harvesting and handling; (2) to provide forest managers with basic information about methods of seed crop management; (3) to establish lines of communication between tree geneticists, seed production specialists and the forest managers on a national basis; and (4) to evaluate the costs and benefits of seed forecasting, production, harvesting and handling operations.

Initial effort has been placed on a thorough literature documentation, familiarization with current practices throughout the country, assessment of areas requiring future study and research, and preparation of proposals for future PNFI studies in this field. It is readily apparent that most of the country lacks sufficient information or techniques to adequately forecast seed crops, to manage seed production areas and seed orchards, or to properly collect and handle cone crops. A basic figure such as seed yield per tree in a good year is not readily available, and proven methods of testing cone ripeness such as specific gravity are usually ignored or unknown in current forestry practices. Furthermore, manuals for seed production management are not available due to a lack of research.

There is obviously a tremendous need and urgency for research and technology transfer throughout Canada in the area of seed crop management. Any opportunity to develop improved field practices or to participate in cooperative research trials with industry or provincial agencies is openly welcomed.

A cooperative trial by Haddon and Winston was established to assess the feasibility of early collection and artificial ripening of red pine and white spruce cones. Cones were collected from 6 trees per species on a periodic basis beginning approximately 8 weeks before normal seedfall.

Four different cone storage techniques and four storage periods were used. Results to date indicate that early collection and storage to artificially ripen cones of the two species is feasible, and seeds from cones collected at least 4 weeks prior to natural seedfall showed excellent germination and healthy early seedling development. Tests are continuing in 1979 to verify results as well as to ensure that a practical technique for cone opening can be found.

Winston has completed a detailed review of the available literature for seed crop forecasting, production and harvesting. The review includes recommendations for future PNFI project studies and is currently under internal review prior to future action.

Winston co-organized with Yeatman (PNFI Genetics Group) a 2-day tree climbing course in 1978 and plans for an expanded version lasting 5 days in 1979 have been well received nationally. The course covers safe methods of tree climbing for seed collection as well as a review of genetic factors and current practices in seed crop management such as prediction, production, protection, collection, processing and testing.

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GENETIC STUDIES IN JACK AND SCOTS PINES, PETAWAWA, 1977-1978

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Keywords: Pinus banksiana; Pinus sylvestris; provenance tests; genecology; population studies; progeny tests.

Genetic improvement of jack pine is progressing from research to application as demand for more and better seed continues to grow. Management foresters see the need to ensure future supplies of source-identified seed as larger portions of their jack pine forests are transformed into man-made forest by planting or direct seeding. Practical long-term strategies are required to maintain and upgrade the genetic quality of seed and planting stock. Comparative costs and gains of particular breeding methods are largely unknown, as are the effects, positive or negative, of indiscriminant mixing of original populations in the "new forests". The Petawawa jack pine program addresses these questions and seeks both general and particular solutions. Research is directed towards the mass production of genetically improved, regionally adapted jack pine seed.

Interest in Scots pine is increasing as an alternative species for reforestation of selected sites in central and eastern Canada. The provenance tests established two to three decades ago have narrowed the geographic limits of suitable seed sources and there is a recognized need for locally produced seed representing superior regional land races.

JACK PINE

Provenance

The range-wide provenance tests planted in Ontario (eight locations) and Quebec (two locations) were measured in 1978 at age 15 years from sowing. Over 30,000 trees were measured for height and diameter and rated for health and injury. These data are being entered into computer files for editing and merging with earlier records from 1969 and 1973. Summaries and analyses within and between years and test locations will be published at the earliest opportunity. Preliminary analyses of 10-year data were supplied to foresters and scientists directly concerned in Ontario, Quebec and New Brunswick. Large signs indicating the purpose and cooperative nature of the test plantations were erected at six Ontario test sites.

In a four-provenance test planted in 1972 at Longlac, the superior resistance to scleroderris canker (Gremmeniella abietina [Lagerb.] Morelet) of eastern Quebec sources (Teich 1967) was confirmed in the survival and rates of infection recorded at 10 years of age. The best Quebec source had 88 percent survival and 17 percent recorded infection in contrast to 49 percent survival and 69 percent infection (including trees killed) recorded for the near-local Caramat source. This tolerance to scleroderris is also exhibited by particular Quebec provenances in four range-wide test sites located in harsh boreal climates in Ontario (2), Quebec (1) and New Brunswick (1) (Yeatman 1976a, 1976b). Seed of selected sources and from single trees within selected populations was sent to Dr. Darroll Skilling, Principal Plant Pathologist, U.S. Forest Service, for testing in northern New York for resistance to the virulent "European" strain of scleroderris.

Selection and Progeny Testing

In the cooperative Petawawa/Ontario Ministry of Natural Resources demonstration of genetic improvement in jack pine centred at Spoor Lake, Algonquin Park, 150 plus trees were selected and seed and scions collected in each of the years 1977, 1978. Close attention to the condition of scions and rootstocks paid off with a high survival of grafts destined for the clone bank. Seed has been sown for the progeny tests. The first, including 150 progenies, is to be planted in 1981. Seed for the seedling seed orchard is being held in storage pending the clearing of land for planting.

Seed samples of two jack pine populations were sent to Mr. N.C. Wheeler at the University of Wisconsin, Madison, for inclusion in his isozyme studies of lodgepole pine/jack pine. One collection of cones from 60 trees was made in the Kirkland Lake District, northeastern Ontario. The other included seed of 60 plus trees in the Spoor Lake area chosen according to a spatial pattern designed to study breeding structure within this natural population.

Cones were collected for the first time from 200 juvenile (14 year old) jack pine in continuation of a test of simple mass selection at 10 years-of-age in a population regenerated after fire. Cones were bulked separately by plus and average trees. Low cone production in dense regeneration and squirrel activity had prevented collection at an earlier age. Clearing a space about the sample trees and prompt cone collection in the fall yielded our harvest. Grafts of the plus trees were set out in a demonstration seed orchard.

Breeding

Seed of control-pollinated provenance hybrids produced at Petawawa and at Rhinelander, Wisconsin (U.S. Forest Service) was distributed to cooperators in New Brunswick, Manitoba and Alberta. Seed was sown in the greenhouse at Petawawa and transplanted to the nursery in 1978 in preparation for planting in 1980. Ontario plantings will include two in the north, two at Petawawa, with the possibility of a small test in the south, on the shore of Lake Erie. Seedlings of a selected sub-set of provenance hybrids were grown in conditions of decreasing photoperiod in controlled environments. Analyses indicated both latitudinal and individual tree effects that were largely additive.

Two series of controlled crosses have been repeated over several years to accumulate sufficient seed for testing. This seed for a 7-tree diallel and plus-tree breeding studies is almost complete and it is hoped to make the initial sowings in 1980. Marked tree to tree differences in cone (seed) production are evident. One tree in particular, originally included in the diallel test, has had consistently a very low fecundity.

Propagation

We have experienced inconsistent results in the winter grafting of jack pine. Scions are very sensitive to conditions between collection and grafting. Potted rootstocks are subject to drought or waterlogging. High temperatures and low humidity in the greenhouse also leads to graft failure. A test was made of graft survival in relation to period of scion storage. Survival of spring and summer grafts was high but the summer grafts failed to develop fully before the onset of winter. The grafting of scions stored frozen for 12 months was a failure.

Extension

Consultations led to the creation of a 600 ac. (240 ha) jack pine seed production area in the Gogama District of Ontario. The objectives, progress to date and future management leading to a progressive seedling seed orchard were described in a paper under joint authorship delivered by Mr. Oldford, District Forest Management Supervisor, at the COJFRC symposium on Tree Improvement, Toronto, in September, 1978 (Oldford et al. 1979). A second paper on the same occasion described the current status of, and proposed a long-term strategy of recurrent selection for, genetic improvement of jack pine seed required for planting and direct seeding in Ontario (Yeatman 1979). Jack pine research and development was the example used in the CFS genetics exhibit displayed at Petawawa for the benefit of visiting groups and also at the Toronto symposium.

Additional publications of a more general nature included a discussion of the importance of seed origin to success of reforestation by planting and seeding (Yeatman and Morgenstern 1979) and a technical bulletin on safe tree climbing, a method for seed collection and sampling directly relevant to the maintenance of scarce forest genetic resources under heavy pressure for seed production or required for future breeding (Yeatman and Nieman 1978).

SCOTS PINE

Interest in Scots pine as a potential source of wood and fibre has been rekindled by recent observations of early provenance trials and the search for alternative species for particular problem areas. At a number of locations in northern Ontario, ranging from Espanola in the east to Dryden in the west, foresters have been impressed by the excellent growth and hardiness of the best Scots pine seed sources. In southeastern

Ontario a vigorous search is on to find suitable species for the difficult soils of that region.

Provenances from the southern fringe of the Scots pine range in European Russia and the Ukraine have grown well at a number of locations ranging from southern Ontario to the Prairies and from calcareous to acid soils. In 1970 Mr. Mark Holst obtained substantial quantities of seed from three sources in the Soviet Union, Kiev (lat. 50°N, long. 30°E), Woronesh (52°N, 40°E) and Orlovsk (53°N, 35°E) with the intention to establish production-scale plantings for evaluation and seed production. The opportunity arose in 1978 to distribute this seed to cooperators in Ontario and Quebec as follows (number of viable seed):

Cooperating Agency	Kiev	Seed Source Woronesh	Orlovsk
Brockville District S.E. Ont. Region	2,000	2,000	--
Espanola District N.E. Ont. Region	25,000	25,000	25,000
N.W. Ont. Region	7,000	7,000	7,000
Quebec Min. T. & F. (Dr. G. Vallee)	5,000	5,000	5,000

Correspondence with the cooperators also included pertinent references to North American and Russian literature, results of recent measurements at Espanola, discussions of objectives and recommendations on plantation design and management intended to develop genetically sound, regionally adapted land races of Scots pine in stands suitable for mass seed production.

An opportunity was also taken to acquire 200-seed samples of each of 72 Russian seed sources ranging from the Polish border to the Amur River in the Soviet Union. The seed was distributed in North America by R.A. Read, U.S. Forest Service, Lincoln, Nebraska and coordinated in Canada by B.D. Haddon, National Tree Seed Centre, Petawawa. The intention is to establish a demonstration plantation of this material at the Petawawa National Forestry Institute.

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WHITE SPRUCE GENETICS, PETAWAWA 1977-1978

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Keywords: provenance, hybridization, inbreeding, early testing, isoenzymes.

The first priority of the white spruce (Picea glauca [Moench] Voss) program continues to be the range-wide cooperative provenance study. This study has passed the planning phase and field experiments are now being established. In addition, we have remeasured most of our existing trials to update the early results. Some of the data have been analyzed and published, and are briefly summarized here. Isoenzyme work has been started. The status of white spruce tree improvement in Ontario was reviewed (Rauter and Ying 1979). This will be my last report from Petawawa as I will assume a position with the British Columbia Forest Service in 1979.

PROVENANCE STUDY

Seven field tests, two all-range and five regional provenance tests, have been established in northwestern Ontario in cooperation with Mr. D.A. Skeates of the Ontario Forest Research Centre at Maple and various districts of the Ontario Ministry of Natural Resources. It is proposed that a total of 18 tests will be planted in Ontario, with one all-range and two regional tests in every pair of site regions. The six all-range tests will constitute Ontario's contribution to the range-wide study. The regional provenance tests, which are based on intensive sampling of stands within regions, are designed to identify outstanding seed sources and to determine variation patterns, i.e. the information needed to delineate seed zones and undertake provenance selection. The establishment phase is expected to be completed before 1983.

In other provinces, plant material is being produced and field tests are expected to be in the ground in a few years.

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CORRELATIONS AND HERITABILITIES OF HEIGHT GROWTH

Four 22-year-old open-pollinated progeny tests were remeasured at Petawawa. The estimated narrow-sense heritability averaged 0.23, and ranged from 0.15 to 0.32.

In one test, progenies from the tall and narrow-crown parent trees were compared with progenies from the short and broad-crown types. At age 22 the mean height of progenies from the former was 519 cm and of the latter 521 cm. The difference was not significant. Phenotypic selection for growth rate in natural forests on the basis of simple comparisons is not effective.

Family correlations between ages 8 and 22 or 11 and 22 ranged from 0.60 to 0.94. Generally, family performance at age 8 or 11 was a good indication of performance at age 22.

INBREEDING AND INTERPROVENANCE HYBRIDIZATION

Selfed progenies grew 18 to 33% less in height than the open-pollinated controls in three small-scale tests (Ying 1978a). On the other hand, hybrids derived from provenances of the Boreal and Great Lakes-St. Lawrence Forest Regions pollinated by native stands at Petawawa, were 17% taller on average than the open-pollinated local controls at 10 years of age (Ying 1978b). This increase is probably due to a reduction of inbreeding through provenance hybridization.

Natural white spruce stands in eastern Canada usually consist of a few hundred trees mixed with other conifers and hardwood species. There is probably very limited gene flow between stands, and the frequent pollination of neighboring trees results in inbreeding. Substantial improvement may be achieved simply by reducing inbreeding.

COMPARISON OF WHITE SPRUCE WITH SITKA, ENGELMANN AND NORWAY SPRUCE

Both pure Sitka and Engelmann spruce and their hybrids with white spruce were compared with pure white spruce in two experiments. Second and 3rd generation hybrid progenies that originated from back-crossing to white spruce as male parent were also included in the tests. None of the western spruces were hardy enough. Even sources from high latitudes (Alaska) were not hardy in the continental Petawawa climate. However, winter hardiness increased progressively as more white spruce germplasm was incorporated into the hybrids. After the third generation of back-crossing, progenies grew as well as local white spruce.

Norway and local white spruce were compared in two trials. Some Norway spruce seedlots grew as fast as white spruce, but were much more susceptible to weevil and late spring frost damage. Norway spruce is a variable species and responds to selection. The potential to select frost-hardy and weevil-resistant populations exists.

ISOENZYME ANALYSIS

Dr. N.C. Bhattacharya, a Visiting Fellow sponsored by the Natural Sciences and Engineering Research Council of Canada, began work with white spruce in September 1978. Initial emphasis was on the development and standardization of sampling and analytic techniques.

CONCLUSIONS

White spruce studies at Petawawa now have a 25-year history. Beginning with Mark Holst who initiated the two eastern provenance studies (Expts. 93, 194) as well as studies in selfing and provenance hybridization, the work was continued by C.W. Yeatman, A. Carlisle, A.H. Teich, and E.K. Morgenstern. Many studies are now yielding valuable information. My three-year involvement with this program has been very rewarding.

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FOREST GENETICS AT THE SCHOOL OF FORESTRY, LAKEHEAD UNIVERSITY

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Lakehead University remains committed to its primary objective of providing a sound, well balanced education in forestry to students enrolled in all of its programs. Within this context the faculty agree that it is important to provide students with an understanding of genetic principles and their application in forestry practice. Consequently, several courses in the School's programs are designed to expose students to both the theoretical and practical aspects of the use of genetics in forestry.

UNDERGRADUATE PROGRAM

Silviculture courses taken by all students in the third and fourth years of the B.Sc.F. program place considerable emphasis on the origin, identification, and importance of genetic variation in a wide range of forest tree species. Lectures are complemented by several laboratory projects during which all students select, collect and test tree seed, and propagate various tree species vegetatively by means of rooted cuttings and grafts. The field program includes inspection of a young seed orchard and the collection and analysis of height growth data in a white spruce (*Picea glauca* [Moench] Voss) provenance trial. In addition to these required courses, an elective senior level course in forest tree improvement has been fully enrolled in each of the past two years. Two of the senior students enrolled in this course also completed the undergraduate theses listed at the end of this report (Cheliak 1978; Monczka 1978).

GRADUATE PROGRAM

A graduate level course in forest genetics for students in the M.Sc.F. program was taught for the first time in 1978/79 by Professors G. Murray, J.E. Barker and W. Parker. One graduate student has also begun a study of the phenology of flowering and vegetative growth in a white spruce and a black spruce (*Picea mariana* [Mill.] B.S.P.) seed orchard.

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TREE BREEDING AND EVALUATION AT THE MORDEN RESEARCH STATION - 1978-79

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Key words: interspecific crosses, Populus, Salix, shelterbelt and shade trees, Dutch elm disease

The main emphasis of the research program was aimed at development of shade and shelterbelt trees and maintenance of an extensive arboretum collection of native and introduced material. Intersectional crosses of Populus were used to combine the characteristics of the aspens (P. tremuloides Michx., P. grandidentata Michx. and P. tremula L.) and white poplars (P. alba L.) with the ease of rooting and fast growth of cottonwood (P. deltoides Marsh.) and the related European black poplar (P. nigra L.). A new columnar poplar was introduced as the 'Tower' cultivar and a hardy strain of hackberry as the 'Delta' strain.

IMPROVEMENT OF POPULUS

Intersectional hybridization in poplars was continued using two female clones with the complex parentage of P. canescens (Ait.) Sm. x (alba x grandidentata) of the Leuce Duby section in crosses to several species in the Aigeiros Duby and Tacamahaca Spach. sections. The F_1 hybrids demonstrated a wide range of vigor and clear intermediate morphology. Preliminary assessment of hardwood cutting rooting indicates that these F_1 hybrids have inherited the characteristics for ease of rooting found in the male parent. Six hybrids having P. deltoides or P. jackii Sarg. as male parents rooted 80% or better compared to less than 10% for the female parent. Most hybrids have a high level of resistance to septoria canker but many are susceptible to leaf rust.

A highly variable progeny both in form and hardiness was obtained by hybridization in 1970 of P. alba with columnar P. tremula 'Erecta'. One clone with exceptional hardiness, disease resistance, and columnar growth form was introduced as P. canescens 'Tower'. This clone will propagate readily from 2 cm long root cuttings or softwood cuttings.

IMPROVEMENT OF SALIX

Hardy S. acutifolia Willd. (acute leaf), alba L. (white) and pentandra L. (laurel) willows were successfully hybridized with the male S. alba 'Tristis' (golden weeping willow). Several selections with hardiness approaching the female parents and the weeping form of the male parent have been selected in the F_1 generation. These selections are being increased for hardiness evaluation at several locations.

IMPROVEMENT OF SHADE TREES

Selection and evaluation of improved shade trees emphasized alternative species to American elm. Hackberry (*Celtis occidentalis* L.) performed well and a composite seed strain from four selected genotypes was introduced. Japanese elm (*Ulmus japonica* (Rehd) Sarg.), a species introduced from Manchuria to the prairie provinces in the 1930's, was cooperatively evaluated for Dutch elm disease resistance with Dr. Kondo of the C.F.S., Sault Ste. Marie. All selections were found to possess a high degree of resistance and one of these was subsequently introduced as the 'Jacan' cultivar. Other promising material under evaluation includes hybrids of black ash (*Fraxinus nigra* Marsh.) with the Manchurian ash (*F. mandshurica* Rupr.), hardy hybrid selections of linden (*Tilia* spp.) and silver maple (*Acer saccharinum* L.).

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TREE IMPROVEMENT RESEARCH AND DEVELOPMENT IN MANITOBA

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The purpose of this biennial progress report is to review briefly the tree improvement studies in the Province of Manitoba with expectations of achieving appreciable gains in the economic traits of growth rate, stem form, adaptation and resistance, survival and longevity, crop yield and wood quality, of conifer trees used in planting and seeding programs. In addition trials of exotic species on short term rotations are also underway to segregate suitable and adaptable provenances.

The present effort to produce trees of improved and superior genetic constitution for the reforestation enterprise focuses primarily on the following projects:

1. Provenance trials of white spruce, jack pine and black spruce.

2. Vegetative propagation techniques of grafting and rooting.

3. Establishment of seed production areas as an interim measure.

4. Selection of phenotypically superior plus trees over a broad genetic base.

5. Establishment and management of clonal and seedling seed orchards.

6. Progeny and hybridization tests.

In the planning stage is the setting up of a controlled genetic environment for accelerated growth of conifers. Also being planned is a tissue and organ culture cloning laboratory for reproducing en masse the 'perfect tree' by propagating many individuals per selected family to maintain enough variation so as to ensure the vitality of our plantations.

In addition a study was conducted over the last two years to ascertain the root form of planted seedlings of jack pine, white spruce and red pine, quantitative comparisons being made of bareroot and containerized stock with that of natural regeneration seedlings of equivalent crop ages. The study of jack pine was also presented at the Symposium on 'Root form of planted trees' held in Victoria, B.C., May 16-19, 1978.

Considering the manpower and resources, Manitoba has made great strides in tree improvement research and the breeding programs are in a dynamic stage of development in the province.

PROVENANCE TRIALS

Under test are provenance trials of white spruce (Picea glauca (Moench) Voss) (Segaran 1977a, 1977b, 1978a), jack pine (Pinus banksiana Lamb)(Segaran 1978b) and black spruce (Picea mariana (Mill) B.S.P.)(Segaran et. al. 1978, 1978c). From the juvenile results to date, provenances having the combined traits of stability and high yielding responses have been segregated for more intensive breeding trials (Segaran 1979a).

Using this provenance information on genetic variation, and together with climatic and soil factors, major seed zone delineations have been developed in the province (Segaran 1979b) to control movement of reproductive planting material and to retain the fast-growing genotypes within defined boundaries. Further monitoring of reforestation efforts may possibly entail sub-divisions of major seed zones.

VEGETATIVE PROPAGATION

Homoplastic grafting of white spruce and black spruce (Segaran and Meseman 1977) were carried out in 1978 and 1979. In the 1978 grafting of white spruce we had a 82 percent success rate. The grafts will be the basis of the first clonal seed orchard of white spruce in Manitoba. The orchard will be established at Hadashville, Manitoba in 1979. The main objectives of grafting are: 1) to perpetuate the superior hereditary traits of the parents in the sexually propagated progeny, 2) to develop a pedigreed breeding population, 3) to concentrate breeding stock for progressive seed improvement, 4) to facilitate controlled pollination, 5) to produce species hybrids, and 6) to establish clonal seed orchards. A manual of general procedures for grafting of conifers has been written for general guidance and ease of reference.

SEED PRODUCTION AREAS

Seed production areas have been established in the province to serve as an interim measure until seed orchards produce superior quality seeds. They permit the gene pool preservation in situ and maintain the gamut of variation inherent in natural stands. The primary aim is to collect source-identified seeds. The residual phenotypes are of above average quality with desirable growth statistics, good stem form and normal fecundity, exceptional vigour, and absence of disease, heavy-branching habit, and spiral grained characteristics.

PLUS TREES

Locating and establishing plus trees of white and black spruce representing wide genetic bases continued as part of the overall program. The criteria established for selecting a plus tree are: 1) straight trunk with little taper, 2) wedge-shaped crown with a single leader, 3) light, short and small diameter branches, 4) branch angle close to 90°, 5) good natural pruning, 6) no visible signs of susceptibility to insects, disease, wind, frost and drought, 7) good cone production, and 8) presence of good scion material. The selected trees are 3 km apart so as to prevent possible inbreeding.

These trees were located during the summer of 1978, scions were collected in February of 1979 and were kept in cold storage until they were grafted in April/May, 1979.

FOREST SEED ORCHARDS

In 1979, it is hoped to establish three seed orchards, a seedling seed orchard of black spruce, a clonal and a seedling seed orchard of white spruce. The sites would be isolated from genetically inferior outside seed origins, methodically managed and systematically cultured for the economic production of early, abundant and easily harvested crops of superior quality seeds. This would be done on a sustained and regular basis to meet the needs of commercial reforestation and intensive forest management practices. Also planned are clonal seed orchards of black spruce and jack pine to be respectively established in 1980 and 1981. Cultural techniques would be employed for initiation of early flowering and enhancement of seed production.

ROOT FORM OF PLANTED TREES

A quantitative assessment of root forms of jack pine (Segaran, et. al. 1978), red pine (Segaran, et. al. 1979a) and white spruce (Segaran, et. al. 1979b) were carried out in the fall of 1977 and 1978. Comparisons of containerized seedlings using Japanese paperpots, bareroot stock with that of naturally regenerated seedlings were made. The highlights of these studies indicate: 1) that the slow biodegradation of Japanese paperpots inhibits root egression subsequent to outplanting, and 2) root deformation caused at the time of planting is still evident eleven years after planting. Both the 'J' and 'S' container shapes resulted from improper planting and the root system, as yet, has not been able to overcome the contriction imposed by both the paperpot and the shape of the planting hole. The long term effects of root malformation are not known but it is reasonable to assume that a well formed root system would provide for better nutrient uptake and greater stability. Since each seedling represents a considerable financial investment more intensive supervision and training has been recommended for planting crews.

TRIALS OF HYBRID POPLAR WALKER

The trials of hybrid Populus Walker (Syn. Populus 44-52) in the province indicate that sites with a high organic matter content, high phosphorus supply, a pH greater than or equal to 7, a friable clayey loam soil and proximities of water contribute to a better growth performance. A pulpwood rotation of 10 years is indicated, (Segaran and Rathwell 1978).

MISCELLANEOUS

From the summer of 1979 it is hoped to commence variant containerized trials to determine the acceptable container for the reforestation programs.

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TREE IMPROVEMENT IN SASKATCHEWAN

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KEYWORDS: Grafting, provenance tests, seed production areas and exotic species.

Tree improvement on a continuing basis was initiated in 1978; past efforts have been haphazard with no individual concentrating all efforts toward this discipline. The work during 1978-79 has been chiefly directed towards improvement of white spruce (Picea glauca (Moench) Voss); some work has been done with jack pine (Pinus banksiana Lamb.), black spruce (Picea mariana (Mill.) B.S.P.) and the exotic species Scots pine (Pinus slyvestris L.), Siberian larch (Larix sibirica Ledeb.), Norway spruce (Picea abies (L.) Karst.) and ponderosa pine (Pinus ponderosa Laws.).

WHITE SPRUCE

White spruce improvement focussed on plus tree selection. Scions from the plus trees were grafted in February 1979, to be placed in a clonal seed orchard in June 1979. Progeny tests will be conducted for the various clones when seed becomes available. Past efforts have included the grafting of white spruce, however, poor climatic controls in the greenhouse facility resulted in poor survival.

The range wide Federal-Provincial co-operative white spruce provenances were sown in July 1978 and will be planted in the spring of 1980 with 72 provenances. The test will be located on three sites across Saskatchewan.

Seed production areas (SPA) for white spruce have been established at six sites with a total area of 46 hectares. One of the SPA's will be used for a co-operative fertilization study with the Northern Forest Research Centre in Edmonton, Alberta. The objective of the study is to determine whether fertilization increases cone production.

JACK PINE

Jack pine tree improvement will be mainly confined to a provincial range wide provenance test to be planted in the spring of 1981. Several of the provenances for this test will be supplied by Prince Albert Pulpwood Company. The location and establishment of jack pine seed collection areas will be the other provincial concern for the near future.

Jack pine family tests were established in Saskatchewan at two sites by Dr. J. Klein of NFRC in 1974 and 1976.

BLACK SPRUCE

A black spruce range wide provenance test was established by Dr. Klein in 1976. A black spruce Nelder spacing plot was established by the province in 1972.

EXOTIC SPECIES

Selected provenances of ponderosa pine were planted at South Branch Forest Nursery in the fall of 1977. Mr. K. Froning of Canadian Forestry Service in Edmonton, Alberta, chose fourteen of the best provenances from a larger co-operative provenance test with the United States Forest Service.

Progeny tests will be conducted with both Scots pine and Siberian larch. Russian provenances from a Scots pine plantation established in 1960, will be used for the progeny test. The original provenances for the Siberian larch are unknown.

A combined white spruce, Norway spruce, Scots pine and jack pine performance test was planted in the spring of 1979. Provenances from Sweden and Latvia are used for both the Scots pine and Norway spruce. A local source of Scots pine of unknown provenance is also included. The white spruce and jack pine provenances are from local sources.

SEED SOURCE IDENTIFICATION

Seed zones have been identified for Saskatchewan based upon administrative and geoclimatic information. There are thirty zones that are used to designate seed locations. The seedlot number is a nine figure alpha-numeric code which identified location, collection number, year of collection and species; further refinements such as township, range, section and stand number can be included.

PRINCE ALBERT PULPWOOD TREE IMPROVEMENT PROGRAM

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In 1967, Prince Albert Pulpwood started harvesting the Provincial forests of Saskatchewan as a prime source of roundwood for the pulp mill in Prince Albert. Shortly thereafter a silvicultural program was initiated to replenish the cut-over lands. These operations have been increasing since that time. Our involvement in a jack pine (Pinus Banksiana Lamb) tree improvement program, beginning in 1977 under the direction of Dr. Bruce Zobel, was just a natural progression in our expanding program. Since this program is still very young, this report will discuss the direction in which we are headed.

The first stage of our two-stage program is the establishment of a clonal seed orchard. During the summer and fall of 1978, phenotypic selection was used to find 30 super trees to act as a basis for this orchard. Field grafting on five acres of 2 + 2 rootstock (planted in 1978) was grafted this past spring. Another 15 acres have been planted to provide us with rootstock for next year's grating. We have established this orchard on Company-owned farm land, 16 miles north of Prince Albert. This orchard will provide us with as much genetic gain as possible, as soon as possible. We will commence controlled pollination, progeny testing and roguing of the seed orchard soon after flower production begins.

The second phase of our program is the collection of open-pollinated seed from 200 outstanding trees for progeny testing. This will take four years to complete, this year being the first, selecting 50 trees per year. These tests will be the basis of future generation seed orchards producing seed of a higher genetic quality than our clonal seed orchard in Stage 1. This genetic base will continue to grow as our harvesting operations progress opening up new areas for selection of new material.

Experimental research, which will commence shortly, will also be conducted on a small scale in areas of jack pine provenance trials.

Cooperation has been established with the programs and personnel of the Government of Saskatchewan and the Canadian Forestry Service in Edmonton.

GENETICS AND TREE IMPROVEMENT RESEARCH, ALBERTA FOREST SERVICE, 1977-1979

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The genetics and tree improvement research program of the Alberta Forest Service is still in its infancy. The work was started only a few years ago. It is mostly devoted to conducting applied genetics and silviculture research, with specific objectives of exploring new possibilities for improving productivity of reforestation projects in the Province, and to develop ways and means for increasing the efficiency of the selection and breeding program. The work is done with active support from forest industries of the Province and in cooperation with various other agencies. Activities of the program over the past two years are described in this report.

SPECIES TRIALS

The choice of species presently prescribed for reforestation in Alberta is very limited. Almost all of the artificial regeneration programs in the Province are based on white spruce and lodgepole pine. A program was developed to examine and demonstrate commercial reforestation potential of other promising tree species, which mostly include black spruce, tamarack and Siberian larch. Over the past two years six field trials were established to test and compare performance of various species on diverse sites in northwestern Alberta. In addition, seven field trials were established by Procter & Gamble Cellulose, Simpson Timber Company and North Canadian Forest Industries for the same purpose.

Limited potential for northward extension of the geographic range of some subalpine species for commercial timber production was also recognized. A small nursery trial of alpine larch and whitebark pine was established with stock grown continuously in a greenhouse for nine months. Evaluation of the test at the end of two growing seasons in nursery transplant beds showed very poor height growth, with the best seedlings having height in the range of 12 - 18 cm.

A nursery outplanting of 400 grand fir seedlings established at Smoky Lake (latitude: $54^0 04$'N) was completely winter killed in its first year. Seed for this trial originated at $49^0 22$'N latitude in British Columbia interior.

Several seedlots of western larch, Douglas-fir, red pine, western white pine and ponderosa pine were procured from various agencies for inclusion in selected species trial plantations, to be established in the coming years.

PROVENANCE TRIALS

Nine additional white spruce provenance trials were established in the nursery; three trials were earlier established in 1976. These trials are part of an extensive series of field tests to be established throughout the Province to determine tolerance limits for geographic movement of white spruce seed, and to provide information on genotype x environment interactions to assist in objective delineation of seed zones and breeding regions for this species. Each test consists of 20 common seed sources and a varying set of 5 to 10 seed sources local to the plantation region. A total of 15 field plantations are planned to be established with three trials to be field planted each year, starting in spring, 1980.

Nursery measurements of nine white spruce provenance trials were started in spring, 1979. These consisted of three trials each in three age groups (1 year, 2 year, and 3 year old materials). Data were recorded on flushing date (all trials) and periodic height growth (weekly intervals; only in 3 year old material) on seed sources common to all tests. Preliminary analysis of flushing date data showed significant differences among age groups. Mean flushing dates (number of days after April 30) for the three age groups were: 1 year old = $22.9 \pm .2$; 2 year old = $24.4 \pm .2$, 3 year old = $27.3 \pm .3$.

A ponderosa pine seed source trial consisting of 14 seed sources and 85 single tree progenies was established in the nursery in 1977 using container stock provided by the Canadian Forestry Service. The material mostly consisted of relatively high elevation seed source origins from South Dakota, Montana, Wyoming and Colorado. Assessment of the material in spring, 1979 showed that no winter injury had occurred in any of the seedlots after overwintering through two seasons.

Seeding or nursery transplanting for production of planting stock for several cooperative trials to be field planted in Alberta was completed. These are:

1. Scots pine seed source trial initiated by the U. S. Forest Service. It consists of 27 seed sources originating from the U.S.S.R.

2. White spruce range-wide seed source trial initiated by Petawawa National Forestry Institute. It consists of 69 seed origins from outside Alberta.

3. Norway maple seed source trial initated by Petawawa National Forestry Institute. It consists of 12 single tree or bulk seedlots from three geographic origins in the U.S.S.R.

GENETIC STUDIES

Controlled pollination of _Larix sibirica_ was started in 1978 to build a collection of biparental crosses for field testing and possible use in breeding. A total of 77 crosses were made (33 in 1978 and 44 in 1979) using 42 female and 22 pollen parents randomly selected in amenity plantings at various locations in Alberta. In addition, pollen from four _sibirica_ parents growing at Petawawa National Forestry Institute was also used. Several _laricina_ x _sibirica_ and _sibirica_ x _laricina_ crosses were also attempted to check cross compatibility of the two species in reciprocal cross combination.

Controlled pollination work with white spruce was started in spring, 1979, primarily to train staff in pollen handling and controlled pollination procedures for this species. A total of 15 crosses were made using 6 female parents to compare seed set in controlled pollinated, open pollinated, and selfing combinations.

A greenhouse study was started to evaluate variability among open pollinated families of lodgepole pine tree selections made within a 1900 square km area in westcentral Alberta. The test consisted of 204 families. Data were collected on greenhouse germination, cotyledon number, seedling height, and root and shoot dry weight at the age of four months. Statistical analyses of the data are currently in progress.

SEED PRODUCTION AND RELATED STUDIES

A study on variability of seed yield and seed quality of white spruce trees growing in a seed production area in the Slave Lake Forest was completed. Fifty trees were examined for total number of seeds per cone, proportion of empty seeds and seed germinability. Highly significant differences ($P \leq .01$) were found for all variables. Summary results are presented in the following table.

Seed characteristics of fifty white spruce trees: Mitsue South seed production area

	Seeds per cone			Germination (%)	
	Total (number)	Empty (%)	Filled (number)	Stratified seed	Unstratified seed
Mean$\pm$S.E.	80.3$\pm$1.9	36.2$\pm$2.7	51.0$\pm$2.5	85.4$\pm$1.9	44.0$\pm$3.7
Range	50-109	8-82	18-87	2-100	1-99

Data on cone and seed characteristics of 648 superior lodgepole pine tree selections made for the tree improvement program were compiled and examined. Trees were felled and invariably all cones were collected. Trees were grouped in five geographic regions and were mostly 80-100 years old. Mean single tree values for several variables examined for the five regions varied as follows:

Total number of cones per tree	274-398
Average number of filled seeds per cone	17.5-25.8
Thousand seed weight	2.9-3.7 g

It was interesting to note that harvest of all cones, which represent accumulated cone crop of several decades, from mostly above average cone producing dominant trees growing in natural stands, generally provided total seed yield in the range of 6,000-10,000 seeds. Significant geographic trends were noted with cone count, average number of seeds per cone, and seed weight decreasing from east to west and from low elevation to high elevation.

Several studies on white spruce and lodgepole seed were conducted in cooperation with the National Tree Seed Centre of the Petawawa National Forestry Institute. Seed yield and germination requirements of 34 trees growing in wet, mesic and dry site stands in the Peace River region were examined. Another study examined seed yield and quality of lodgepole pine seed recovered from cones of various age-classes (1 to approximately 15 year old cones). Study materials were collected from five sample trees in each of 12 stands located in southwestern Alberta. It was concluded that seed yield and germinability of lodgepole pine was not affected by cone age. However, seed recovered in the oldest age-class (10-15 year old) consistently showed a higher level of seed dormancy. Detailed results of these studies are being compiled by Petawawa National Forestry Institute for publication.

TREE IMPROVEMENT IN ALBERTA, 1977-1979

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Key words: Selection; tree breeding; seed production; lodgepole pine; and white spruce.

Work on tree improvement in Alberta was started by the Alberta Forest Service nearly three years ago. Since then substantial progress has been made in developing and implementing a comprehensive program of genetic improvement of important forest tree species in cooperation with the major forest industries of the Province. This report briefly describes progress on the work carried out by the Alberta Forest Service, Procter & Gamble Cellulose, Ltd., Simpson Timber Company (Alberta) Ltd. and North Canadian Forest Industries Ltd. over the past two years. An accompanying report describes genetics and tree improvement research conducted by the Alberta Forest Service over the same period. The tree improvement program of St. Regis (Alberta) Ltd. is described by P. Sziklai in a separate report.

PROGRAM DEVELOPMENT

A report defining the nature, size and scope of the tree improvement program and general work plans was written by the Alberta Forest Service in 1977. The report was reviewed by several geneticists and tree breeders, and revised to incorporate new ideas and input received through the review process. It received final approval from the Alberta Forest Service and participating forest industries in 1978, and was accepted as a statement of program contents and general direction for tree improvement work in Alberta.

Substantial increases in funding and staffing levels for the genetics and tree improvement program were approved by the Alberta Forest Service. Similar commitments were indicated by the participating forest industries. A new genetics and tree improvement laboratory-greenhouse facility was built by the Alberta Forest Service in 1978. Located at the site of the Pine Ridge Forest Nursery near Smoky Lake, the facility provides 3,000 square feet of greenhouse space and 3,200 square feet of building area. These developments provided a substantial boost to tree improvement activities in the Province and pave the way for progressive expansion of intensive forest management in Alberta.

ASSEMBLY OF BREEDING STOCK

Selection of superior trees to provide base material for selection and breeding projects continued with most of the efforts directed at lodgepole pine in west-central Alberta. During the report period a total of 770 trees were selected by systematically cruising approximately 13 500 square km of forests. Much of the area was accessed by helicopter or tracked vehicles. To date a total of 971 lodgepole pine selections have been made by cruising approximately 15 400 square km of forests. Cone collections were made from selected individual trees to provide seed for establishing progeny tests and seedling seed orchards. Complete sets of seedlots have been assembled for two lodgepole pine breeding programs.

Superior tree selections made during
1977-1979

Cooperators	Number of Selected Trees	
	Lodgepole Pine	White Spruce
Alberta Forest Service Procter & Gamble Cellulose	340	35
Alberta Forest Service North Canadian Forest Ind.	142	14
Alberta Forest Service Simpson Timber Company	288	--
Total	770	49

With the completion of field work to locate and select the required number of trees for the two lodgepole pine breeding programs currently in progress, the emphasis of field work has shifted to selection of superior white spruce trees. Five breeding programs are planned for this species. Four of these programs require establishment of clonal seed orchards and corresponding open pollinated progeny trials. Field work for selection of superior parent trees for these programs was started in February, 1979 and a total of 49 selections have been made so far. All of the selected trees were reported to have a fair to good cone crop this year.

One white spruce breeding program is based on developing a seedling seed orchard following half-sib family selection scheme. A total of 83 open pollinated individual tree seedlots were collected for this program in 1976, but no additional seed collections could be made in 1977 and 1978 because of extremely poor cone crops.

PROGENY TESTS AND SEED ORCHARDS

Field outplanting of lodgepole pine open pollinated family tests will start in 1980. Selection of suitable test sites and site preparation for these trial areas is continuing. Three test sites have already been developed by Procter & Gamble Cellulose and Simpson Timber Company.

Plans for establishing one lodgepole pine seedling seed orchard in the Grande Prairie Forest were finalized. The orchard is being established jointly by the Alberta Forest Service and Procter & Gamble Cellulose. A 12 ha site was prepared to establish the seed orchard plantation by bulking a portion of open pollinated seed collected from 206 individual tree selections. Seedlings were reared in containers in the greenhouse and will be outplanted in spring, 1980 as a relatively close spaced plantation, which will be progressively thinned to retain about 20 percent of the best trees for seed production. The project is primarily intended to evaluate effectiveness of simple recurrent selection as an alternate breeding scheme to provide relatively low cost seed that may be economical for use in direct seeding programs.

SEED PRODUCTION AND SEED COLLECTION AREAS

Field data on nearly 200 forest stands, earlier surveyed for selection of superior lodgepole pine trees, were summarized and reviewed to identify excellent quality stands which may be acceptable as designated seed collection area reserves. Four stands were tentatively selected for this purpose, and will be evaluated further before any of these are ear-marked as seed collection stands.

Two small seed production areas were developed by the Alberta Forest Service in the Slave Lake Forest. These stands, and a black spruce seed production area developed earlier in the same region, were fertilized with calcium nitrate at the rate of 340 kg of elemental nitrogen per hectare applied in two equal applications (one in late spring and the other in mid-summer, 1978). Control and monitoring plots were established to assess the effect of fertilizer treatment on cone crop, and seed yield and quality. Procter & Gamble Cellulose established two field trials to assess the effectiveness of Furadan (a systemic pesticide) in controlling cone insects in seed production stands. The insecticide was applied as soil dressing at three treatment dosages and its uptake by selected treatment trees is being monitored by gas-liquid chromatography of cone and foliage samples. Observations on seed loss due to insect damage in these trials will be completed when cones are harvested in late August, 1979.

SEED BANK AND NURSERY PRODUCTION

During the period 1,115 seedlot entries were added to the seed bank maintained by the Genetics Section of the Alberta Forest Service. A total of 954 single tree or bulk seed collections were made and processed. These represented open pollinated seedlots of selected trees and seed source stands, as well as general collections made for building seed inventory for experimental work. The species from which collections were made were as follows: *Picea glauca*; *Picea mariana*; *Pinus contorta*; *Pinus banksiana*; *Pinus albicaulis*; *Pinus flexilis*; *Larix laricina*; *Larix lyallii*; and *Betula papyrifera*. In addition 161 seedlots representing 17 species were acquired through requests and seed exchanges with various agencies in Canada, United States and abroad.

Planting stock production for various genetics and tree improvement projects during the report period consisted of 108,000 seedlings and 1,591 grafts. This provided material for various research and operational trials, which mostly consisted of relatively large scale outplantings to compare performance of several species on diverse sites in northwestern Alberta.

GENETIC IMPROVEMENT OF JACK PINE FOR THE PRAIRIE PROVINCES, 1977-1979

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Keywords: Pinus banksiana, family test, clone bank, grafting, genetic gain.

Partial analysis of measurements for two of the three family tests of the jack pine (Pinus banksiana Lamb.) breeding program has indicated an opportunity for gains on the order of 10-15% in height growth to five years from planting. Application of these results has been pursued to some extent. The amount of effort that can be expended in this direction, and toward complete documentation of the program's strategy and progress, has been limited. Completion of the regional clone bank, and development of the Chip Lake Research Planting Area, in which the clone bank is located, have absorbed a large portion of Canadian Forestry Service tree improvement resources in the region during the past two years.

FAMILY TEST RESULTS AND APPLICATION

Eastern Manitoba

The family test in this breeding district was measured in fall 1976, following the fifth growing season from planting. Mean height was 75 cm. One-way analysis of variance with 215 and 9617 degrees of freedom for progenies and error, yielded an F-ratio of 3.4 and a standard error of 3.3 cm for a family mean. Inspection of a map of source stand means on source locations revealed three areas having several neighboring stands averaging about 5% above the test mean. Some genetic improvement may be achieved by seed collection in those areas. Twenty-six progenies had height means at least 10% above the test mean (Klein, 1978a).

At a meeting in Winnipeg in March 1979, agreement was reached to establish a production orchard in eastern Manitoba using genotypes selected on the basis of family test results. The Province of Manitoba and the Canadian Forestry Service will cooperate in this enterprise. Some of the tallest 26 progenies do not have parent clones. Their clone bank grafts are ramets of progeny trees selected on the basis of five-year height, and grafted beginning in 1978. It may not be feasible to obtain scions from the clone bank ramets or family test ortets of those progenies at the time of initial orchard grafting. Consequently, the selection differential will have to be lowered in order to provide a suitable number of selected parent clones. There are 23 parent clones, each from a different source stand, having progenies at least 6% taller than the test mean, with a mean progeny height of 81 cm, or 8.5% above the test mean. Because the pollen parentage of the progenies was unselected, although more or less related to the seed parents, the superiority of the selected parent clones is expected to exceed the superiority of their tested progenies.

Central to Western Saskatchewan

The family test for the western breeding district was measured in fall 1978. Progeny mean heights were computed manually, and the tallest progenies identified by inspection. The test mean at five years from planting was 138 cm. As for the eastern breeding district, some of the tallest progenies lack parent clones. Selection of progeny ortets has not yet been done for those families. About 100 grafts of 18 selected parent clones are available to be included in a seed orchard being established by Prince Albert Pulpwood Ltd. These clones have a mean progeny height of 150 cm, or 8.3% above the test mean. Each selected clone is from a different source stand. The Province of Saskatchewan has expressed interest in cooperating on establishment of a seed orchard of selected western district genotypes.

CLONE BANK

The regional clone bank for the jack pine breeding program is located at the Chip Lake Research Planting Area, about 120 km west of Edmonton. Climate, soil, and site preparation have been described in earlier progress reports (Klein 1976, 1978b). Planting of grafts began in 1977. When filled, the clone bank will contain five grafts for each of the 637 families included in one of the three family tests. As of October 1978, 2,123 planted grafts had at least one living scion bud, leaving 1,062 to be added.

Planting positions were assigned in sequence according to family accession number in each of two separate blocks accommodating two and three grafts, respectively, of each parent clone or progeny. Spacing is 3 m x 3 m. Each planted graft has been labelled with a livestock tag on a key ring. The key rings can be opened for convenience in moving the tags upward as the grafts grow, until the tags are at eye level.

Hand weeding, a circular brush saw, and a tractor-drawn brush mower are used to control competing vegetation. All but a few stumps have been cut off at ground level and removed from the plantation, to allow effective use of the brush mower. A fence appears to be effective in excluding rabbits, but moderate damage by mice and ungulates may require use of a repellent spray for protection of the grafts. Staking of scions and gradual removal of rootstock shoots are done annually. Stocking and condition of the grafts are recorded annually on a permanent record form.

GRAFTING

Aside from the small amount of orchard grafting done this year, our grafting program has been entirely directed toward filling of the regional clone bank. Scions are collected from primary grafted ramets of parent clones in preliminary clone banks, and from selected progeny trees of families lacking parent clones, in family test plantation. Grafting is done on potted rootstocks at the Northern Forest Research Centre.

Now that completion of the clone bank seems to be within reach of one year's grafting capacity (ca. 1500 grafts), our success rate is dropping. In the 1979 exercise, we did reasonably well with clones that had at least one ramet in the regional clone bank, and with some clones that had not previously produced usable scions on the ramets in the preliminary clone banks. Results were disappointing for clones that had been regrafted unsuccessfully in previous years. For some of these, as many as 15 attempts in 1979 did not result in a single successful graft. There are about 20 clones in the program which have yielded from nil to two successful grafts in 20 or more attempts since 1975. The success rate with progeny scions was another disappointment at 39%. These scions were obtained from trees nine years of age, roughly 1-2 m in height, in deep snow in early March; and grafted before the end of March.

In order to overcome these difficulties, it will be necessary to change our procedures. Possibly useful changes include use of dormant rootstocks, scion collection earlier in the dormant season, closer control and more appropriate selection of scion storage and conditioning temperatures, and use of bottle grafting. Reduction of storage time, and refinement of our current side-veneer technique, appear to offer less hope for improvement of success with difficult clones. Modification of the incubation environment for completed grafts, perhaps toward 70-80% r.h. and temperatures somewhere in the 16-20°C range, may be useful if attainable.

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ST. REGIS (ALBERTA) LTD. TREE IMPROVEMENT

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In 1978 the company name of the Alberta operations of St. Regis Paper Company was changed from North Western Pulp & Power Ltd. to St. Regis (Alberta) Ltd. This report outlines the progress made since 1977, when the biennial report was submitted under the former company name.

Short term objectives are being met partly through a continuation and expansion of our pre-commercial lodgepole pine (Pinus contorta var. latifolia Engelm.) thinning operations. By the end of the 1979 thinning season four of the five St. Regis working circles will have thinned areas. Some phenotypic selection is possible at this stage and improvement is hoped for in the treated stands and the seed obtained from these stands. Test sites being planted in 1979 will provide information of seed quality.

A proposal has been written, and accepted in principal, to collect seed from individually selected lodgepole pine for use in reforestation seedling production at the St. Regis nursery. The benefits of this program are expected to be: increased wood production through improvement in stem form and other characteristics; complete control of seed source; and provision of a potential source of seed for breeding research. Selection in the field will be ocular, with no parent tree information other than location recorded. Selection criteria will be simple, larger than average defect-free trees well distributed through the stand. Cost of this project, to provide sufficient seed to produce 3,000,000 seedlings over the years 1981-1983, is expected to be $3.80 per thousand seedlings produced.

The first phase of the long term program, a local seed source test, was started in 1978, with collection of seed from 12 trees in each of 13 stands. The St. Regis Forest Management Area was divided into eight tentative seed zones, and two stands were selected in each of five zones, and one stand in each of the other three zones.

The original plan had called for the seed to be bulked, and one test site of three replications of each stand to be planted in each zone. After discussions with the company and outside personnel the format was changed and individual tree identification maintained. In all cases, this identity will be maintained through the greenhouse seedling stage, and in three of the test sites individual identification will be maintained through the test. In the other five sites, the stand seedlings will be bulked and the size of the replications will be reduced from 10 x 10 to 6 x 6. With the maintenance of parent tree identification the test can be described as a limited range provenance/half-sib progeny trial.

Each site also includes local controls, some of which are standardized throughout the test, and others which vary from site to site.

Two sites were planted in 1978 and three more will be completed in 1979. The final three bulked-lot test sites will be planted in 1980. Planting over three years simplifies both establishment and data collection of the approximately 27,000 seedlings.

FOREST GENETICS STUDIES AT THE UNIVERSITY OF ALBERTA

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Key words: Genetic differentiation, gas-liquid chromatography, chemotaxonomy, gel electrophoresis, vegetative propagation, introgression, population genetics.

Forest genetics activities at The University of Alberta have been concentrated in the areas of natural variation, chemotaxonomy, gel electrophoresis, and vegetative propagation. Over the past two years, two projects have been completed, one is continuing, and several have been initiated. Most of these projects rely upon the work of graduate students or post-doctoral fellows for their completion.

NATURAL GENETIC VARIATION OF WHITE SPRUCE IN ALBERTA

Mr. B. Glen Dunsworth completed his M. Sc. thesis on "Genetic variability of white spruce (*Picea glauca* (Moench) Voss) in Alberta" in the fall of 1977. Twenty-seven sources of white spruce were used to investigate the nature and amount of genetic variability of white spruce in Alberta. Seedlings from these sources were grown in containers for two growing seasons, in a factorial design, under two controlled environment regimes simulating northern and southern Alberta forest conditions. Height growth was measured at bi-weekly intervals throughout both growing seasons. At the end of the experiment, height, diameter, number of branches, total and top fresh weight, total and top dry weight, fresh and dry weight root/shoot ratios, and total and top relative dry matter were measured.

Analysis of variance was used to determine the significance of differences among sources. The relationships of characters with environmental parameters of the source were tested using regression analysis. Duncan's Multiple Range Test was used to determine significantly different groups of sources. Principle components analysis was employed, using all characters, to determine significant multivariate source groupings.

Analysis of variance indicated that total and top relative dry matter and number of branches were the only characters with significant among-source variation. Regression analysis and Duncan's Multiple Range Test showed northern Alberta sources to have significantly higher total and top relative dry matter than all other sources, while sources from central and north-central Alberta were shown to have significantly greater branchiness than all other sources tested. Assuming relative dry matter to be a measure of winter hardiness, the northern Alberta sources were the most hardy and the high elevation, east-slope sources the least hardy of all sources tested.

The patterns of variability of relative dry matter and number of branches differed. Relative dry matter exhibited continuous variation with respect to latitude and elevation of the source, similar to that in a number of characters tested previously in range-wide studies of white spruce. Number of branches exhibited a banded pattern of variation, which appeared to be similar to that previously reported for seed weight of a number of sources of Alberta white spruce.

It appears feasible that the patterns of variability reported in this study could have developed since the late post-glacial period in Alberta. This period may have been characterized by the retreat and re-establishment of boreal species from central and north-central Alberta due to the extension and retreat of grasslands in this region. The effects of isolation was well as selection and genetic differentiation over a period of several thousand years may have resulted in the differing patterns of variation illustrated in this study.

The results of this study indicate that:

1. Northern Alberta sources of white spruce can be moved and will survive throughout the province (with the exception of movement to high elevation, east-slope sites).
2. Local sources should not be moved from high elevation, east-slope sites.
3. Central and north-central sources will have more branches particularly on southern Alberta sites.

A manuscript has been condensed from the bulk of the thesis and will be submitted for publication in the summer of 1979. This study was supported by the Alberta Forest Development Research Trust Fund.

HYBRID PINES IN ALBERTA

Mr. John C. Pollack completed his M. Sc. thesis on "Monoterpene analysis of the jack pine-lodgepole pine complex in Alberta" in July, 1979. The primary objective of this study was to determine which traits could be used to identify pure lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.) in a region where hybridization with jack pine (*P. banksiana* Lamb.) commonly has been reported. Five monoterpenes from cortical oleoresin of 592 individuals, and 17 morphological characters of 178 of the 592 individuals, in 14 stands in Alberta were measured. Of the 22 characters, α-pinene, β-phellandrene, and needle length best separated lodgepole pine from the combined group of jack pine and the putative hybrids. Morphologically pure jack pine at Cold Lake contained an average of 75.6% α-pinene, 10.76% β-pinene, 0.01% myrcene, 13.22% 3-carene, and 0.34%

β-phellandrene. Morphologically pure lodgepole pine at Hinton contained an average of 7.96% α-pinene, 11.27% β-pinene, 2.62% myrcene, 20.79% 3-carene, and 57.36% β-phellandrene. The monoterpene composition of two putative hybrid stands at Onoway and Devon closely resembled the monoterpene composition of the Cold Lake jack pine stand, with the exception of a small group of suspected hybrid backcrosses to jack pine. The morphology of a tree did not always correlate with its monoterpene composition. Thus, the discrimination between lodgepole pine and the combined jack pine-putative hybrid group was accomplished best with the monoterpenes. Previously reported dominance of jack pine pinenes in F_1 hybrids made this discrimination stronger than if the jack pine pinenes had been recessive.

Myrcene could be eliminated from the analyses since it was a trace compound. Analysis of the other four monoterpenes in 14 stands revealed a transition zone between jack pine and lodgepole pine in the province. This zone occurred further to the west than reported by previous researchers. The transition zone contained mixed stands of jack pine, lodgepole pine, and many hybrid monoterpene types.

The presence of variant monoterpene types in Front Range lodgepole pine stands from Coleman to Hinton, and the absence of such individuals in the Cypress Hills, is evidence of introgression of jack pine into lodgepole pine. Similar evidence of gene flow of lodgepole pine into jack pine was found in the putative hybrid stands. No evidence of gene flow of lodgepole pine into jack pine was found in the Cold Lake jack pine stand.

This study was supported by the Alberta Forest Development Research Trust Fund. While I am on study leave during this year (July 1, 1979 to June 30, 1980), I intend to study allele frequencies of these same pines by means of gel electrophoresis in the laboratory of Dr. Francis Yeh in Victoria.

VEGETATIVE PROPAGATION OF *PINUS* AND OTHER SPECIES

Mr. Richard H. Hillson, research associate, has been conducting studies into the rooting of needle fascicles of *Pinus* over the past two years. Short shoots of the pines can be induced to "proliferate" (develop into long shoots) be removing stem and branch apices of the parent plant. Not only does this make possible the production of many cuttings from young seedlings, but these cuttings can be rooted with ease when pretreated with IBA and then placed in a misting bench provided with bottom heat.

Ever greater numbers of cuttings can be obtained when seedling stock plants (ortets) are subjected to an accelerated-growth regime involving continuous illumination and complete nutrient (NPK) solution--the latter used for 60% of all watering.

Removal of proliferating short shoots from stem and branch stubs of stock plants results in the proliferation of further short shoots--each of which provides a potentially rootable cutting (ramet). Rooted cuttings produced in this way can themselves be used as stock plants thus giving rise to a second "generation" of cuttings.

When stock plants are kept growing under the accelerated-growth regime, cuttings can be taken at frequent intervals. Early indications are that this procedure--a type of "bedding"--can be kept going long enough to produce clones of sufficient size to be used in small-scale experiments where uniform material would provide an advantage. Further application depends on the outcome of continued research.

Mr. Hillson's work has been partially supported by a special grant from the National Research Council.

GENECOLOGY OF THE *BETULA PAPYRIFERA-B. NEOALASKANA* COMPLEX

Morphological characters of trees in several populations of paper birch (*Betula papyrifera* Marsh.) and Alaska paper birch (*B. neoalaskana* Sarg.) have been analyzed by univariate and multivariate statistical techniques. Multivariate analyses of 22 leaf and fruit characters of 103 individuals revealed a continuous pattern of variation between the two named taxa; there were no distinct differences between the taxa. Trees with large leaves seem to be associated with dry sites, while those with small leaves appear to be found on wet sites. Further analysis is necessary before any further conclusions are made.

Dr. Lewis Enu-Kwesi, a post-doctoral fellow supported by the National Research Council, has begun a study of variation in leaf-wax alkanes and inner bark constituents in these birches (using gas-liquid chromatography). Studies of these birches have been supported by the National Research Council.

ISOZYMES OF TREMBLING ASPEN

With the guidance of Dr. Francis C. Yeh of the B.C. Forest Service, an isozyme laboratory has been established in the Department. A graduate student, Mr. William Cheliak, has just begun a study of isozymes of populations of *Populus tremuloides* Michx. Bill is looking at approximately a dozen enzyme systems in the initial shoots emerging from aspen roots collected from about 35 clones in each of several populations in Alberta

In addition, we plan on comparing gene frequencies and genetic distances (as determined by isozymes) among the Alberta aspen populations and those in Utah (with the cooperation of Dr. George Schier of the U.S.F.S., Logan, Utah) and other locations on the continent.

This study has been supported by a portion of a C.F.S. Research Agreement with the Department of Forest Science.

NATURAL VARIATION IN LEAF-WAX ALKANES IN *POPULUS TREMULOIDES*

Mr. Barry Jaquish has just started his M. Sc. study of seasonal, clonal, sexual, and positional differences of alkanes of the leaf-waxes of clones of trembling aspen. In addition, if he has time, he will study inheritance patterns of the leaf-wax alkanes.

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A BREEDING PROGRAM IN COASTAL DOUGLAS FIR (*P. MENZIESII* MIRB. (FRANCO))

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

Tree improvement work in coastal Douglas fir has been taking place since 1957 with early emphasis on selection and seed orchard establishment. Emphasis is now placed on a breeding program where controlled pollinated progeny of the original plus tree selections are being established in field trials. Selections will be made in the pedigreed F1 material for the second generation of seed orchards and information will be generated to guide breeding approaches and to cull the first seed production orchards. The first test sites from this project were planted in 1975 and now 44 have been established. Preliminary measurements have been made but the present work is largely devoted towards crossing and establishing the plantations.

BACKGROUND

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

Selection has continued where gaps occurred in this initial coverage. For example during 1978 trees were added to the register from the Johnstone Straits area by Crown Zellerbach crews. While a scattering of selections had been made across that zone in the initial period, the islands now represent an important area for intensive management by the company which is establishing a seed orchard for that region.

The selected trees were grafted for use in the first level seed orchards and also established in the clone bank at Cowichan Lake Experiment Station. This serves as an archive for the artificial preservation of a gene pool and as a breeding arboretum. As cones and pollen are produced there and in the seed orchards, a breeding program has been set up. This program will provide information and reselected material to form the basis of improved orchards.

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

RECURRENT SELECTION PROGRAM

First priority has been given to a recurrent selection program in a population of selected trees from Coastal British Columbia and Northern Washington. Eventually about 350 trees will be involved and the project is designed to provide material and information from which future, reconstituted seed orchards may be developed. Its chief impact will be on the lower to middle elevation zones.

The objectives are:

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

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

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

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

A disconnected modified diallel mating design is being used and five crosses per parent should provide adequate information and yet represent a feasible project. Each cross will be represented in the field tests by almost 200 seedlings and the sites will be distributed to sample the range of coastal environments.

Each modified diallel comprises six parent trees taken in theory at random from the total population and as reciprocal effects are being ignored for the present, the allocation of parents will depend on the available numbers of reproductive buds. In this way a completed diallel will contain 15 crosses. Groups of 5-10 of these diallels are being used in a single year of field testing and overlapping crosses will provide some control between years of planting.

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

The stock is grown as long season, styro-8 plugs. These are sown in the greenhouse in early spring and are ready for planting in the fall or following spring. The field design calls for four replications of four-tree row-plots with all crosses planted on the eleven test sites, which are widely distributed to provide information on genotype by environmental interactions.

PROGRESS

From this brief outline it will be seen that this is an extensive program and during the early stages major efforts have to be devoted to producing the cross-pollinated families and establishing the test sites. Achievement is measured in terms of area planted, parent trees brought into the testing program and crosses made.

In this way, two more seasons of controlled pollination have been carried out since the last report and this has brought 246 plus tree parents into the plantation phases. A total of 44 test sites, each of about 3.5 ha, have been planted (Fig 1). A further eleven sites are currently being laid out to receive the stock now growing in the greenhouse at Cowichan Lake. A further crossing program in 1979 will, if successful, bring the total parents up to 294.

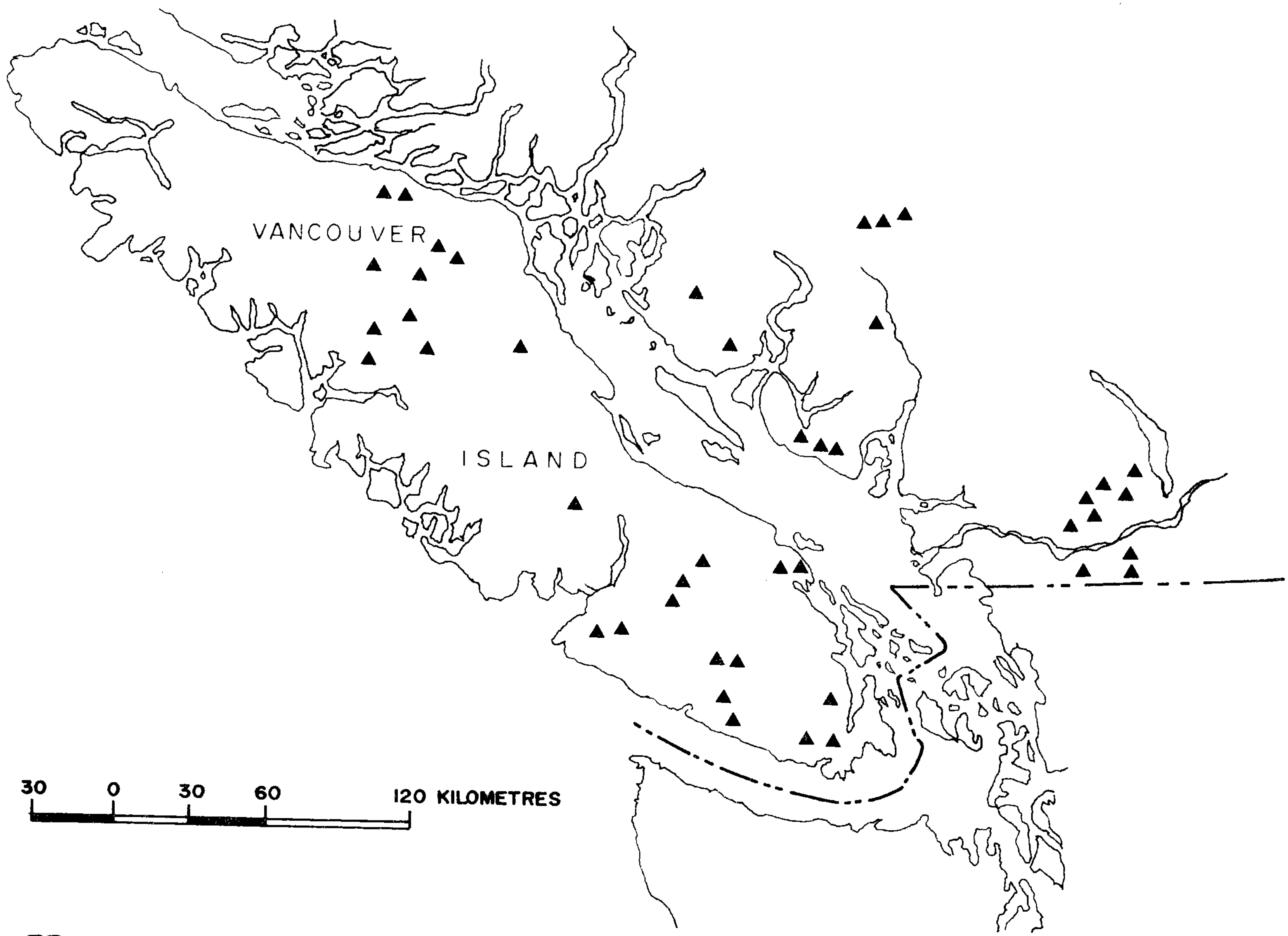
Table 1. Progress in E.P. 708, A Breeding Program in Coastal Douglas Fir.

Series	Sowing Year	Parents	Modified Diallel Groups	Crosses Planted *	Test Sites
I	1975	60	10	177	11
II**	1976	30	5	99	11
III	1977	54	9	165	11
IV	1978	54	9	170	11
V	1979	48	8	153	11
Totals		246	41	764	55

* Includes 10% overlap crosses and reciprocal samples
** Sowing in 1976 included two factorals of the interracial crosses

The accumulation of information will be slow but for example, by 1990 there should be 10-year field measures on all of these 246 parents, each of which is represented in five crosses. Measurements of height, and later of height and diameter are planned at 5, 10 and 15 years after planting. A form of index selection will be developed and it is planned that the preliminary selections will be made and propagated when the 10-year measures are available.

Crosses on six of the first eleven sites were measured in 1978, after 3 years in the field (4 years from seed), and the plantation means varied from 61.20 cm to 89.68 cm. Parental mean effects varied $\pm$ 10-20% of the plantation mean. The data are being used to develop analysis techniques and to provide some insight into variation patterns and trends. It is still too early to draw conclusions from these figures.



EP. 708. A BREEDING PROGRAM FOR COASTAL DOUGLAS FIR.
DISTRIBUTION OF TEST SITE NUMBERS 1 - 44
ESTABLISHED 1975 - 1979.

The work to date is labour intensive and hence costly. A six man crew is used for site establishment and the plots are staked and mapped to the randomized design before planting. A three-man maintenance crew is also needed to remove brush and vegetation from the established plots. The use of large 1-0 plugs has many advantages for stock handling with a small plot design but the trees are still too small to overcome early weed competition without help.

After the original planting, spare stock is held in the nursery transplant bed to be used to replace early field mortality. While such replacement stock may not be useful in the early assessments due to its different history, the maintenance of full stocking is worthwhile and it is hoped that in later assessments, these replaced trees may still be acceptable for analysis. Records of each planting position are held to allow their exclusion if necessary.

Record keeping presents a problem and a computer based program has been designed. Plantation records are maintained on a master file and plantation maps generated on the plotter with the latest survival information. Once the system has been developed, it will simplify summary and analysis, provide a permanent record and reduce errors.

RECIPROCAL RECURRENT SELECTION

While the recurrent selection program, using a single "local" population represents a more conservative approach, a second project to examine the possible advantages of interracial crossing and the use of this material in reforestation programs is justified. This project has been loosely termed Reciprocal Recurrent Selection and is designed to follow up some of the encouraging results of Dr. Orr-Ewing's interracial crossing studies (Orr-Ewing, et al 1972; Orr-Ewing and Yeh, 1978). Here an incomplete factorial mating design is being used with two populations designated "Local" and "Exotic"; five crosses will be made with each parent brought into the program. The parents for the local population have been taken from Lower Coastal B.C. and Northern Washington as in the recurrent selection program, while the "exotic" population is being drawn from the Northern British Columbia Coast (e.g. Bella Coola) and trees from Southern Washington, Oregon and Coastal California. The first crosses for this program were made in 1975.

To guide the choice of these approaches and to provide an early assessment of such a variation pattern, two of these five by five factorial blocks were sown in 1976 and have also been planted on eleven test sites. Although the stock for these 1976 plantations suffered from root problems in the nursery, they are now established and the first measures on some sites should be made in 1979. Under the nursery conditions of that year, extreme variations showed up in the first year performance of certain crosses but when some of these were resown the following year, the reduced variation was striking. From this the extent of growing environment x cross interactions were emphasised and indicated that caution was needed in trying to interpret early results based on a single year's observation.

The Breeding Collection at Cowichan Lake Experiment Station (Orr-Ewing, 1973) is now reaching the stage where reproductive buds are being produced and where some selection is possible. Hence in the next few years this interracial crossing project will receive more attention.

Since Dr. Orr-Ewing's retirement in 1978, the work of his interracial crossing project will be handled with the Douglas fir breeding program. At present the work consists of maintenance and measurement. Before retirement, Alan Orr-Ewing summarised the results to date (Orr-Ewing and Yeh, 1978).

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COWICHAN LAKE RESEARCH STATION

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Key words: flower stimulation; supplemental pollination; compatible rootstocks.

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

FLOWER STIMULATION IN DOUGLAS FIR (E.P. 780.03)

Stem girdling has been used as one means of increasing flower production in Douglas fir clonebanks at the Cowichan Lake Research Station. It was found that the incomplete girdling done in the spring of 1976, with a 2.5 cm wide strip of bark left as a bridge did not result in any more cones in 1977 than did the control. The 1975 girdling, however, which cut around the whole stem resulted in a large increase of cones in 1976 and in a definite carry-over effect to 1977. There is no carry over effect after 2 years.

Table 1. Effect of girdling on flowering in Douglas fir.

Treatment	Total No. of ramets	No. of ramets with cones 1976	1977	No. of cones per ramet 1976	1977	Ramets with reproductive buds 1978
Girdled May 1975	39	20	13	188	15	4
Control	39	5	1	39	5	6

SUPPLEMENTAL POLLINATION IN DOUGLAS FIR (E.P. 780.05)

In an experiment with supplemental pollination in 1976 (708.04) the seed yield was increased 20% over the control. The pollen was then applied using a power sprayer with a dusting attachment. Because no flower bud count was done, it was not possible to determine whether the pollination method had any effect on cone retention.

A new experiment was conducted on nine clones in 1978 with the objective of studying both seed yield and cone retention when using different pollination methods. In order to better utilize the supplemental pollen, it was applied this time with a hand sprayer with the pollen projected into an inverted plastic bucket which was held over the female flowers. By using this method, the flowers became saturated with pollen. Some flowers were pollinated on one occasion and some on two, with an interval of a few days between the two pollinations. Following are the average results obtained from the supplemental pollination and from the wind pollinated control.

Supplemental pollination	Cone retention percent	Filled seeds per cone
One application	66	24
Two applications	43	22
Control	70	29

This unexpected negative result from the supplemental pollination could be caused by either the wet and humid weather which prevailed during the pollination period, or from the possibility that excessive quantities of damp pollen on the flowers prevented proper pollination and even caused some flowers to abort.

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

The first lot of 22 controlled crosses involving 460 grafts were compatibility tested using the micro-technique method (Copes 1967). Most of the parents of these crosses exhibited a high degree of compatibility in the clonebanks, but some crosses from incompatible parents were also included. The rating of these rootstocks following the micro-technique test ranged between 85% compatibility for the best cross to 20% for the poorest. The latter was a cross between two incompatible parents.

For testing in 1979 to 1981, some 2200 grafts from 63 controlled crosses are now being grown in the nursery.

In order to gain more knowledge about graft compatibility and how it is related to the growth characteristic of the rootstock, some further crosses were made in 1978. This crossing involved six trees in a complete diallel and the 30 crosses produced were sown in the greenhouse in the spring of 1979.

GROWTH RATE OF DOUGLAS FIR GRAFTS ON DIFFERENT UNDERSTOCK (E.P. 648.03)

In a study of the effects of root stock origin on scion growth, rootstock provenances were selected among coastal, transition and dry interior samples. These grafts were field-planted in March, 1978. A second replication using the same provenances and two inbred lines as understock was grafted in the spring of 1977.

In both replications height growth of the scions showed significant differences between rootstock sources the first year after grafting.

ROOTED CUTTINGS IN YELLOW CEDAR (E.P. 750)

A plantation was established in October 1976 to compare the survival and growth rate of yellow cedar plants originating from seed and from rooted cuttings. After one growing season in the field the survival was 99% for both seedlings and cuttings and the following height measurements were recorded:

Seedlings	42.0 cm
Cuttings taken from 1-year-old seedlings	58.0 cm
Cuttings taken from 3-year-old seedlings	50.4 cm
Cuttings taken from 5-year-old seedlings	47.2 cm

The height difference in favour of the cuttings is attributed to the initial length of the cuttings at the time they were prepared and set in the greenhouse. This height advantage over the seedlings has remained for two growing seasons.

HEDGED BANK OF YELLOW CEDAR (E.P. 750.3)

The first phase of an 0.7 hectare hedge plantation of yellow cedar was established to produce material for large scale production of rooted cuttings. Included in this plantation are nursery grown seedlings from selected single trees, from production seedlots as well as naturally regenerated seedlings taken from beneath high elevation stands.

The seedlings were planted in rows, 3.75 m apart with 90 cm between seedlings and will be maintained as hedges to increase the amount of vegetative material. In order to obtain the best possible growth and early production, the soil will be cultivated and an irrigation system installed.

REFERENCE

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THE SEED ORCHARD PROGRAM OF THE SILVICULTURE BRANCH, BRITISH COLUMBIA FOREST SERVICE, 1977-1978

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Keywords: supplemental mass-pollination, root-pruning, selection.

British Columbia is presently divided into three seed orchard management zones: coastal, central interior and southern interior. This paper will briefly describe the significant progress that has been made in each of these zones during 1977 and 1978.

The Silviculture Branch manages four Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) seed orchards in the coastal region. Three of these orchards are productive and the seed harvest totalled 1.5 kg and 17.0 kg during 1977 and 1978 respectively which provided a seedling potential of approximately 1,300,000 trees. Root-pruning trials were conducted in these orchards and proved to be a promising method to enhance flower production. In addition, supplemental mass-pollination was undertaken within the three productive orchards.

A proposal for a Cooperative Government/Industry Tree Improvement Program for the coastal region was approved in 1978. Under this program approximately 45 first generation orchards will eventually be managed with the forest companies assuming a large part of the new orchard establishment work. All commercially important species will be included and the seed produced in the orchards shared among the cooperators.

In the central interior region the lodgepole pine (Pinus contorta Dougl.) seed orchard program expanded. Two new orchards were established on the Red Rock Reserve south of Prince George and land was prepared for an additional orchard to be planted in 1979. Female strobili production in a lodgepole pine orchard established at Red Rock in 1974 was impressive. However pollen production seven years after grafting has been negligible. Plans have therefore been formulated to pollinate the orchard with pollen collected from natural stands.

The selection of interior spruce (Picea glauca (Moench) Voss/P. engelmannii Parry) also progressed in the central interior. In isolated areas trees were selected by helicopter. A specially developed hydraulic clipper unit enabled the collection of scions from the helicopter. Most interior spruce orchards will be established in south central British Columbia because strobili production has proven profuse on the drier sites in this area.

Table 1. Summary of seed orchards established in British Columbia as of 1978.

Seed Orchard #	Agency	Date(s) Est. i.e. Grafted or planted	Orchard Location	Spp.*	Seed Orchard Seed Utilization Area: Seed Zone	Seed Orchard Seed Utilization Area: Elev. Band	Type of Orchard	Present Orchard Size/ha	Seed Production (kg): 1978	Seed Production (kg): Accumulated to Dec. 31/78
	Coastal Region									
1	B.C.F.S.	1963	Campbell R.	F	1020	450-610	Clonal + Seedlings (O.P.+C.P.)**	6.6	5.530	16.365
2	Tahsis "A"	1962-69	Gold R.	F	1010	0-450	Clonal	2.2	......	0.460
3	B.C.F.P.	1963-64	Cayeuse	F	1010-1020	400-660	Clonal	1.8	......	......
4	Crown Zellerbach	1964-65	Courtenay	F	1020-1030	0-450	Clonal	1.9	......	0.250
5	" "	1964-65	Nanaimo L.	F	1020-1030	450+	Clonal	1.8	0.750	0.905
6	Rayonier	1964-65	Gordon R.	F	1010-1020	450	Clonal	4.1	......	0.233
7	Tahsis "B"	1964-68	Gold R.	F	1010	450+	Clonal	1.8	......	0.234
8	Tahsis Local	1968-75	Gold R.	F	1010	0-910	Clonal	2.3	......	......
					Nootka PSYU only.			....	......	0.018
9	Pacific Logging	1964	Saanich	F	1020	0-450	Clonal	1.8	......	......
							+ Seedlings (O.P.)	...	0.960	1.981
10	Pacific Logging	1964	Saanich	F	1020	550	Clonal	3.4	22.365	40.710
11	Tahsis "C"	1968-75	Saanich	F	1010	0-450	Clonal	4.9	......	......
					Low Coastal		+ Seedlings (C.P.+O.P.)	...	25.250	59.535
12	Rayonier	1968	Jordan R.	F	1010-1020		Seedlings (O.P.)	0.4	......	......
13	Rayonier	1969	Pt. McNeill	F	1010-1020		Seedlings (O.P.)	0.4	......	.....
14	B.C.F.S.	1970	Duncan	F	1040, 1050, 1060	430-640	Seedlings (O.P.)	4.5	11.270	25.923
15	B.C.F.S.	1971	Campbell R.	F	1030	0-300	Seedlings (O.P.)	4.9		
							+ Clonal	...	0.425	0.425
16	Canadian Forest Prod.	1971	Sechelt	F	1020	450-610	Clonal	2.4	......	0.095
17	Tahsis	1969-70	Gold R.	Hw	1010	0-910	Clonal			
		1970-75	Gold R.	Hw	1010	0-910	+ Seedlings (O.P.)	3.7	......	......
18	Tahsis	1973	Saanich	Ss	1010	0-450	Clonal	0.8	1.710	2.594
19	B.C.F.S.	1977	Chilliwack	Sw			Seedling	1.6	......	......
20	B.C.F.S.	1975	Saanich	F	1050, 1060, 1070	760-1070	Seedlings (O.P.) + Clonal	7.4	......	.....

Table 1. Continued.

Seed Orchard #	Agency	Date(s) Est. i.e. Grafted or planted	Orchard Location	Spp.*	Seed Orchard Seed Utilization Area: Seed Zone	Elev. Band	Type of Orchard	Present Orchard Size/ha	Seed Production (kg): 1978	Accumulated to Dec. 31/78
21	Pacific Logging	1976	Saanich	F	1020	550	Seedling (C.P.)	6.0	......	......
22	MacMillan Bloedel Ltd.	1976-78	Harmac	F	Dry	Mid.	Clonal	1.2	......	......
23	MacMillan Bloedel Ltd.	1976-78	Harmac	F	Wet	Mid.	Clonal	1.0	......	......
24	MacMillan Bloedel Ltd.	1976	Harmac	F	Dry	Low	Clonal	0.5	......	......
25	MacMillan Bloedel Ltd.	1976	Harmac	F	Wet	Low	Clonal	1.0	......	......
						Totals - Coastal Region Orchards		68.3	68.260	149.748
Central Interior Region										
200	B.C.F.S.	1974	Red Rock	Pl	6050-6060		Clonal	4.4	......	......
201	B.C.F.S.	1978	Red Rock	Pl	7030		Clonal	1.7	......	......
202	B.C.F.S.	1978	Red Rock	Pl	6010-3100		Clonal	3.2	......	......
						Totals - Central Interior Region Orchards		9.3	......	......

*F - Douglas Fir

Hw - Western Hemlock

Ss - Sicka spruce

Pl - Lodgepole

**O.P. - seedlings resulting from open pollination

C.P. - seedlings resulting from controlled pollination

Note: Pacific Logging Seed Orchards are for reforestation in Private Lands.

In the southern interior region selection, collection of scions and cones, and propagation for the interior spruce orchards continued at the Skimikin Nursery site near Salmon Arm. Land preparation also progressed at Skimikin and the first spruce orchard will be planted in 1979.

A summary of seed orchards established by both the Forest Service and forest companies as of 1978 in British Columbia is presented in Table 1.

WESTERN HEMLOCK TREE IMPROVEMENT FOR COASTAL BRITISH COLUMBIA

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Keywords:

Tsuga heterophylla, tree selection, progeny testing, provenance testing, breeding

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

Parent tree selection by both Ministry and forest company personnel was continued, and a total of 671 trees have now been registered. Selections are made to targets established by elevation band within seed zone, and are further separated by agency.

Propagation by both grafting and rooting is conducted for all new selections, and the status of all previous selections is under review towards determining the need for repropagating. Every parent tree will be duplicated in gene archives, and many will be used in the seed orchards currently being planned. Propagation for both the seed orchards and the gene archives will be conducted at the Cowichan Lake Experiment Station.

Due to a limited cone crop in 1978, open-pollinated seeds were collected from only 139 trees. Seed collections for a proposed Canada - U.S. cooperative provenance test were made from 52 stands in 1978. Further collections appear possible in 1979, perhaps enabling sowing to start in 1980.

Measurements of nine-year height were taken from the Canadian Forestry Service (C.F.S.) population study (Piesch, 1974), and 6 to 8 year heights were obtained from the Tahsis Company progeny tests. These data were analysed to guide design of the progeny tests that will screen the parents for GCA.

Analysis of the C.F.S. population study indicated differences in total growth per test site and in population performance within sites. No population ranked first on all sites, but some showed stability and fairly high ranking on all sites. Parent tree selection, which has been planned to provide a large pool of well-distributed trees across all seed zones and elevation bands, will be concentrated somewhat in the vicinities of those origins producing the "more stable" populations, i.e. Tahsis Inlet (Tlupana), Quatsino Sound (San Josef River), East Thurlow Island, Sooke (Sheringham Beach).

Support research projects planned include vegetative propagation, cone induction and breeding techniques, early progeny testing, inbreeding and outcrossing, pollen storage and testing, population variability determined by isoenzyme and terpene analyses.

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THE LODGEPOLE PINE IMPROVEMENT PROGRAM IN BRITISH COLUMBIA

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Keywords: Pinus contorta, parent-tree selection, growth acceleration, flower induction, breeding arboreta.

The establishment phase of the lodgepole pine (Pinus contorta Dougl.) improvement program neared completion in 1979 with the final selection of parent-trees in the southern interior of British Columbia. Breeding arboreta for 3 of 4 selection units have been successfully established with grafted materials, and ancillary breeding populations have been increased with northern B.C. and Yukon materials of select tree origin. Related support studies designed to elucidate the effect of cultural treatments on growth acceleration and promotion were concluded with encouraging results.

PARENT-TREE SELECTIONS

The initial objective of this program was to establish broad-based breeding populations for 4 geographically delineated selection units in British Columbia (Wheeler, 1977; 1978). The parent-tree selection phase of the program concluded in July, 1979, with the addition of approximately 100 trees from the Okanagan region of south central B.C. This brought the total parent-tree base to over 550 trees. Furthermore, the total number of selections representing northern B.C. and the Yukon, and maintained in ancillary arboreta, was increased to 264 with the acquisition of 79 parent trees from Scandinavian cooperators. A summary of parent-tree materials by selection unit is presented in Table 1.

BREEDING ARBORETA

The development of 2 clonal orchards commenced in the fall of 1976 and was completed during the summer of 1978. The orchards, totalling nearly 9 hectares, are now occupied by over 4100 ramets representing some 450 parent tree clones. The arboreta are located on the Red Rock Forest Reserve near Prince George, B.C. Completion of all breeding arboreta is anticipated for the spring of 1980.

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Table 1. Number of parent-tree selections by selection unit and date of establishment of materials in clonal breeding arboreta.

Selection Unit	Number of parent-tree selections	Date established
Prince George	135	1977
Smithers	150	1978
East Kootenay	153	1979
Okanagan	100	1980*
Northern B.C. and Yukon	264	1970-1979
Total	802	

* Projected date of establishment.

Flowering has been observed in the first arboretum established in 1977 (Wheeler, 1978a). At the beginning of the 3rd growing season (2 full years after grafting and 1 full year after outplanting), over 41% (56 clones) of the clones exhibited female flowering. Interestingly, a significant difference existed in flowering response for ramets established on potted vs. field grown rootstock. While only 11% of ramets grafted on potted stock flowered, over 62% of the field grown stock supported flowering ramets. Recommendations for more grafting on field established rootstock were made.

In addition to breeding arboreta, first - phase clonal seed orchards containing most of the selections from the Prince George and Smithers selection units have been established at separate sites on the Red Rock Reserve.

SUPPORT STUDIES

Flower Enhancement

Two exploratory studies on the influence of exogenous applications of gibberellins on flower enhancement in grafts and seedlings of lodgepole pine were completed in 1978 (Wheeler, 1977, 1978b). Ovulate strobilus production was enhanced in both 7 year-old seedlings and 5 year-old grafts using topical applications of gibberellins (GA $_{4/7}$) throughout the period of primordia differentiation. Staminate strobilus production was not affected by GA alone or in combination with napthaleneacetic acid (NAA). The increased production of female cones on treated seedlings and ramets (3-5 times greater than controls) was judged large enough to be of practical value in an applied breeding program.

Considerable variation in flowering response to GA treatment was observed among clones (p=.05) and among provenances (p=.01). Response was not unqualified, however, and seemed only to occur in those clones and provenances that had apparently passed out of the juvenile stage. Perhaps the most attractive result of the seedling study was that positive responses were observed using rather simple and inexpensive spray application techniques. GA was applied topically with a perfume atomizer which proved to be less wasteful than intravenous systems and less time consuming than syringe pipettes. In short, the perfume atomizer appeared to provide a viable and relatively efficient means of promoting flower production in lodgepole pine on a breed orchard scale.

An adjunct treatment, girdling, was deemed unnecessarily destructive and its further use was discouraged. A review of current research in hormonal flower induction of conifers has been provided by Pharis and Kuo (1977). Data from the studies mentioned here are, in part, summarized in that paper.

Accelerated Growth

Wind pollinated seed and grafted materials of 8 selected parent-trees were established and maintained under 24 hour photoperiods for 6 months prior to outplanting in the nursery. The objectives of the study were to determine the effect of continuous light on: i) graft establishment and growth, ii) seedling growth, iii) flower promotion and iv) ability to make early selections in advanced generations. The effects were dramatic (Wheeler, 1977a, 1979). Rapid growth of seedlings reported for the period of initial treatment were maintained during the second and third growing seasons in the field. At 21 months (2 growing seasons), height and diameter of accelerated seedlings were 5 times greater than control seedlings (71.7 vs. 12.0 cm and 19.9 vs. 4.0 mm, respectively) (Figure 1). Shoot-root ratios were significantly smaller (p=.01) for seedlings grown under light indicating better balanced seedlings were being produced. Unfortunately, large family X treatment interactions prevented the extrapolation of rapid growth data for early selection purposes.

Flower promotion was not significantly enhanced in treated seedlings after 3 growing seasons. However, the continuous photoperiod did apparently play a significant role in enhancing ovulate strobilus production in grafts. In their 3rd growing season, 5 clones established under 24 hour photoperiods and retained in breeding arboreta produced .65 flowers/ramet while control ramets averaged less than .16 flowers/ramet (p=.01). Furthermore, frequency of flowering clones for treated materials was twice (80 vs. 41%) that of control stock. Vegetative growth of treated grafts was also significantly enhanced by the initial photoperiod treatment with response carrying over to the second and third growing seasons.

Figure 1. Lodgepole pine seedling, 21 months from seed, grown for 6 months under continuous photoperiod and transplanted to the nursery at 1x1 meter spacing. Control seedlings of the same age can be seen within the side-boards in background.

It was concluded that the most immediate and practical application of the rapid growth obtained with treated seedlings and grafts was that it provides for a more rapid establishment of seedling and clonal seed orchards and breeding arboreta.

Rootstock

A comparison was made between styro 4 plug + 1 and nursery grown 2 + 1 stock for value as rootstock in our grafting program (Wheeler and Andersen, 1978). The plug + 1 seedling was far superior, exhibiting long, clean stems, free of encumbering branches. They were easily grown and required minimal expenditures for mechanization and labor in the nursery. They were prepared for grafting by simply stripping the stem of needles and because of their lack of branches, required reduced maintenance after graft establishment.

Graft Survival

A study of the effect of date of scion collection and storage conditions on graft survival was conducted to establish guidelines for our extensive grafting programs (Wheeler, 1977b). It was concluded that for central and northern B.C. materials, scions should be collected no earlier than October 15 and preferably after December 1 to insure reasonable survival and good vigor. Scions may be kept for up to 6 months in air tight bags at subfreezing temperatures if they are collected after complete dormancy has occurred (after Dec. 1).

Concluding Remarks

Responsibility for the lodgepole pine improvement program changed hands in mid-1978. The present author is now at the Dept. of Forestry, University of Wisconsin, Madison, 53706. Dr. C. C. Ying, formerly of the Petawawa Forest Experiment Station, has assumed the research forester position in charge of lodgepole pine improvement. Future inquiries on the program should be addressed to Dr. Ying, Research Division, B.C. Ministry of Forests, Victoria, B.C.

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GENETIC VARIATION AT THE ENZYME LEVEL

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Gel electrophoresis is an efficient tool for large-scale genetic investigations. In the field of tree breeding and forest genetics research, the potential application of the information generated by gel electrophoresis are only beginning to be exploited.

Within the past two years, our laboratory has completed major studies of population structure in three conifer species of interest to the Ministry of Forests: Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco); sitka spruce (*Picea sitchensis* (Bong.) Carr.); and lodgepole pine (*Pinus contorta* Doug. ex Loud.)

The Douglas-fir study consisted of two parts: a survey of 11 populations of the interior variety, and a second survey of 11 populations of the coastal variety. Approximately 118 megagametophytes were genotyped for each population. Our technique allowed us to assay 15 enzyme systems and to score allelic variation at 21 gene loci within each population.

The second major project was a survey of 10 I.U.F.R.O. sitka spruce provenances. Approximately 80 megagametophyes from each population were scored for variation coded by 24 loci within 14 enzyme systems.

In our lodgepole pine study, we genotyped approximately 15 families within each of 17 populations. We were able to survey 16 enzyme systems and score 27 loci for variation.

Our studies allow us to advance the following generalizations:

1. There is a large amount of inter-locus variation in heterozygosity. Therefore, in order to get a reasonable estimate of species heterozygosity it is important to sample a large number of loci.

2. Most conifer species exhibit large amounts of variability.

3. The majority of a species genetic variation is maintained within individual populations.

4. Allelic frequencies can be diagnostic of taxonomic "entities".

TREE SEED RESEARCH, PACIFIC FOREST RESEARCH CENTRE, B.C., 1977-1979

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Keywords: Seed sorting, germination stimulation, seed pathology, cone and seed insects.

The main objective of the tree seed research program at the Pacific Forest Research Centre is the enhancement of the quality and quantity of seed supply in British Columbia and the Yukon through improved methods of selection, production, procurement, processing and utilization. Seed and tree improvement research have been allied since 1978 under one project, the leader of which is Dr. D.F.W. Pollard whose report on tree improvement aspects appears elsewhere in these proceedings.

IMPROVING USE EFFICIENCY OF SEEDLOTS

Studies to find methods of improving the use efficiency of seedlots, by identifying and separating germinable and non-germinable seeds, have concentrated on *Abies amabilis* (Dougl.) Forbes, *A. grandis* (Dougl.) Lindl., *A. lasiocarpa* (Hook.) Nutt. Separation of filled and empty seeds was fairly successful for several seedlots using a flotation-in-alcohol method, best results being obtained with absolute ethanol. However, even brief immersions (5 minutes or less) in ethanol reduced germination below 50% of the control, while immersions longer than 30 minutes completely eliminated germinability in most seedlots. Using lower concentrations of alcohol, germination was severely affected after short immersions. Other flotation media are being studied.

Alternative methods of sorting *Abies* seeds have been investigated, including air separation. A successful aspirator-type seed cleaner/sorter has been developed by Edwards (1979) that works well with seeds of most conifer species, although its effectiveness with *Abies* seedlots remains relatively poor; it has increased, however, the separation of filled and empty true fir seedlots commercially processed by other means. Designed specifically for laboratory use, the size of the unit could be increased to process large seedlots; the B.C. Forest Service has built a larger version for the Seed Centre at Duncan.

Efforts to identify germinable and non-germinable seeds in mixture have included trials with x-ray contrast agents; these are materials that, on penetrating damaged or less viable seeds, enhance contrast on an x-ray photograph, since the radiopacity of the agents is high. One trial completed so far comprised exposing seeds for various periods of time to the vapors of organic solvents, notably dichloroethane and chloroform. Radiographic images, and germination, were recorded immediately after treatment and after the seeds had air "dried" for 4 days to permit the vapors to evaporate. Germination responses of an A. grandis seedlot to dichloroethane vapor, shown in the following table, typify the results obtained.

	Time exposed to vapor (hours)					
	0(control)	1	2	4	8	24
Tested immediately after exposure	92.0	51.0	66.0	22.0	26.0	4.0
Tested 4 days after exposure	92.0	76.0	74.0	46.0	22.0	10.0

The degree of enhanced contrast on the radiograph, referred to as "staining", increased with the duration of exposure; after 24 hours, most seeds showed some tissue areas as stained. Some residual staining remained visible after vapors had evaporated for 4 days. Germinability decreased with increased exposure to vapor, there being some recovery in germination after vapor evaporation. Exposing seeds to chloroform resulted in greater losses of germinability with less, or no, gain after vapor evaporation. No strong relationship has yet been obtained between stained seeds and germinability. Staining occurs readily at or around resin vesicles in Abies seedcoats, masking other signs of tissue damage. It is not clear to what extent the vapor treatment causes tissue damage. Other contrast agents and shorter exposure times are to be tested.

Work has been undertaken on other so-called "quick" methods for estimating viability, including the hydrogen peroxide test (an actual growth test) and the tetrazolium chloride test. Confidence in the tetrazolium test is low since the results usually overestimate actual germination. Hydrogen peroxide was studied for its effects both as a germination stimulant and as a surface sterilant on A. amabilis and A. grandis; no benefit was found in increasing either rate or germination capacity, although certain treatments reduced the numbers of seed-borne fungi (Edwards and Sutherland 1979).

A report that prechilled (stratified) seeds of Pinus ponderosa could be air-dried and returned to cold storage for up to 9 months without their viability being adversely affected (Danielson and Tanaka 1978) stimulated similar investigations on Abies seeds from B.C. sources. Several seedlots were routinely prechilled for 4 weeks then samples were dried to 35%, 25% and 15% moisture content (fresh weight basis); control samples were not dried and contained natural moisture levels after prechilling which varied between 45% and 55%. Standard germination tests were performed immediately after drying and again after 1, 2, 3 and 4 weeks', 3, 6,9 and 12 months' storage in the same refrigerator used for prechilling (1-4 C). The experiment revealed that not only can prechilled Abies seeds be dried and stored for a considerable period but that significant increases in germination can accrue (Fig. 1). Both germination rate and capacity was

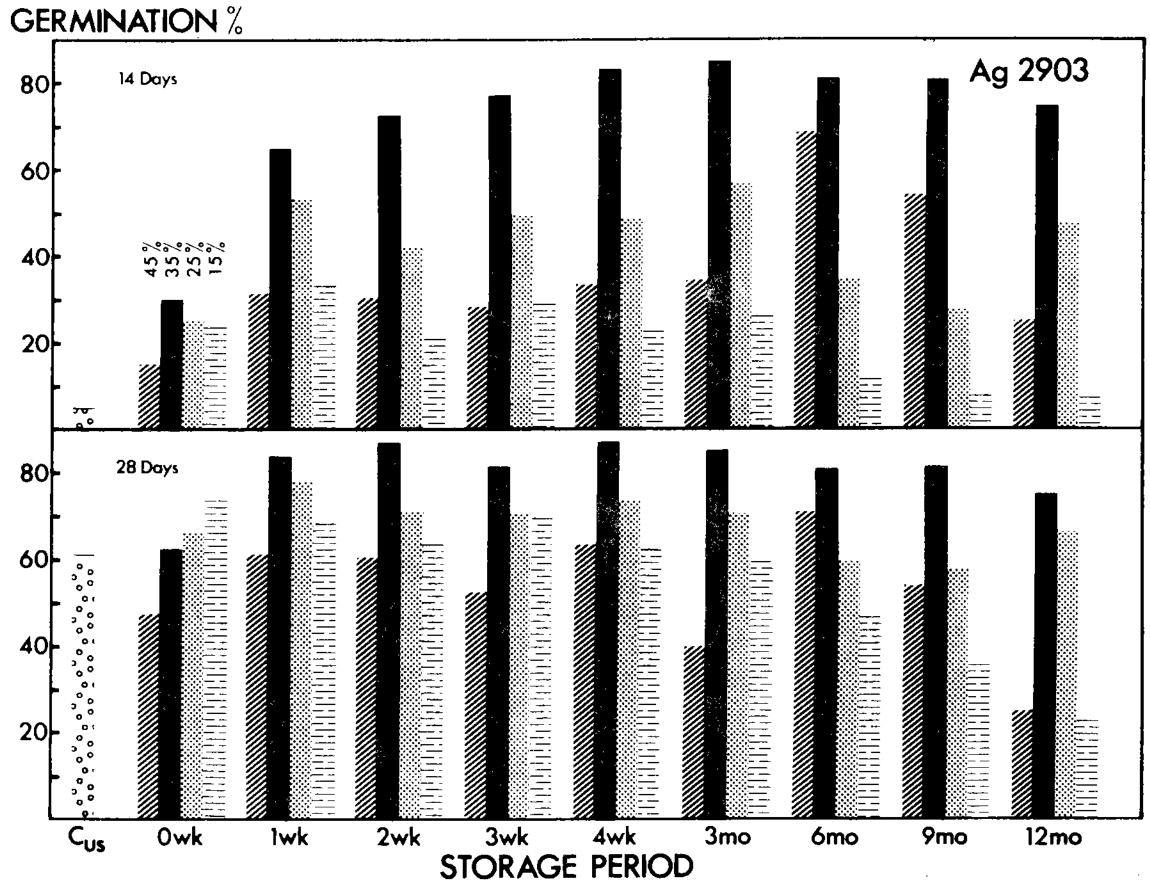

Figure 1. The effect of drying and storing prechilled seeds on A. grandis germination. C_{us}-unstratified control. Upper bars indicate germination after 14 days, lower bars show germination after 28 days.

increased after almost all storage periods by drying to the 35% moisture level. Germination was poorer at 25% moisture but between 25% and 35% it appeared that these seedlots not only retained the benefit of the prechilling but germinated at least as well as the controls 12 months later. For seeds stored longer than 1 month, all the germination occurred within the first 14 days of the test. A. lasiocarpa seeds, usually considered very dormant, did not respond until they had been stored after drying for at least 3 months; germination then increased to 70%, 3.5 times that of the control. A field trial of the procedure will be undertaken during 1979 in collaboration with the B.C. Forest Service. The treatment has been applied to several other conifer species, and increases in germination have been noted in some cases; moisture levels at which significant effects occur appear to be critically narrow.

CONE AND SEED PATHOLOGY STUDIES

Research conducted by Dr. J. Sutherland has shown that about 30% of the spruce (Picea glauca (Moench) Voss, P. engelmanii Parry, P. sitchensis (Bong.) Carr.) lots stored by the B.C. Forest Service are infested with the seed fungus Caloscypha fulgens. (This is the perfect-sexual-stage and this name now has preference over that of the asexual stage, Geniculodendron pyriforme.) The fungus also occurs in some 10% of Pseudotsuga menziesii (Mirb.) Franco and Abies grandis seedlots. So far, all other species have been found to be disease free. Seeds originating from ground picked cones, especially those from squirrel caches, are more likely to be infested with the pathogen which is a common inhabitant of forest duff. Within infested seedlots disease incidence ranges from 1% to 33%. The fungus can be isolated best by surface sterilizing the seeds for 30 to 60 minutes with 30% hydrogen peroxide.

Preliminary studies on the inland spruce cone rust (Chrysomyxa pirolata) have been conducted to determine the kinds, abundance and ecology of the alternate host (Pyrola spp.) at the Skimikin seed orchard. The effects of the cone rust on quantity and quality of seeds have also been studied.

CONE AND SEED INSECT STUDIES

Studies conducted by Mr. A.F. Hedlin on insect attraction have demonstrated that traps baited with a ratio of 80:20 cis-9-dodecen-1-ol:cis-9-dodecen-1-yl acetate are strongly attractive to male Douglas-fir cone moths (Barbara colfaxiana); traps baited with volatile Douglas-fir flower extracts also attract male moths. Mixtures of trans-7-dodecen-1-ol and trans-7-dodecen-1-yl acetate have been found to be attractive to male spruce seedworm moths (Laspeyresia youngana). Male seedworm moths are also attracted to traps baited with either female or male moths. Refinements of these techniques could provide safe, practical methods of reducing seed losses caused by major seed-destroying pests in seed orchards.

OFFICIAL TESTING OF TREE SEEDS

The Pacific Forest Research Centre became an official member laboratory of the International Seed Testing Association in 1978; Dr. D.G.W. Edwards was appointed as the accredited member. Authorization to issue international certificates (orange and blue) was received in 1979. PFRC membership in ISTA was sought primarily to compliment the role already performed in seed certification under the OECD Scheme (see Pollard report); since 1970, all Canadian tree seed certified under OECD have originated from B.C. and the Yukon.

Blue certificates apply only to the sample(s) submitted by the dealer. For orange certificates, which certify the seedlot as a whole, samples must be withdrawn by the ISTA agency and the seed containers then sealed to prevent tampering. Several members of staff have received instruction in seed sampling techniques from CDA officials. Since the OECD

Scheme requires that two official (yellow) labels be attached to certified lots, one inside and one outside the bags, coordination of the completion of seed certification with ISTA sampling/sealing is crucial. Arrangements have been made with CDA (Plant Quarantine Division) for PFRC inspectors to withdraw a seed sample for phytosanitary inspection before containers are sealed.

So far, 16 orange and 4 blue certificates, all for *Pinus contorta*, have been issued; 17 lots were OECD certified. There is some indication that seed dealers may request combined certification for all future *Pinus contorta* collections, and perhaps those of other species as well.

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SEED AND TREE IMPROVEMENT AT THE PACIFIC FOREST RESEARCH CENTRE

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Key-words: western hemlock, provenances, flower induction, seed certification.

In 1978, the Pacific Forest Research Centre established a new project under the title "Tree and Seed Improvement: B.C. and Yukon Conifers". The project has a five year plan that seeks to integrate 14 existing studies and 4 new studies into a comprehensive program for enhancing the quality and quantity of forest tree and seed supply in B.C. and the Yukon. Objectives identified for 1983 are:

i) provenances of western hemlock evaluated for reforestation on Vancouver Island, and natural inbreeding estimated for sample populations;
ii) methods of vegetative propagation and precocious flowering developed for breeding programs in B.C. conifers;
iii) an aerial branch sampler and cone collector developed and tested;
iv) efficiency of seed utilization improved;
v) prescriptions developed for high germination rates in important B.C. conifers;
vi) guidelines produced for seed source management, cone collection, seed processing and flower bud recognition;
vii) a reliable cone and seed crop forecasting system established for B.C.;
viii) an international scheme (O.E.C.D.) administered for seed source certification, and methods developed for identifying and characterizing seed sources;
ix) an international scheme (I.S.T.A.) established and administered for seed sampling and testing;

Two project leaders, R.C. Dobbs and R.F. Piesch, have departed from the Pacific Forest Research Centre since 1977. The author, formerly tree physiologist in the tree improvement program at Petawawa Forest Experiment Station, assumed R.C. Dobbs' duties in May 1978, and took responsibility for the development of an integrated project on seed and tree improvement, including the western hemlock program developed by R.F. Piesch. The tree physiology program continued at P.F.S. by Logan was curtailed as a result of widespread staff reduction in the Canadian Public Service in 1978.

x) a computerized information storage and retrieval system devised and established for inventory of regional forest genetic resources, with special reference to in-situ resources of federal lands, and ex-situ resources including seed banks and provenance trials.

The remainder of this report is concerned principally with those topics for which the author is directly responsible, namely western hemlock tree improvement, flower enhancement and source certification for seed exports. A separate report has been submitted by George Edwards, covering seed-oriented studies.

WESTERN HEMLOCK TREE IMPROVEMENT

This study was initiated in 1968 at the request of B.C. forest industries, in the absence of other programs for the species at that time. The study first focussed on provenance selection through the establishment in 1971 of a replicated test of western hemlock provenance from Vancouver Island. A number of subsidiary experiments and plantations were established later, including a clone test, a clone bank and reserve, a half-sib progeny trial, a breeding arboretum of other *Tsuga* species, and a series of flower-induction experiments.

In anticipation of a growing demand for genetically improved seed of this species, the British Columbia Forest Service has since established an operationally-oriented improvement program based on plus-tree selection and testing. Western hemlock tree improvement at PFRC has been reviewed and revised to complement this development. The revised program also reflects changes in staff at this Centre.

The provenance test forms the core of the revised study. The test comprises 15 provenances, planted out in a replicated test at four locations on Vancouver Island. Heights recorded in summer 1978 indicated strong site differences after 8 years growth, with Quatse Lake showing a three-fold increase over Gold River. Some site interaction was apparent from provenance means, although certain provenances have shown consistently fast (e.g. Sheringham Beach) or slow growth (e.g. Misery Creek). The experiment will be remeasured in spring 1981, 10 years after planting.

A pressing problem with this experiment is the influx of wild seedlings from surrounding native stands. The problem was assessed in spring 1979, and will be tackled with cleaning and labelling in 1980, prior to remeasurement the following year. Several flowering trees were noticed in 1979, and a survey for flowering precocity will be conducted during clean-up in 1980. This species does not normally flower regularly before the age of 20 years.

Outcrossing through controlled pollination of mature wild trees was conducted in Jordan River and Port Renfrew stands of hemlock in spring 1979. Cuttings were taken for a more detailed future study of outcrossing effects over distances from 5 to 50,000 m. Seed will be tested for germination and seedling vigour. A collection of outcrossed seed was assembled from the hemlock clone test established by Piesch at the Cobble Hill test site on Vancouver Island, and is undergoing analysis in a controlled-environment test.

The Tsuga breeding arboretum is being maintained, and efforts are being made to obtain seed of *T. chinensis* (Franchet) Pritzel, *T. dumosa* (D. Don) Eichler, *T. yunnanesis* (Franchet) Masters, and *T. forrestii* Downie from the Peoples' Republic of China. Growth acceleration techniques are being applied to increase size of slower growing species.

All other experiments and plantations established in this study, in particular the clone test and clone bank, are being retained for flower enhancement study or are to be eliminated where survival has been inadequate for experimental purposes.

FLOWER ENHANCEMENT

The success of initial experiments into the induction of flowering in rooted cuttings of western hemlock prompted establishment of a separate study identified as Improved Breeding Methods. Three experiments completed thus far indicate the most efficacious treatment to be spray or stem-injected applications of 100 ppm $GA_{4/7}$ during May-July, with calcium nitrate fertilizer and moisture stress both acting synergistically with gibberellins. Manuscripts describing these experiments are in preparation by Piesch and Ross.

While inherent sexual maturity undoubtedly contributed to the responsiveness of rooted cuttings, Holger Brix has recently stimulated flowering in 2- and 3-year old seedlings of western hemlock, with a combination of $GA_{4/7}$ and moisture stress. Research with seedlings is being pursued.

Factors requiring more attention include temperature, timing and methods of GA application and refinements on present prescriptions. Little is known about the carry-over effects of treatments (into following years of flowering), and enhancement of male flowering remains a problem.

Eleanor McMullan and George Puritch have obtained significant flower enhancement in Douglas-fir (*Pseudotsuga menzeisii* (Mirb.) Franco.) seed orchards with $GA_{4/7}$. Crude extracts from trees known to be abundant cone bearers have also enhanced flowering with notable increases in male flowers. However, good- and poor-flowering trees have yet to be distinguished by hormonal assays, and attempts to isolate active ingredients from crude extracts have not always been successful.

CERTIFICATION OF FOREST TREE SEED UNDER THE OECD SCHEME.

As Certifying Authority for the Pacific and Yukon Region of the Canadian Forestry Service, PFRC has certified all forest tree seed exported from Canada under a scheme developed by the Organization for Economic Cooperation and Development. An average of 22 seedlots have been certified each year since 1970, when the scheme began; many times that number of certificates have been issued, however, because seedlots are divided for the export market.

Currently, lodgepole pine (*Pinus contorta* var. *latifolia* Engelm.) is the most important species by weight and by value of seed exported. The demand for certification of collections of this species stems from large quantities imported by Sweden. While Canadian seed dealers have had many seedlots certified by choice, they are now able to sell only certified seed to this important market. In 1978, the Swedish government introduced legislation insisting on certification (by O.E.C.D. regulations) of all imported lodgepole seed. An interim measure was drawn up in cooperation with PFRC so that uncertified seed already in dealers' stocks could be sold, provided it had been inspected and documented by C.F.S. Seed Inspectors. Some 770 Kg from 24 different sources, and valued at about $250,000., were thus approved. Seed certified in the period April 1978 - March 1979 ammounted to 2334 Kg., and accounted for 157 certificates for 60 seedlots. Three official Seed Inspectors are now qualified for operations in the Pacific and Yukon Region.

While the O.E.C.D. Seed Certification Scheme is essentially a service performed by PFRC, it provides opportunities to collect valuable data and material for research and resource inventory:

i) seed inspectors conduct site and stand descriptions at collection sites for forest genetic resource inventory;
ii) seed inspectors collect cone and seed samples for in-house and external research needs;
iii) O.E.C.D. certification forms a data base for inventory of *ex-situ* forest genetic resources;
iv) O.E.C.D. certification provides a common platform for cooperation and scientific exchange with European and other forestry agencies.

As an example of iv), the author conducted a tour of northern B.C. and Yukon seed sources for Finnish and Swedish forest scientists. The excursion provided a better understanding of opportunities and problems in seed supply from the region, and has resulted in valuable exchange of information, particularly with regard to future seed demand from Sweden.

The quantities of seed collected for export form a significant proportion of seed utilized in this Region. For example, recent commercial collections of lodgepole pine totalled 465 Kg. (1976), 786 Kg. (1977) and 1373.6 Kg. (1978, exlcuding 770 Kg. approved uncertified seed). They compare strikingly with 72, 90 and 107 Kg. withdrawn from B.C. Forest Service seed store in the same years. In 1976, 1192 Kg. Douglas-fir were certified, compared to 523 Kg. used domestically. Overseas demand for species other than lodgepole pine has been erratic, but substantial.

The seed export trade from this Region thus represents a significant movement of forest genetic resources. It is in the interests of both Canadian and overseas forest agencies that this movement is properly conducted, monitored and recorded. Certification through the O.E.C.D. scheme provides the means for meeting this need.

RELATED ACTIVITIES

1. Rooting of Cuttings

Holger Brix has initiated research into the effect of crown position in the rooting of western hemlock cuttings. The effectiveness of rooting compounds and fungicides is being examined in several species. The B.C. Forest Service and various forest industries have been provided assistance in the rooting of cuttings of plus trees for the development of seed orchards.

2. Cone and seed insects

Research into sex pheromones of Douglas-fir cone moth and spruce seedworm has continued under Al Hedlin, and field tests in seed orchards are in progress.

3. Cone crop forecasting

Under the leadership of Dr. S.O. Eis, a cone-crop forecasting system is under development for the Region. Forecasting is based on samples taken at strategic points by CFS and BCFS rangers and forest industry staff. The first annual bulletin was published in 1977.

A manual for identification and interpretation of reproductive buds is in preparation.

4. Aerial cone rake

Two designs were built in 1977 and tested in 1978. The devices were suitable for special collections from otherwise inaccessible trees. Modification and retesting are scheduled for 1979; if results are unsatisfactory, further development may cease.

5. Inventory of forest genetic resources

A computerized information storage and retrieval system is under development for forest genetic resource inventory for the Region. In addition to O.E.C.D. certification and export records, the system will eventually include data banks on seed collection, seed testing (International Seed Testing Association), resources of federal lands (especially Indian Reserves), overseas (especially I.U.F.R.O. trials) representation, and cone crop forecasting. The system is intended to be fully interactive with forest insect and disease survey records, fire records, and other pertinent resource information.

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Pollard, D.F.W. and C.C. Ying. Variation in response to declining photoperiod among families and stands of white spruce in southeastern Ontario. Can. J. Forest. Res. (in press).

Puritch, G.S., E.E. McMullan, M. Meagher and C.S. Simmons. Hormonal enhancement of cone production in Douglas-fir grafts and seedlings. In press, Can. J. For. Res.

MACMILLAN BLOEDEL LIMITED
PROGRESS REPORT 1977-1979

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Keywords: seed orchards, progeny tests, provenance tests

MacMillan Bloedel Limited has been involved in several tree improvement-forest genetics activities during the period covered by this report. Establishment of clonal Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco var. menziesii) seed orchards continued at the Tree Improvement Center near Nanaimo. Two of the planned five Douglas-fir orchards are now essentially completed. The Company has become a member of the newly formed Coastal Tree Improvement Cooperative. Two western redcedar (Thuja plicata Donn), one western hemlock (Tsuga heterophylla (Raf.) Sarg.) and one amabilis fir (Abies amabilis (Dougl.) Forbes) orchard will be established by MacMillan Bloedel under the cooperative agreement. A 21 hectare farm has recently been purchased for the outplanting of these orchards. Tests with a variety of species have been established.

Western Hemlock

A study of the effects of varied competition from nearby trees on the selection of western hemlock plus tree candidates was completed and a report written (Thomas and Stevens 1977).

Western White Pine (Pinus monticola Dougl.)

A progeny test was established in 1972-1973 in cooperation with the U.S. Department of Agriculture, Intermountain Forest and Range Experiment Station project on blister rust resistant white pine. They provided F_2 seed from their F_1 resistant arboretum. Locally collected, apparently rust resistant material was used as control.

The plantation was assessed for survival, blister rust resistance and height growth in 1978. The area has been severely browsed by both deer and grouse and some trees are no taller than when planted. Results of the assessment are as follows.

Table 1. Results of 1978 Assessment of Western White Pine Progeny Test

	Planted November 1972		Planted May 1973	
	Control	F_2	Control	F_2
Number of trees	35	463	40	100
Survival (%)	70	92	100	99
Rust (%)	17	3	0	0
Ht $\bar{x}$ (cm)	48	53	62	65
Ht Range (cm)	16-99	10-125	16-138	26-128

Some white pine trees appear to be able to inactivate rust cankers in the branches before they can enter the stem. Isolated trees have been located on MB land which exhibit this phenomenon. Therefore, a project was initiated in 1978 with the following objectives:

- Continued observation of the selected trees to determine if the rust canker inactivation is permanent.

- To evaluate, under plantation conditions, the open-pollinated progeny of the selected trees for blister rust resistance and growth.

Test plantations were established at three locations in fall 1978. Mortality will be replaced in 1979 with the first survival and disease incidence assessments planned for fall 1980.

Noble Fir (Abies procera Rehd.)

Plantations were established in fall 1977 to test the potential value of Noble fir as a timber species on Vancouver Island. Five test sites were established. Six Noble fir provenances from Washington and Oregon were used. A randomized complete block design with 25-tree row plots was used. Four replications were planted at each test location.

Survival after one year was assessed in October 1978. Statistical analysis of the data showed highly significant (significant at the .01 level of probability) differences between provenances, between locations and the provenance x location interaction.

Species comparison tests were established in conjunction with the Noble fir provenance tests. Species additional to Noble fir were: amabilis fir, Douglas-fir, western hemlock, mountain hemlock (Tsuga mertensiana (Bong.) Carr.) and western larch (Larix occidentalis Nutt.). These tests were established as randomized complete blocks with 25-tree row plots and four replications at each site. Survivals were assessed at the same time as the provenance tests. Statistical analysis of this data showed highly significant differences between locations, between species and the species x location interaction.

Western Larch

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

Survival after one year was assessed in October 1978. Statistical analysis showed significant differences between locations but not between provenances. A slight provenance-by-location interaction was indicated.

Species comparison tests were established along with the provenance tests. Species included were western larch, Douglas-fir and lodgepole pine (Pinus contorta Dougl. var. contorta). A randomized complete block design with 16-tree row plots and two replications per site was used for this test. These tests were assessed at the same time as the provenance tests. Statistical analysis showed highly significant differences between species, between locations and the species location interaction.

PUBLICATIONS AND REFERENCES

Thomas, C.A. and R.D. Stevens. 1977. The influence of competition from nearby trees on the selection of western hemlock plus trees. Final report, contract No. OSS7-02040, Science Sector, Science Procurement Branch, Supply and Services Branch, Canada. 62 p.

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

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Key words: forest genetics, education, WFGA meeting, IUFRO meeting

UNDERGRADUATE PROGRAM

Forest genetics as an elective one term course for undergraduate students has been offered at U.B.C. since 1950, as Biol. 331, For. 352 and presently as For. 302.

During these 29 years, approximately 630 students have been exposed to forest genetics principles, and student enrollment has fluctuated as follows during the last five years: 19, 30, 15, 10 and 18. Besides this course, each undergraduate student has also been exposed to topics of basic genetics in Dendrology (For. 111), and to tree improvement principles, methods and results in Silviculture (For. 304).

GRADUATE AND RESEARCH PROGRAM

Graduate programs concentrate on research related to variation and heritabilities of western conifers. Ph.D., M.Sc. and M.F. programs are offered in close co-operation with other faculties. The following persons have already graduated or are in residence at the various programs.

Ph.D.

Orr-Ewing. 1956. An investigation into the effects of self-pollination on *Pseudotsuga menziesii* (Mirb.) Franco. 110 pp.

Tusko. 1963. A study of variability in certain Douglas-fir populations in British Columbia. 173 pp.

Sziklai. 1964. Variation and inheritance of some physiological and morphological traits in *Pseudotsuga menziesii* (Mirb.) Franco var. *menziesii*. 126 pp.

Roche. 1967. Geographic variation in *Picea glauca* in British Columbia. 207 pp.

El-Lakany. 1969. Studies on the effects of ionizing radiation on some western coniferous species. 250 pp.

Ho. 1972. Studies on pollen of selected species in *Pinaceae*. 159 pp.

Falkenhagen. 1974. A study of the phenotypic and genotypic variation of 545 single tree progenies of the 1970 IUFRO Sitka spruce collection. 235 pp.

Meagher. 1976. Studies of variation in hemlock (*Tsuga*) populations and individuals from southern British Columbia. 381 pp.

In Residence

El-Kassaby. Isozyme patterns of spectral Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) populations.

M.Sc.

Ho. 1968. Some observations on germination of *Pseudotsuga menziesii* (Mirb.) Franco pollen *in vitro*. 66 pp.

De-Vescovi. 1974. Comparative karyotype analysis of four Douglas-fir provenances. 43 pp.

Bartram. 1977. Early results of the Douglas-fir co-operative progeny test. 74 pp.

M.F.

Bolotin. 1958. Polyploidy and its application in forestry and a preliminary study of aberrant Douglas-fir seedlings. 55 pp.

Wang. 1960. The effects of stratification and incubation temperature on the germination of grand fir seed. 110 pp.

Sziklai. 1961. A program for improvement of basket willow on the Carpathian Plains of Hungary. 75 pp.

Roche. 1962. Geographic variation in lodgepole pine and its role in the genetic improvement of caostal form. 98 pp.

Addison. 1966. Some factors affecting the survival of planted Douglas-fir seedlings in the coastal forests of British Columbia. 136 pp.

Reuter. 1971. Some problems in testing provenance with special reference to the co-operative Douglas-fir provenance test at the University of B.C. Research Forest. 93 pp.

Yao. 1971. Geographic variation in seed weights, some cone measurements and seed germination of Douglas-fir. 88 pp.

Berney. 1972. Studies on the probable origin of some European Douglas-fir plantations. 99 pp.

Galloway. 1978. Tissue culture development and future use in forestry. 92 pp.

Fashler. 1979. Intraspecific variation in non-selected natural populations of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco).

In Residence

Nelson. Variation in gross stem volume/crown surface area of western hemlock (*Tsuga heterophylla* (Rab.) Sarg.).

OTHER ACTIVITIES

During the last two years we were actively involved in the organization of the Western Forest Genetics Association (WFGA) Annual Meeting and the IUFRO Provenance Working Parties Meeting at U.B.C., Vancouver, in 1978. The WFGA Meeting was held from August 16-18 and 111 persons attended. This meeting was followed by the IUFRO Working Parties Meeting which was held from August 21 to September 9, 1978. During the first week eight working parties (S2.02-05, Douglas-fir provenances; S2.02-06, Contorta pine provenances; S2.02-12, Sitka spruce provenances; S2.02-14, Abies provenances; S2.04-01, Population and Ecological Genetics; S2.04-02, Breeding Theory; S2.04-03, Progeny Testing; S2.04-05, Biochemical Genetics and Cytogenetics) held their technical meeting. This was followed by a one-week field trip to Vancouver Island (August 26 - September 3), and two post-congress tours (September 4-9), to Queen Charlotte Island and Washington/Oregon.

A total of 121 persons participated in this meeting--32 from Europe, 42 from U.S.A., and 47 from Canada. The four Provenance Working Parties were especially prolific. The Douglas-fir Working Party presented 19 papers: lodgepole pine, 15; Sitka spruce, 12; Abies, 6. All of them dealt with the up-to-date results of provenances planted under their environmental conditions. Eleven introductory papers dealt with: environmental characteristics of western North America; distribution, genetics and silvical characteristics of the four major species; seed procurement of North America; and the implementation of results of provenance research. The total number of pages of the 63 papers is close to 800 pages, and the proceedings are presently in the process of being edited. It is expected to be printed by the fall.

The field tours included the four western North American species, and allowed the participants the opportunity to study these species in their native habitat.

The S2.04-01, -02, -03, and -05 Working Parties and the North American Quantitative Forest Genetics Group held their meetings on August 25th.

It was a challenging and enjoyable experience, renewing acquaintenances and exchanging ideas with the members of the Working Parties. Even the weather co-operated as much as can be expected in the Pacific Northwest.

During July 23 - August 11 a group of 24 forestry-oriented persons had a chance to travel to Peking, Changchun, Shanghai and Canton. We had the opportunity to meet our counterparts at the Academie of Science at Peking, at Nanking University and at two Research Forests. We had thorough discussions on forestry education and forest research, especially related to tree breeding.

In connection with the Exchange Program of NSERC, I had an opportunity to study the Japanese tree improvement program from September 16 - October 15, 1978.

Presently, I am working with Professor Tompa (Sopron, Hungary) on a forest genetics textbook. This book will be published in Hungarian, and attempts to bring together the east and west experiences in the field.

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Nelson, G.L. & O. Sziklai. 1979. Variation in crown morphology of western hemlock. Abstract. Northwest Science, March 29-31, 1979.

Smith, J.H.G. & O. Sziklai. 1979. Present and potential energy yield of major tree species in B.C. NWS, Abstract, March 29-31, 1979.

Fashler, A.M.K. & O. Sziklai. 1979. Further studies of the intraspecific variation in Douglas-fir. Abstract, NWS, March 29-31, 1979.

PROCEEDINGS, PART 2

SYMPOSIUM:

TREE IMPROVEMENT IN THE BOREAL FOREST: TODAY AND TOMORROW

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Gander, Newfoundland, August 1979

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