

Fourth Edition

Welcome to the fourth edition of *TICtalk*, the periodic newsletter of British Columbia's Forest Genetics Council (FGC).

The forest sector, like agriculture and medicine, is under pressure from a range of publics regarding the use of biotechnology, and genetic engineering in particular. Given the sensitivity of these issues, and the level of misunderstanding about current applications of these technologies in British Columbia, we feel that members of our own community need accurate information.

As a result, this issue of *TICtalk* contains five articles that discuss potential applications/ aspects of biotechnology in tree breeding and the production of reforestation materials. Three clear messages emerge:

- British Columbia Crown land reforestation programs do not use genetically modified organisms. Seed orchard trees are bred from selected wild-stand trees that express naturally superior growth and resistance characteristics.
- British Columbia is approaching the use of biotechnology cautiously. Current research focuses on improving understanding of where biotechnology can augment traditional tree improvement activities, and the implications of these applications.
- Significant technical, ethical, and regulatory challenges must be overcome before genetically engineered trees could be used for operational reforestation.

Other features to look for in this issue:

- an overview of Council's first Annual Report
- profiles of the NSERC/Industrial Research Chair and newly established Centre for Forest Gene Conservation at the University of B.C.
- an introduction to the new Alberta Forest Genetics Resource Council
- tree improvement, biotechnology terms
- where to find superior provenance lodgepole pine
- tree improvement activities of the international Food and Agriculture Organization.

Enjoy!



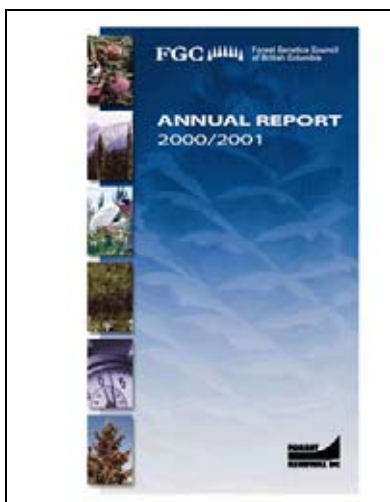
For more information on the Council and its activities, see www.fgcouncil.bc.ca

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FGC Annual Report 2000/01

In June 2001, the FGC produced its first annual report, describing progress on work outlined in the FGC Business Plan 2000/2001. Most of this work is funded through the Forest Renewal BC Tree Improvement Program, which takes direction from Council's strategic and annual business plans. This article presents an overview of the FGC Annual Report 2000/01.



Council's four technical advisory committees (TACs) lay the groundwork for the annual FGC Business Plan.

The Gene Conservation TAC (GCTAC) advises Council on issues and activities related to gene conservation and genetic diversity.

The Coastal and Interior TACs, through their Species Committees, prepare Species Plans that estimate seed demand, production capacity, and genetic gain for each of the 42 seed planning units (SPUs) in the provincial forest gene resource management program.

The Extension TAC (ETAC) advises Council on extension and communication activities. Each TAC identifies subprogram priorities and evaluates proposals for funding.

Council reviews all strategies, plans, or recommendations from the TACs or other agencies for approval (or revision) before incorporating them into the FGC Business Plan.

Forest Renewal BC Tree Improvement Program

The Forest Renewal BC Tree Improvement Program (TIP) seeks to increase the growth rate, wood quality, and pest resistance of seedlings, and to preserve the genetic diversity of tree species across the province.

Through its TIP, Forest Renewal BC invests in forest gene resource management activities that support its objectives and are incremental to existing government and industry activities.

TIP activities are organized into seven subprograms that correspond to those in the FGC Business Plan (see figure and table).

Performance monitoring and reporting are carried out for each subprogram.

Copies of the FGC Annual Report 2000/01 can be obtained from the FGC Secretariat.

Forest Gene Resource Management

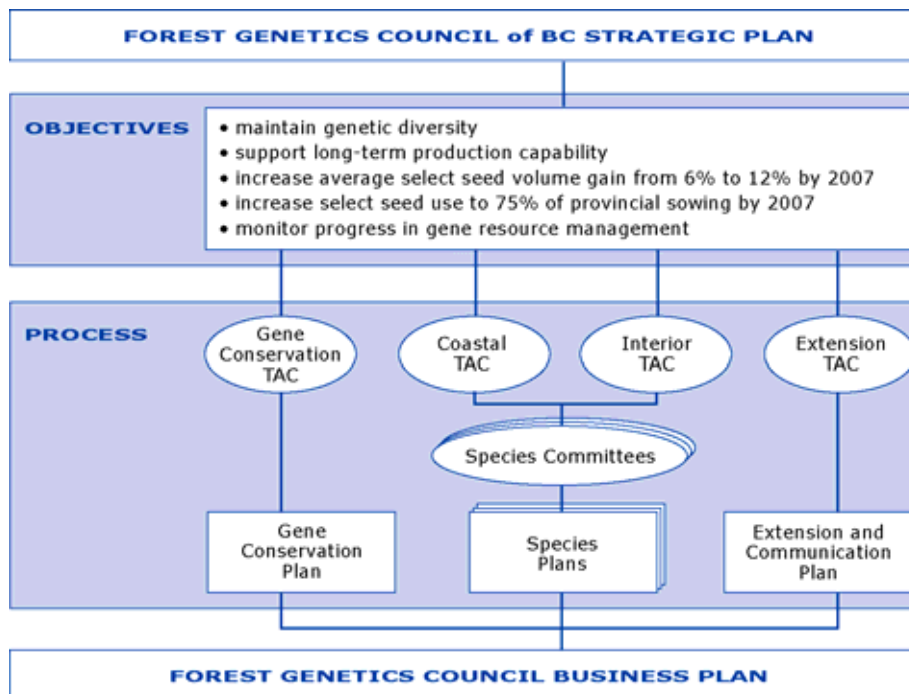
The FGC coordinates a provincial forest gene resource management program that is implemented by stakeholders in the forest industry, Ministry of Forests (MOF), Canadian Forest Service (CFS), and universities.

Forest Renewal BC is the major funding agency for forest gene resource management. Industry, MOF, and university cooperators contribute substantial in-kind, staff, and other resources.

Business Planning

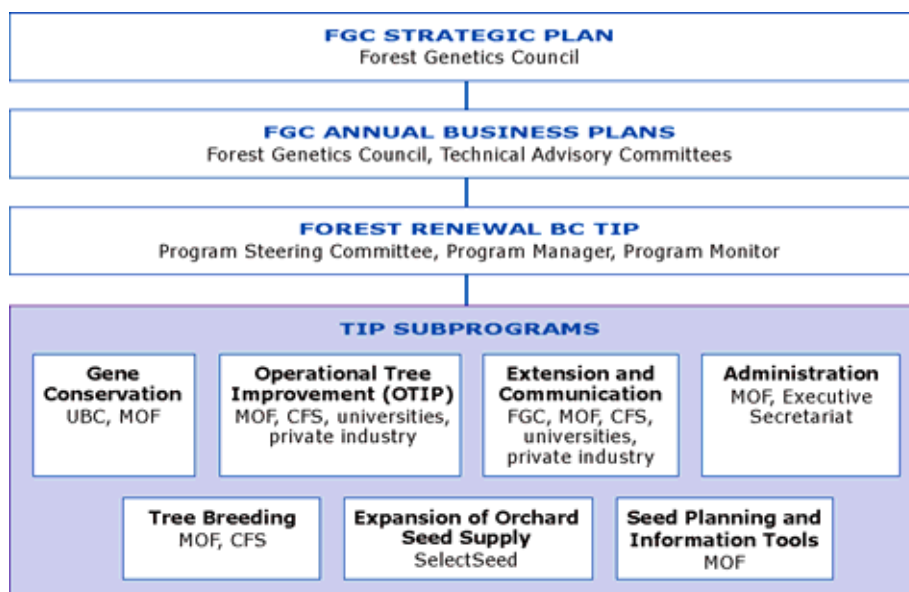
The Council provides a forum for stakeholder representatives to set goals and objectives, and to oversee the development and delivery of business plans to fulfill them (see figure).

The link between FGC objectives, planning processes, and the FGC Business Plan.



Council's Technical Advisory Committees lay the groundwork for the annual FGC Business Plan.

Relationship between FGC strategic and annual business plans, and Forest Renewal BC TIP; participants in various forest gene resource management activities.



Forest gene resource management—the conservation, controlled use, and enhancement of genetic resources of forest tree species—is a cooperative effort in British Columbia.

TIP subprogram descriptions.

Subprogram	Description
Gene Conservation	Protects the gene pool needed for species to adapt to future environmental conditions and ensure that genetic resources are maintained for future generations.
Tree Breeding	Focuses on the continued improvement of seed and vegetative materials for reforestation. Activities include selecting parents in wild stands, propagating, testing offspring, mating, establishing/maintaining/measuring trials, and delivering technical support.
Operational Tree Improvement (OTIP)	Supports the FGC objectives to increase the quality and quantity of Class A seed produced from existing forest company and MOF seed orchards. Provides technical support for orchard production and management.
Expansion of Orchard Seed Supply	Through SelectSeed Ltd., supports needed seed orchard expansions and the cooperative production of vegetative materials to meet FGC objectives. Also provides program management services to FGC.
Extension and Communication	Provides technical information and training to seed users and tree improvement specialists. Develops and disseminates information on the provincial forest gene resource management program to all FGC target audiences. Supports the education (and continuing education) of tree improvement specialists and technologists.
Seed Planning and Information Tools	Supports development of computer-based information systems that improve user access to information on reforestation materials for planning and deployment.
Administration	Includes the administrative infrastructure provided by the MOF for FGC subprograms and the FGC Executive Secretariat that supports Council's strategic and business planning, and day-to-day activities.

Funding

Forest Renewal BC funds forest gene resource management activities identified in the FGC Business Plan through contribution agreements with the University of British Columbia, Ministry of Forests, and SelectSeed Ltd.

TIP annual budgets are based on recommendations from the FGC Business Plan, subject to Forest Renewal BC budgeting processes and approvals.

In 2000/01, Forest Renewal BC provided over \$9 million support to the FGC Business Plan.

Summary of Forest Renewal BC TIP subprogram budgets, expenditures for April 1, 2000 through March 31, 2001.

Subprogram	Budget (\$)	Expenditures (\$)
Gene Conservation	183 700	183 700
Tree Breeding	2 350 000	2 238 283
Operational Tree Improvement (OTIP)	1 545 000	1 426 892
Expansion of Orchard Seed Supply (SelectSeed Ltd.)	4 766 300 ^a	368 031
Extension and Communication	170 000	108 083
Seed Planning and Information Tools	275 000	274 966
Administration	365 000	363 849
Forest Renewal BC TIP Contribution ^b	\$9 655 000	\$4 963 804

^a Approximately \$4 400 000 was placed in a long-term fund to support orchard development.

^b Excludes FRBC administration costs.

SelectSeed Company Update

submitted by Jack Woods

SelectSeed Company Ltd. ("SelectSeed") is a mechanism for Forest Renewal BC to invest in seed orchards in a way that is responsive to needs identified in the FGC Business Plan, and supports seed market development.

A board of directors elected through the FGC controls SelectSeed. Orchard investments will be made as business investments to meet identified orchard expansion needs, and generate cash flow through future seed sales. SelectSeed will become financially self-sufficient, and give the FGC another mechanism for program financing and delivery.

SelectSeed also coordinates program management on behalf of the FGC.

2000/01 Activities

SelectSeed activities in 2000/01 included:

- hiring a staff person
- establishing corporate structure, accounting, and financial systems

- developing contract procedures and documents
- developing a SelectSeed Business Plan
- propagating (10 300) and holding (13 100) ramets for orchard development
- FGC program planning, budgeting, and management
- reporting to Forest Renewal BC and the FGC on all tree improvement initiatives.

2001/02 Orchard Development Work

Eleven new seed orchards or orchard expansions identified in the FGC Business Plan will be undertaken in 2001/02 (see table). Planting will proceed in four orchards, and site preparation work will be done in the remaining orchards.

Propagation and holding of stock for orchard expansions will be carried out on contract—approximately 14 300 grafts will be made, and an additional 12 000 grafted ramets will be maintained in holding beds.

SelectSeed was formerly known as GenSeed.

Company activities involve the production of seed or rooted cuttings using trees selected from natural stands.

SelectSeed is not involved in genetic engineering or the use of genetically modified organisms.

SelectSeed orchard development activities for 2001/02.

Seed planning unit				2001/02 planting	Final orchard size
SPU #	Species	SPZ	Elev. band (m)	(ramets)	(ramets)
7	Pli	NE low	< 1400	0	1 579
10	Pli	TO low	< 1400	0	3 229
12	Pli	PG low	< 1200	0	5 077
16	Pli	TO high	> 1400	0	4 957
17	Pli	BV low	< 1200	0	6 973
18	Pli	CP low	< 900 N of 56 < 1100 S of 56	0	3 978
21	Fd	NE low	< 1000	700	2 200
28	Sx	TO high	1300–1850	1 049	1 049
30	Sx	TO low	< 1300	454	454
37	Fd	QL	< 1200	0	975
41	Fd	PG	< 1000	790	786
Totals				2 993	31 257

FGC Extension

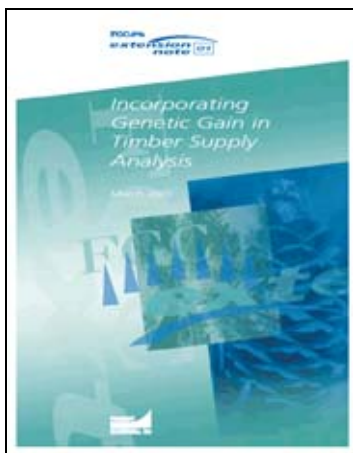
Extension activities received a great boost in 2000/01, thanks to the efforts of Council's Extension Technical Advisory Committee (ETAC). In its March 2000 strategy, ETAC identified tree improvement specialists, decision-makers, and users of improved reforestation materials as key audiences for the fiscal year, and funded several activities to meet their needs. The following overview testifies to the energy and creativity of many cooperators involved in developing and delivering extension materials and events. More information on each of these items can be found on the FGC Web site:

www.fgcouncil.bc.ca

Extension Notes

ETAC commissioned preparation of the first Extension Notes to be published by the FGC.

Incorporating Genetic Gain in Timber Supply Analysis, explains genetic gain, how it affects timber supply, and how it is modelled in timber supply analysis. The discussion draws on examples from a recent study of timber supply in the Arrow Timber Supply Area (TSA), in Nelson Forest Region.



Biotechnology: Potential Applications in Tree Improvement, introduces the tree improvement cycle (breeding and orchards), identifies where biotechnology offers a tool to enhance breeding and production of improved reforestation materials, explains the difference between traditional tree

breeding and genetic engineering, and identifies concerns and regulations related to genetic engineering. [Editor's note: see article on page 14.]

These extension notes are available in colour hardcopy, on request from the FGC Secretariat, or as downloadable PDFs from the FGC Web site.

Workshops

Building on the success of the pilot workshop in March 2000, the Ministry of Forests Tree Improvement Branch Extension Services hosted two 1-day *Seed Planning, Policy, and Programs* workshops in 2001. Over 100 people, representing MOF regions and districts, consultants, and forest licensees participated. These workshops highlighted provincial issues of gene conservation, genetic diversity, and genetic worth, and included a presentation on the impact of the current and planned seed orchard program in Nelson Region on timber flow in the Arrow TSA.

MOF Extension Services also held a 2-day workshop on lodgepole pine pollen management. Topics included the role of pollen in seed orchard production; equipment and procedures for storing, testing, and applying pollen; and recommendations for incorporating pollen testing in both breeding and orchard programs. Some 30 people attended.

TI Publications Database

To help guide its decisions on extension and communication priorities, ETAC funded a classification and assessment of existing tree improvement publications. The project classified some 60 publications according to type, scope, and other descriptors; assessed the publications for relevance to FGC audiences and extension and communication goals, and the currency and sensitivity of content; and recommended priorities for ETAC consideration in ranking its audiences and goals for fiscal year 2001/02.

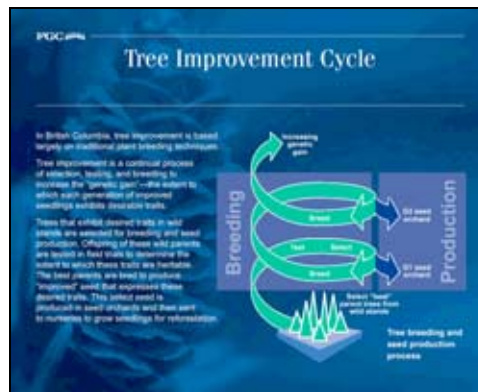
FGC cooperators completed six extension and four communication projects in 2000/01.

Journal Article

A journal article on *Biotechnology: Potential Applications in Tree Improvement* was produced for submission to the Forestry Chronicle. The target audience is foresters and other resource professionals with no special training in tree improvement. The article is intended to clarify the difference between traditional tree breeding and genetic engineering, to indicate where opportunities exist for biotechnology to enhance tree breeding and seed production, and to clarify the current use of biotechnology in research and reforestation programs in British Columbia and Canada.

Display Panels

Two new panels on tree improvement and biotechnology were produced for the FGC display. All panels can be viewed by clicking on any of the blinking photos on the FGC Web site home page.



The FGC display unit is available for workshops and meetings, on request from the FGC Secretariat.

Southeastern U.S. Tree Improvement Tour

From November 6 to 12, 2000, ten people affiliated with the Forest Genetics Council of B.C. joined members of the North West Tree Improvement Co-op (NWTIC) from Washington and Oregon, and the Director of the Inland Empire Tree Improvement Co-op (IETIC), on a tour of industrial forest land and tree improvement facilities in Georgia.¹ The group visited seed orchards, operational plantations, progeny tests, nurseries, and various research trials. Participants also attended the annual meeting of the Cooperative Forest Genetic Research Program (CFGRP—University of Florida based tree improvement co-op), where seven North American tree improvement co-ops were represented.

The tour gave a first-class overview of industrial forestry and tree improvement in the southeastern United States and illustrated the value of cooperation in tree improvement and forest genetics activities.

In the southeastern U.S., the co-ops are organized through universities, but are focused on industrial private lands. The co-ops are funded through university and industry contributions. Financial incentives of increased productivity have maintained a high level of corporate interest for several decades. Interestingly, most of the co-ops operate through informal, rather than contractual agreements.

Some insights from participants included:

- The integration of expertise in universities, industry, and government in tree improvement cooperatives has led to large gains in productivity, value, and health in over 1.5 billion trees planted annually in the region. Planting stock is mostly 1-year-old bareroot seedlings from first- or second-generation seed orchards of loblolly pine (*Pinus taeda*) and slash pine (*Pinus elliottii*).
- Co-ops breeding loblolly and slash pines use a complementary mating design, with polymix mating for general

The tour included industrial forest land and tree improvement facilities in Georgia, and the annual meeting of the Cooperative Forest Genetic Research Program.

¹ Forest Renewal BC partially funded the participation of B.C. participants.

The integration of expertise in universities, industry, and government has achieved large gains in productivity, value, and health in over 1.5 billion trees planted annually.

combining ability (GCA) tests, and full-sib crosses within sublines for selection of a new breeding population. All programs have moved from the use of row-plots to either single-tree or non-contiguous plots with about 30–40 trees per family per test site.

Progeny testing is simple relative to B.C. conditions. Operational silviculture normally prepares sites to a farm-field condition. Several herbicide and fertilization treatments before age 4 or 5 keep trees free-growing. Sites are fully occupied within 3–4 years. Final test measurements are taken at full crown closure (about age 5) or at age 8, which is about 1/4 to 1/3 of the 20- to 25-year rotation age.

- The group heard about a deployment strategy in which all the trees planted in a cutblock are from a single half-sib family. Genetic diversity within the management unit (several thousand acres) is maintained by controlling how often the high-yield family is used — i.e., once every 4–6 years.
- In Georgia, non-orchard pollen can contaminate 30–80% of orchard seed. Controlled mass pollination (CMP) is used to control which pollen is applied to the female cones of a selected parent, to ensure the identity of the breeding pair is known and to produce high quality seed for planting. Currently, companies can only meet 1–2% of their total planting needs with CMP seed. Projects are underway to bulk the high-gain CMP seed by planting it as donor stock for rooted cuttings. Some companies are involved in research to develop somatic embryogenesis (SE), and are in field-testing stages with this type of material.
- Top grafting—making grafts on large trees rather than seedling rootstock—has been used to speed up breeding by creating grafts that produce flowers earlier. Orchard trees are grafted at

heights of 2–8 m using bucket lifts to reach the crown. Since the orchard trees are grafts themselves, each tree becomes a composite of genotypes: the original rootstock, the “interstock” (the original orchard graft), and one or more top grafts. Often, several different parent clones are grafted onto a single tree. Graft survival is 50–75% when using young material for scions. Weyerhaeuser’s Lyons Seed Orchard in Georgia is testing top grafting to upgrade existing orchards by replacing undesirable clones with better ones.

A loblolly pine top-graft at the Weyerhaeuser seed orchard facility near Lyons, Georgia. Photo: C. Walsh



A report on the tour activities can be downloaded from the FGC Web site: www.fgcouncil.bc.ca

Upcoming Events

Vernon will host the next Forest Nursery Association of B.C. AGM from September 24 to 26, 2001. For information on this meeting, contact 2001 President, Stewart Haywood-Farmer.

Centre for Forest Gene Conservation at UBC

submitted by Sally Aitken

Gene conservation is the maintenance of genetic diversity found in natural populations to provide raw material for the adaptation of species to future environmental conditions and genetic resources for the use of future generations.

The Centre for Forest Gene Conservation (CFGC) has been established in the University of B.C. Department of Forest Sciences with funding from Forest Renewal BC and the Forest Genetics Council of B.C.

The CFGC will bring together expertise on forest genetics and conservation to explore issues in gene conservation, develop conservation strategies, evaluate needed versus current levels of protection of genetic diversity, and carry out fundamental research on genetic diversity in native species. The Centre will also advise the FGC on specific matters relating to the conservation of genetic diversity in British Columbia's forests.

CFGC projects underway include developing a forest gene conservation

strategy and framework for B.C., investigating genetic diversity and degree of inbreeding in whitebark pine, and developing sampling strategies for conservation of rare alleles.

Projects to be started in the coming year:

- updating the 1996 inventory of degree of *in situ* protection of conifer species to reflect additional protected areas in B.C.
- initiating an inventory of protection of hardwoods
- exploring genetic issues in forest products certification globally and locally
- developing a genetic marker-based method for monitoring and managing relatedness in breeding populations
- investigating genetic diversity in minor tree species not previously studied.

For more information, contact Dr. Aitken, CFGC Director.

Gene conservation is the maintenance of genetic diversity found in natural populations.

My Experience as NSERC Research Chair

submitted by Kermit Ritland

For the past five years, I have held, along with Dr. Sally Aitken, an NSERC/Industrial Research Chair at the University of British Columbia. This position has allowed me to collaborate with people in government and industry on projects spanning gene conservation, tree breeding, and seed orchard genetics. Because a geneticist can work with anything containing DNA, my studies have involved both animals (bears, frogs, shrews) and plants (mainly commercially important conifer species).

I consider establishment of the UBC Genetic Data Centre (GDC), funded by a Canadian Foundation for Innovation grant, as my most

significant achievement. This facility provides space, equipment, and the knowledge base for collecting and analyzing molecular genetic data in forestry, agriculture, and biology. The GDC has helped my research, as well as that of others.

Some examples of my research illustrate how molecular techniques combined with statistical models can assist in current tree improvement activities.

Production of orchard seed often involves supplemental mass pollination (SMP). The efficiency of SMP to reduce pollen contamination and selfing can be measured

My research illustrates how molecular techniques combined with statistical models can assist tree improvement activities.

This position allows me to collaborate with government and industry on projects in gene conservation, tree breeding, and seed orchard genetics.

with genetic markers (variable pieces of DNA) which we assay for in the GDC. In one study at the Vernon Seed Orchard Company (VSOC) spruce seed orchard 214, isozyme markers showed that 75–85% of seed was successfully pollinated via SMP as opposed to background pollen. Isozymes are enzymes that differ in electric charge and are easy to assay, but may not confer enough genetic information.

Another study at the Lost Lake western redcedar seed orchard recently found that SMP reduced self-fertilized seed from 25 to 5%. Pollen blowing was found to not decrease selfing at all. Redcedar has essentially no isozyme variation, so we developed microsatellite markers for the species. Microsatellites are highly variable genetic markers characterized by differences in the number of simple repeats within a certain region of DNA.

In yellow-cedar, a recent range-wide isozyme survey revealed striking regional

differentiation, which either reflects multiple glacial refugia or regional adaptive differences. For more detail and for estimating clonality in natural stands, we are developing microsatellite markers for yellow-cedar.

We are also developing microsatellites to characterize diversity in the breeding populations of western hemlock. This research is one of the projects of the Centre for Forest Gene Conservation, recently organized by Dr. Sally Aitken.

I am also interested in statistical issues underlying inferences such as those listed above. For example, I will be looking at more efficient ways to assay for seed quality (SMP, selfing, paternal imbalance) via the bulking of seed before DNA assays. I have also been developing methods for estimating selfing rates, migration, and phylogeny.

I invite you to contact me with ideas about how my research may benefit your operations.

On the move...

John Pollack

Council is sincerely grateful to Mr. Pollack for his two years of service to the tree improvement community. We benefited greatly from the enthusiasm and intelligent perspective he brought to Council meetings. John is the Forest Sciences and Strategic Issues Manager with MOF, Nelson Forest Region. He is currently working on the mitigation of reduction to the region's AAC.

John Owens, PhD

Dr. Owens retires from the Centre for Forest Biology, University of Victoria in July 2001. He commented that he's been "practising" for this change during the last year with a sabbatical spent researching pine and teak trees in Thailand. He will be writing on reproductive biology of forest trees and hopes to continue some research on conifers in his new role as UVic professor emeritus.

Brian Barber, RPF

In January 2001, after three years with MOF Resource and Tenures Branch, Brian rejoined the Tree Improvement Branch as a Technical Advisor. He is working on strategic issues on behalf of the branch and the tree improvement community.

Greg O'Neill, RPF, PhD

In April 2001, Dr. O'Neill joined the Kalamalka Research Station, where he will be working with interior spruce and lodgepole pine.

Alvin Yanchuk, Ministry of Forests

Alvin has recently returned to his position as Manager, Forest Genetics Section, MOF Research Branch, after an intensive six months working on forest genetic resource management projects with the FAO in Rome.

Alberta Forest Genetics Resource Council Up and Running

submitted by Cliff Smith

The Alberta Forest Genetics Resource Council (AFGRC), formed in the spring of 2000, advises the provincial Minister of Environment and the forestry community on policy and regulation related to managing the gene resources of Alberta's forests.

The Council's goal is to establish a solid foundation for managing forest genetic resources including the operational delivery of tree improvement programs in the context of sustainable forest management. The goal focuses on four themes: genetic gain, adaptation, genetic diversity, and conservation.

The 13-member Council includes scientific experts, policy makers, and practitioners from the scientific community, forest industry, biological sector, and provincial government. The scientific community has two members from the University of Alberta and one from the Canadian Forest Service. The forest industry has five representatives—four from member companies of the Alberta Forest Products Association (AFPA) (three coniferous and one hardwood) and one non-AFPA member. The government of Alberta has four representatives: three from Lands and Forests Services and a wildlife biologist from Natural Resource Services. C.B. (Cliff) Smith, a former Alberta Deputy Minister of Forestry, chairs the AFGRC and provides secretariat services.

More than 22 tree improvement programs, involving six native conifer and two native deciduous species, are active in Alberta. Several non-native species are under consideration, either as pure or as parents in hybrid programs. Non-native tree species programs are presently targeted to private land forestry. Most programs are being developed through cooperative arrangements, either among companies or between the government and single or multiple companies.

Over the past 25 years, the province has successfully established and led a strong program in forest genetics and tree improvement. Scientists at Alberta's universities and research institutions have completed many leading-edge research initiatives in forest genetics. In the past decade, however, tree improvement programs have shifted to the private sector through industry-led programs involving individual companies and/or industry or government/industry cooperatives. While maintaining a smaller role in operational tree improvement, the province will take on more of a policy and regulatory role, particularly in deployment. It will continue its primary responsibility in the conservation of forest gene resources.

Given the increasing number of players in tree improvement programs, the creation of AFGRC is most timely to ensure strong coordination, cooperation, and communication. Since its inaugural meeting in April 2000, the Council has tackled several issues, many of which are ongoing:

- a status report on genetic tree improvement in Alberta
- a policy framework for deployment of genetically improved stock onto public lands
- status and strategy papers on conservation of forest gene resources
- a position paper on genetically modified organisms (GMOs) and GMO trees
- benchmarking of genetic resources of forest trees.

The Alberta government has funded the operation of the Council to date. For more information, contact Cliff Smith or check the AFGRC website at

<http://www.gov.ab.ca/env/forests/fmd/genetics/index.html>

The AFGRC represents a productive partnership of government, industry, and the scientific community to manage Alberta's forest genetic resources.

TICtalk Terms

The following terms are used throughout this issue. "Select seed" is highlighted to ensure that the tree improvement community is aware of the recent expansion of the term to include superior provenance B+ seed as well as seed orchard Class A seed.

"Select" is used to describe seed and vegetative material having a level of genetic gain (GW>0).

This includes seed and vegetative lots from seed orchards (Class A) and superior provenance (Class B+) sources.

Select Seed

In July 2000, the capture of genetic gain was expanded to include not only seed and vegetative material produced from orchards and production facilities, but also seed identified as superior provenances from natural stands. Based on results from a superior provenance review undertaken by MOF Research Branch, all superior provenances (with the exception of Sitka spruce) were assigned a Genetic Worth for growth (GW-G). This new information was released as a Seed and Vegetative Material Guidebook update in September 18, 2000 (Guidebook Update #5). At that time, all interior spruce (Sx) and interior lodgepole pine (Pli) superior provenance seed lots registered on the Seed Planning and Registry system (SPAR) were assigned a Genetic Worth (GW).

With the implementation of this expanded genetic gain definition now complete, a need has arisen to distinguish those lots with a GW from those lots in which no GW is assigned. Two new terms are now being used within the tree improvement program to make this distinction: "select" and "standard."

"Select" is used to describe seed and vegetative material having a level of genetic gain (GW>0). "Standard" is used to describe seed and vegetative material with no known level of genetic gain (no GW is assigned).

Thus, all seed and vegetative lots derived from orchards and production facilities (genetic Class A) and superior provenances (genetic Class B+) are now considered *select seed sources*. All seed and vegetative lots derived from natural stand sources and not identified as superior provenances (genetic Class B) are now considered *standard seed sources*.

It is anticipated that the use of these new terms—select and standard—will help clients to clearly identify those seed sources having the best genetic quality for the purposes of meeting their silviculture obligations specified within the Silviculture Practices Regulation under the *Forest Practices Code of British Columbia Act*. Over the next couple of years you can also expect to see more frequent use of these terms as report selection filters for querying seed inventories and seed use summaries on the ministry's new SPAR Web and SeedMap applications.

Other tree improvement terms can be found in the following electronic glossaries:

Forest Genetics Council
<http://www.fgcouncil.bc.ca/>

Canadian Forest Service
http://www.nrcan-rncan.gc.ca/cfs-sc/science/prodserve/glossary_e.html

or in relevant Ministry of Forests regulations, policies, and guidebooks
<http://www.for.gov.bc.ca/tip/publications/pubs.htm>

Family	The term “family” refers to a group of seedlings for which one or both parents are known. When only the female parent is known, it is called a “half-sib” family; when both parents are known, it is a “full-sib” family.
Genetic Class A	Seed and vegetative material derived from orchards and production facilities. Generally, seed and vegetative lots registered as Class A have a Genetic Worth greater than ‘zero’.
Genetic Class B+	Seed and vegetative material derived from natural stands and identified as superior provenances. Generally, seed and vegetative lots registered as Class B+ have a Genetic Worth greater than ‘zero’.
Genetic Class B	Seed and vegetative material derived from natural stands. Seed and vegetative lots registered as Class B are not assigned a Genetic Worth.
Genetic engineering (GE)	Inserting, suppressing, or removing genetic material from a tree.
Genetic markers	Similar sequences of DNA that occur within certain tree families or that are associated with certain traits.
Gene map	A “map” of an organism’s genome, identifying and locating all its DNA sequences (genes).
Genetically modified organism (GMO)	Organisms that result from the introduction, removal, or suppression of genes using DNA manipulation technology.
Genetic worth (GW)	A measure of the genetic quality of a seed or vegetative lot over wild stand material, measured for a specific trait (i.e., growth, wood density, pest resistance).
Genome	All the genes of a living organism.
Genomics	The activity of determining the DNA sequences of genes, what they do, and how they affect cell and organism function.
Seedlot	A quantity of cones or seeds having uniformity of species, source, quality, and year of collection.
Seed source tested	Seed sources tested in scientifically designed provenance (seed source) trials, typically across a series of test sites.
Select seed	Seed and vegetative material having a level of gain greater than zero for some trait of interest. Generally, lots registered as select are assigned a Genetic Worth.
Selfing	Self-pollination, when a female cone is pollinated with pollen from the same tree or clone.
Somatic embryogenesis (SE)	A process by which somatic cells (non-reproductive seed tissue) are differentiated into somatic embryos.
Source	The geographic source (provenance) of cones, seeds, and vegetative material, including the latitude, longitude, and elevation of the source, or the name and licence number of the seed orchard or cutting orchard.
Superior provenance	Provenances (seed sources) derived from natural stands that have been identified as having superior traits (e.g., growth performance) over that of local natural stand seed sources as shown through an extensive series of provenance trials. Typically referred to as B+.
Progeny tested	Selected parents which have been evaluated based on the performance of their offspring in scientifically designed progeny trials.
Provenance tested	Seed sources that have been tested in provenance trials where population samples from stands of known evolutionary origins are grown together in fair comparisons in one or more locations.
Transgenic tree	Trees to which genes are added through genetic engineering. See <i>GMO</i> .
Vegetative lot	A quantity of vegetative material or vegetative propagules having a uniformity of species, source, and year of collection.
Vegetative material	Material produced asexually. Most vegetative material used in B.C.’s reforestation program is from hedges and stoolbeds for species with a limited supply of high quality seed (e.g., yellow-cedar) or for which vegetative propagation is preferred (e.g., hybrid and native poplars).

Biotechnology: Potential Applications in Tree Improvement

This is an excerpt from an extension note of the same name produced by Council. See www.fgcouncil.bc.ca or contact the Executive Secretariat for information on how to obtain the publication.

Selective breeding combines genetic material from individuals of the same species through natural sexual reproduction.

Introduction

This article describes the types of biotechnology that are being used or have potential for use in tree breeding and production of planting stock. It describes genetic engineering (GE) and the fundamental differences between GE and traditional selective breeding. It notes some of the concerns about the use of GE in tree improvement, and how British Columbia is responding to these issues.

Tree Improvement Cycle

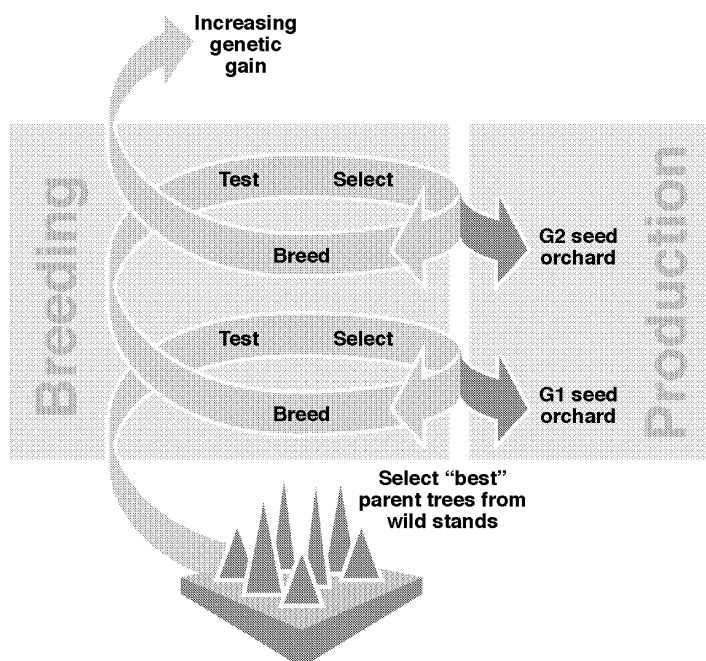
Research has shown that many traits—including growth rate, size, form, timing of growth, seed germination, wood properties, leaf characteristics, cone morphology, pest

resistance, and capacity to withstand climatic stresses—vary from one tree to another, and that these differences are in part due to genetic variation among trees.

Tree breeding programs take advantage of these natural differences between individual trees of the same species. Trees that exhibit desired traits in wild stands are selected as parent stock to breed and produce seed that carries these traits. Tree improvement specialists test the offspring (“progeny”) of these wild parents in field trials to determine the extent to which these traits are heritable (i.e., a result of genetic differences rather than environmental effects). Seed produced through this process of selective breeding is “improved” in that it expresses higher levels of these desired traits.

Continual cycles of selection, testing, and breeding increase the extent to which each generation of improved seedlings exhibits desirable traits—the “genetic gain” (see figure).

Tree breeding and seed production process. New parent material collected from wild stands is added throughout the cycle to continue to increase genetic diversity and gain.

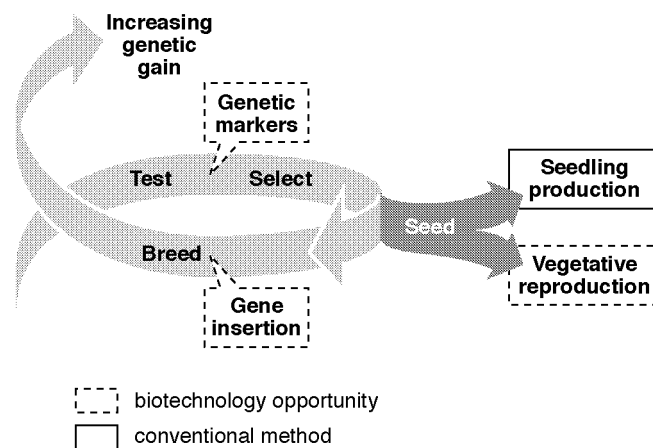


Biotechnology Opportunities in Tree Improvement

Biotechnology—the application of technology in the use of biological processes or living organisms—can support tree breeding and seed production activities in

several ways. These range from vegetatively reproducing large numbers of seedlings from seed tissue (somatic embryogenesis) to inserting, suppressing, or removing genetic material (GE) (see figure).

Biotechnology opportunities in tree breeding and seed production.



Selective tree breeding and genetic engineering are fundamentally different processes.

Vegetative Reproduction

While trees have been vegetatively reproduced from rooted cuttings for ages, a new biotechnology—somatic embryogenesis (SE)—allows the production of embryonic plants from the somatic (non-reproductive) tissue of a seed. The resulting “somatic seedlings,” like rooted cuttings, contain only the genetic material found in their parent trees. The primary difference between using cuttings and SE is the “unlimited” number of plants that theoretically can be produced from SE.

SE is not used in British Columbia’s reforestation programs, although several trials are underway. It will take several years of field testing and analysis to clarify the economic value and biological appropriateness of using SE in the province.

Genetic Markers

Biotechnology has also introduced new ways to study genes and their functions. British Columbia forest researchers are currently working with genetic markers—similar sequences of DNA that occur within certain trees or are associated with certain traits—on

several projects related to tree breeding. These include using such markers to help understand mating patterns in seed orchards, to identify the parentage of certain trees or seedlots, and to help quantify levels of genetic diversity in natural and seed orchard populations of trees. *[Editor’s note: see article “Genetic Markers: New Tool for Tree Improvement.”]*

Genetic Engineering

Genetic engineering (GE) is the modification of an organism’s genetic makeup, or genome, by deliberately introducing genes or by removing or suppressing a part of the organism’s genetic material. Organisms that result from this process are currently referred to as “genetically modified organisms” (GMOs). While introduced genes may come from other individuals of the same species, they typically come from other species (e.g., viruses, bacteria, other plants or animals). The introduced genes may act only as genetic markers, or they may allow the organism to express a novel trait. When the introduced genes are from another species, the organism is referred to as “transgenic.”

In most cases, the new gene combinations produced through GE do not exist in nature and cannot be obtained through selective breeding.

British Columbia is focusing on understanding how and where biotechnology can augment traditional tree improvement activities.

Although it may be 15–20 years before a genetically engineered tree could be released for commercial use anywhere in Canada, the use of GE technologies in tree genetics research may benefit tree breeding programs sooner. [Editor's note: see article "Forest Biotechnology Research at the CFS."]

What is the Future for Biotechnology in Tree Improvement?

The application of biotechnologies in tree breeding and seed production is under scientific and public scrutiny.

Biotechnology may augment traditional tree improvement activities by providing valuable information to tree breeders and supplementing the production of high quality seed. GE may enable forest researchers to grow trees with new and desirable traits. Whether such knowledge will have widespread commercial application, however, remains uncertain. Significant technical challenges must be overcome before GE trees could be used for operational reforestation. The ethical issues may be even more difficult to address.

There are many questions about the potential impacts associated with transgenic

trees. Some of these relate to whether introduced genes can be transferred from GE trees to wild populations through cross-pollination, whether transgenic trees will act in unpredictable ways or will have qualities that enable them to out-compete their wild relatives, or whether they will affect ecosystem processes in subtle, undesirable ways.

No such concerns exist with the planting stock used for reforestation in British Columbia today. Seedlings produced through conventional breeding contain no introduced genes—the genetic makeup of the planted trees is derived from the natural, well-adapted wild trees among which they are planted.

Given public concern, scientific uncertainty, and forests with high ecological, aesthetic, and commercial values, British Columbia is taking a cautious approach to the application of biotechnology. Current efforts are focusing on research to improve understanding of where biotechnologies can augment traditional tree improvement activities, and the implications of their application.

Genomics: New Horsepower or Trojan Horse?

submitted by Kermit Ritland

Genomics is the task of determining the DNA sequence of the organism, and finding out where the genes are located along the sequence, and what they do.

With the recent arrival of complete gene sequences for several organisms, including that for us (*Homo sapiens*) and the plant *Arabidopsis thaliana* (a member of the mustard family), scientists are already talking about the "post-genomics" era. Wait a minute, this is happening too fast!

First, what is a genome and what is genomics? A genome is all the genes of a living organism. It includes not only what we normally regard as a gene (a DNA sequence that is translated into a protein) but also regulatory regions, derelict genes, jumping genes, parasitic genes, and the what-have-you that has accumulated in the DNA sequence during evolution. Genomics is the activity of determining the DNA

sequence of the organism, and finding out where the genes are along the sequence and what they do. If you aren't working with hundreds or thousands of genes at one time, you aren't doing genomics.

In the past year, scientists have determined several genome sequences. Most interestingly, these sequences indicate that the minimum number of genes for multicellular life is 10 000–15 000. Possibly this number is all that natural selection can maintain. By gene number criteria, we are slightly more sophisticated than a plant (30 000 for humans vs. 25 000 for *Arabidopsis*). Obviously our genes are qualitatively different. Also, comparison of the *Arabidopsis* genome with animals shows

that duplication of genes resulting in gene “families” is much more common in plants. This finding might be because plants live in one place and sit still and weather the elements—a diversity of strategies within a species is better than a diversity of single-strategy species.

Will a tree be sequenced? Not a conifer, at least not soon, as current techniques do not work with the large amount of repetitive DNA found in conifers. There is some chance that most genes reside in “islands” within the genome that can be sequenced. The poplar genome is small enough to be sequenced, but this project would cost an estimated \$60 million. Genomics never was cheap, but recent advances in technology have greatly speeded genome projects. All recently finished projects have been completed well under their budgets, so the poplar sequence seems likely to be determined within a few years. *[Editor’s note: see article “Gene Mapping of Poplar.”]*

As an alternative to complete sequencing, current tree genome projects are directed towards sequencing the ends of “expressed genes” (messenger RNA) in model species (loblolly pine, radiata pine, Norway spruce). From these sequences, improved genetic

markers for breeding and population characterization will be obtained. As well, sequence evolution among species can be studied.

More interestingly, these sequences can be used to construct “microarrays,” which can measure the extent to which hundreds or even thousands of genes are expressed in specific tissues. As well, gene expression under certain stresses such as insect attack or drought can be characterized, and provenance variation and breeding effects can be studied. Our ability to “phenotype” or “see” traits in organisms will be vastly increased.

A possible Trojan horse with this activity is that genomics puts genetics in the public spotlight. Misunderstanding of this research activity and apprehension about where this knowledge will lead us may undermine public support for genomics and, via confusion infused by the rhetoric of some, even traditional tree breeding activities may be eventually questioned. Therefore, a vital component of any genome program is “GELS”: genetics, ethics, legalities, and society. Public education about these four components by people at arm’s length from those practicing genomics is needed.

Because genomics puts genetics in the public spotlight, all genome programs should include public education about genetics, ethics, legalities, and society.

Genetic Markers: New Tool for Tree Improvement

submitted by Michael Stoehr

Forest researchers in British Columbia are gaining a deeper understanding of genes and their functions through the use of genetic markers—similar sequences of DNA that occur within certain tree families or that are associated with certain traits.

A genetic marker can be a whole gene, part of a gene, a sequence in non-coding DNA between genes, or an enzyme produced by a gene. The marker can be used to identify a location in a genome, or to identify an individual or group of related individuals. Different types of markers are used for different research applications.

Several recent studies using markers derived from chloroplast DNA provide insights into the dynamics of pollen competition, the measurement of genetic worth, and the effectiveness of seed orchard management techniques.²

² Stoehr, M.U. and C.H. Newton. [2001]. Evaluation of mating dynamics in a lodgepole pine seed orchard using chloroplast DNA markers. Can. J. For. Res. Submitted. Stoehr, M.U., M.C. Mullen, D.L.S. Harrison, and J.E. Webber. 1999. Evaluating pollen competition in Douglas-fir using a chloroplast DNA marker. For. Gen. 6:49–53. Stoehr, M.U., B.L. Orvar, T.M. Vo, J.R. Gawley, J.E. Webber, and C.H. Newton. 1998. Application of a chloroplast DNA marker in seed orchard management evaluations of Douglas-fir. Can. J. For. Res. 28:187–195.

A genetic marker can be all or part of a gene, a sequence in non-coding DNA between genes, or an enzyme produced by a gene.

Markers are also being used to help quantify levels of genetic diversity in natural and seed orchard populations of trees.³

Chloroplast DNA Markers Help Establish Paternity

One of the barriers tree breeders face in examining mating dynamics is establishing paternity—the identification of the pollen parent. Genetic markers based on chloroplast DNA (cpDNA) are being used in British Columbia to help overcome this barrier.

Chloroplasts are chlorophyll-containing organelles (specialized structures that form part of a cell) abundant in plants that photosynthesize. In a seedling, the chloroplast DNA is inherited from the male parent, but can also be detected in the megagametophyte tissue of seeds to determine the female parent of seed in a bulked, wind-pollinated seedlot. Chloroplast DNA markers can, therefore, be used as molecular “fingerprints” to identify which seed came from which parent. To do this, the cpDNA marker for each parent tree in a seed orchard must be identified, so that the cpDNA for the seed or seedlot can be compared for matches with these known markers.

The first step in determining which seed orchard male fathered a given seedling is to extract DNA from the seedling. Next, a stretch of DNA that includes the location of the known genetic marker is amplified through a process called PCR (polymerase chain reaction). Then, using a process called gel electrophoresis, the amplified DNA strands are exposed to an electrical charge while they are suspended in a gel. Finally, the amplified DNA strands are stained to make the marker band visible. The visualized band of the seedling is then compared to the band produced by the putative male parent. If the band from the seedling DNA is in the same position on the gel as the band of the DNA of the male parent, then parentage can be assigned

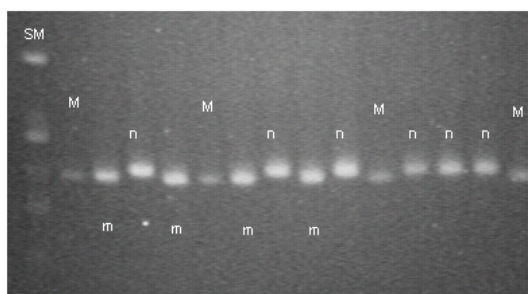
unambiguously. If seeds cannot be matched to any of the males in the orchard, they are classified as pollen contaminants (i.e., pollinated by males outside the orchard).

The photo shows an example where ten embryo (seed) DNA bands (“m” and “n”) are compared to the band of an assumed male parent (“M”). The bands “m” and “M” match, establishing that M was the father. Embryo DNA bands “n” are at a slightly different location than M, which means that M was not the father.

Agarose electrophoresis gel showing the result of a verification of control crosses.

SM indicates DNA size marker.

Photo: M. Stoehr.



Genetic Markers in Tree Breeding and Seed Orchard Production

The genetic quality of an orchard seedlot represents the specific mating dynamics and conditions during pollination in a given year. It depends on the contribution of each orchard parent, and on the amount of pollen contamination from outside the orchard. Orchard managers control these factors with techniques such as supplemental mass pollination (SMP) and cooling with overhead irrigation.

Three recent studies using cpDNA markers provide new information about some of the factors that affect genetic quality.

- Researchers used a cpDNA marker to assess the level of outside orchard pollen contamination, and the effectiveness of SMP in a Douglas-fir seed orchard.
- The same cpDNA marker was used to test pollen competition in Douglas-fir, as reflected in the reproductive success

Genetic markers are being used to study the dynamics of pollen competition, the measurement of genetic worth, the effectiveness of seed orchard management techniques, and to help quantify genetic diversity in natural and seed orchard populations of trees.

³ Stoehr, M.U. and Y.A. El-Kassaby. 1997. Levels of genetic diversity at different stages of the domestication cycle of interior spruce in British Columbia. *Theor. Appl. Genet.* 94:83-90.

of different pollen lots from six genetically different trees.

- A set of six polymorphic (genetically variable) cpDNA markers was used to determine the paternity of wind-pollinated seedlots collected from 15 orchard trees from an operational lodgepole pine orchard. The results were used to estimate pollen (male gamete) contribution of all male parents in the seed orchard, selfing rates, and outside pollen contamination.

The three studies suggest that male reproductive bias exists in both Douglas-fir and lodgepole pine. In Douglas-fir, male reproductive success is linked with pollen viability⁴ and individual male clones. Successful males show enhanced mating with a range of maternal clones. The studies also suggest that in both species, specific male x female pairs produce proportionately more offspring. The Douglas-fir study identified levels of self-pollination from 0 to 19%, averaging 6%, and the lodgepole pine study from 0 to 6%, with an average of 1.7%. The Douglas-fir and lodgepole pine studies showed 40% and 6% contamination, respectively, by pollen from trees outside the orchards.

⁴ The quality of pollen determined by its ability to fertilize egg cells. Pollen germination and pollen respiration rates are measured to determine viability.

Conclusions

Researchers in British Columbia are demonstrating the potential of cpDNA markers to enhance seed orchard management and research into reproductive biology. The ability to estimate individual pollen contribution of many orchard clones and accurately assess potential contamination from trees outside the orchard using cpDNA may improve our ability to:

- rate seedlots using direct measurements of genetic balance,⁵ pollen contamination, and selfing rather than the indirect methods currently used
- evaluate and optimize management practices such as SMP, overhead water cooling, and orchard design
- obtain a more balanced distribution of the male and female gametes in bulked seedlots, sometimes by mixing individual seed crops clone by clone; all clones in the orchard would ideally produce and pollinate an equal number of seeds to maximize diversity
- study other aspects of sexual reproduction, such as pollen competition, pollination success under various pollen loads,⁶ and specific male x female interactions
- verify male parentage in controlled crosses for applications such as realized gain trials, advanced generation testing and selection, and other aspects of pedigree analysis and clonal identification.

⁵ The equal contribution of male and female gametes by each orchard parent.

⁶ The amount of pollen in the air during orchard pollen shed.

Researchers in B.C. are using genetic markers to enhance seed orchard management and research into reproductive biology.

Forest Biotechnology Research at the CFS

submitted by Anne-Christine Bonfils

In August 2000, the Canadian Council of Forest Ministers (CCFM) announced an innovative Canada-wide strategic plan—*Forest 2020*—to increase the conservation value of forests. Improved productivity from selected areas and high yield plantations would sustain forest industry growth. In this context, advances in forest biotechnology could provide unprecedented opportunities and challenges for Canada.

The Canadian Forest Service (CFS) of Natural Resources Canada, in partnership with universities, provincial governments, and industry, has built core expertise and research facilities for forest biotechnology research. From 1998 to 2000, it received an additional \$3.5 million annual funding for genomics and regulatory research from the Canadian Biotechnology Strategy. This article outlines CFS research related to forest conservation, regeneration, forest protection, and environmental risk assessment.

Forest Conservation

The characterization of genetic diversity of trees, insects, and microbes is an important criterion for evaluating a country's progress toward sustainability. DNA fingerprinting⁷ is being used to establish genetic reference bases and distinguish closely related species and their potential hybrids (e.g., hybrids of the endangered native red mulberry and the introduced Asian white mulberry).

Similar DNA probing techniques are being used to detect and monitor introduced quarantine fungi and beetles (e.g., brown spruce longhorn beetle), and to ensure export of pest-free materials. DNA matching based on microsatellite markers was also developed as a forensic tool against tree smuggling. This illegal activity results in an

⁷ Pieces of DNA (molecules of various lengths) from individual organisms make up unique banding patterns following gel separation. This allows matching with known samples. For example, in the case of a stolen redcedar, DNA patterns from the stump can be matched with DNA patterns from suspect pieces of wood.

estimated \$75–150 million annual loss of old-growth western redcedar on the British Columbia coast.

Forest Regeneration

The CFS is studying the structure and function of conifer and poplar genes, focusing on genes associated with traits like mature wood density and fibre length, and genes involved in tree differentiation and development (resistance to pests and pathogens, cold tolerance, flower sterility). Genes have been isolated for resistance to fungal diseases and cold tolerance in white pine. Maps of the relative positions of genes on chromosomes are being constructed for white and black spruce. The CFS is also providing expertise to assist researchers in producing transgenic poplar and conifer lines to improve understanding of the function of selected genes.

The CFS has been a world leader in somatic embryogenesis (SE), which makes it possible to produce unlimited numbers of genetically identical seedlings from a single seed. SE is now used commercially for large volume tree production with species of larch, spruce, and pine. Canada's millennium tree (white spruce) was propagated this way. CFS scientists continue to innovate in this technology, and now successfully regenerate species that are less amenable to SE, such as eastern white pine and jack pine. Cryopreservation—preserving at low temperatures—will allow the safe storage of lines until the materials have been tested for field performance.

The CFS was the first to successfully insert marker genes into black spruce and tamarack (1993) and, more recently, has introduced genes for pest and disease tolerance into white spruce, poplar, white pine, and European larch. These trees, currently at an early research stage, are invaluable for the study of gene function, gene stability, and environmental risk assessment research.

Editors note:
Genetic engineering work being undertaken by the CFS is centered in Quebec. Genetically modified trees are not being developed for or planted in British Columbia.

CFS has been a world leader in somatic embryogenesis.

It was also the first to successfully insert marker genes into black spruce and tamarack.

Forest Protection

Research at the CFS has pioneered the development of *Bacillus thuringiensis*, or *B.t.*, for use against a broad range of lepidopterous pests such as the spruce budworm and gypsy moth. The CFS is now studying how to make *B.t.*'s mode of action more effective. The CFS obtained Canada's first registrations of insect viruses against the redheaded pine sawfly, Douglas-fir tussock moth, and gypsy moth. Genome sequencing⁸ and functional genomics⁹ of spruce budworm and its viruses are underway. Diagnostic assays based on DNA were developed to detect fungal diseases in seedlings for effective disease management in plantations. New technologies are being designed to provide information on species, race, and virulence for all major forest pathogens. Other approaches involve the molecular investigation of naturally derived products for managing forest insect pests, such as pheromones, insect repellents, and substances that disrupt insect physiology.

Environmental Risk Assessment Research

The commercial release of genetically engineered forest products in Canada is not expected soon. This delay provides time for research into the environmental safety and responsible deployment of forest biotechnology products. The assessment of potential environmental impacts requires a baseline understanding of the species biology and ecosystem interactions; a thorough characterization of the genetically modified tree or micro-organism, as well as of the transferred gene and its products; and the development of appropriate tools and criteria for risk assessments.

CFS scientists have developed forest soil, leaf litter, and aquatic microcosms to evaluate the potential impact of genetically modified organisms. Issues such as competition and gene transfer among microorganisms, and the potential for development of insect

resistance to transgenic spruce containing a *B.t.* gene are examined.

The CFS is carrying out small-scale field trials of transgenic poplar, white spruce, and black spruce under strict confinement conditions and monitoring protocols, under the regulatory authority of the Canadian Food Inspection Agency. The trials are used to develop a protocol for tracking the fate of genetically modified DNA in forest soil and litter, to monitor changes in soil microbial populations, and to enhance scientific understanding of the performance of the experimental trees. These trees will not be allowed to flower or produce seed.

A sound regulatory framework also requires national and international policy developments. The CFS participates in federal, provincial, and ad-hoc expert committee discussions on the issue. The CFS co-organized the international Workshop on Environmental Impacts of Transgenic Trees of the Organization for Economic Cooperation and Development (OECD), held in late 1999 in Norway. The CFS also participates in the development of Canada's position on the Cartagena Protocol on Biosafety, which outlines international rules to protect biological diversity from the risks posed by international movement of living modified organisms.

The need to pursue basic research to understand forest ecosystems, tree species, forest pests, and potential biological control agents at the molecular and cellular levels continues. Genomics and environmental risk assessment research are high priority areas. Other areas that will require particular attention in coming years include long-term monitoring of environmental impacts, identification and control of exotic pests, technology transfer, intellectual property and patenting of higher life forms, the development of sound social and ethical frameworks, and public and forest industry involvement. Canada's prominence in forest science and policy development gives us the opportunity to become a world leader in forest biotechnology, if we have the foresight to support this emerging field and address its complexities.

Forest biotechnology could also benefit other sectors such as agriculture and medicine.

Complex social, public opinion, and environmental safety issues attend the development and application of forest biotechnology—particularly those aspects related to genetic modification.

⁸ The sequencing (i.e., reading of DNA base pairs, in sequence) of the genes in a tree.

⁹ The understanding of the function of genes—the protein they code for and therefore the traits that they express.

Gene Mapping of Poplar

submitted by Dan Carson

A gene map of the poplar genome is anticipated by 2010.

Gene mapping of poplar is expected to yield important clues to the location of similar genes in other tree species, including conifers.

Gene mapping is the process of identifying and locating all the DNA sequences (genes) that comprise an individual organism. Knowing the location of specific genes makes it possible to screen for their presence and, if desired, to manipulate them.

Gene mapping of trees is in its early stages, but based on experience with agricultural crops, genetic mapping of tree species is expected to enhance tree breeding activities related to stock selection, stock development, and forest productivity.

The more genes that make up a genome, the more effort is required to map it. Gene maps are nearing completion for corn, tobacco, rice, and wheat—each of which has about 100 000 genes. By comparison, most conifer genomes are estimated to exceed one million genes. The poplar genome is considerably less than conifer genomes, and is estimated to be similar in size to that of corn. Work on poplar is expected to provide important clues to the location of similar genes in other tree species, including conifers.

Poplar is a natural starting point for gene mapping of tree species because:

- it has a relatively small number of genes
- its ability to propagate asexually makes it easy to replicate genetically identical individuals
- it becomes sexually active by age 4, which means less time between successive generations of offspring
- it responds well to controlled breeding and each successful cross yields hundreds of offspring (large families of siblings are required for genetic analysis and screening)¹⁰
- its rapid initial growth allows early screening for attributes

¹⁰ A family recently created at the University of Washington has over 3000 individuals.

- intensive management regimes of hybrid poplar have rotation lengths of 5–14 years, which makes it possible to screen each clone¹¹ for one rotation before operational planting.

Mapping the poplar genome is underway by two industry–academic cooperatives in the Pacific Northwest. With the help of genetic markers, researchers have identified—or are near to identifying—the location of genes that control resistance to conifer–cottonwood leaf rust (mmd1), salt tolerance, cellulose composition, and sterility. Hopes are high that a gene map of the poplar genome will be completed by 2010.

A gene map will make it possible to screen conventionally bred clones for genes of interest, such as the presence of the gene mmd1. Early identification of this gene may eliminate the need for extensive screening for the pathogen, thus decreasing the time required for stock development.

A gene map will also facilitate the development of clones (through conventional tree breeding) with special characteristics, such as resistance to specific herbicides.

A gene map is like a road map. It is useful in identifying the terrain and is a precursor to identifying possible routes of travel. Of equal (or greater) effort is deciding where you want to go and how best to get there. In the world of genetics, this means considering ethical issues and social implications associated with using “designer clones”—areas that British Columbia and Canada have yet to resolve.

¹¹ Vegetative, or asexual, reproduction results in many plants of the same genetic makeup (clones). Because vegetative reproduction is faster and more easily controlled than sexual reproduction, most operational poplar planting stock consists of clones. Clones are usually planted in small “checkerboard” blocks, rather than freely mixed. That way, if one clone develops problems, it can easily be replaced with another.

Forest Certification and Implications for Tree Improvement, and Seedling Production and Use

submitted by Brian Barber

This article reviews the four major forest certification systems being pursued in British Columbia, and discusses their implications for tree improvement activities, and seedling production and use.

Certification Scheme Overview

Environmental non-government organizations (ENGOS), international and national standards associations, and forest industry associations are developing forest land and forest products certification systems. Under most schemes, accredited independent third parties, or verifiers, grant certification to ensure compliance with the certifying body's requirements. Certification schemes can be grouped into four broad categories:

1. **Process-based schemes** require a forest land or mill manager to design and implement an administrative environmental framework, and to set and meet specific standards. These standards can be developed internally or through public consultation.
2. **Performance-based schemes** require an applicant to meet environmental, social, and cultural standards defined by the certifying body and/or the applicant.
3. **Mixed schemes** have elements of both process- and performance-based systems.
4. **Chain of custody schemes** verify that manufacturers have used forest products derived from certified forests.

The certification schemes with direct consequence to tree improvement are the process- and performance-based schemes used to verify sustainable forest management.

To date, forest land managers in British Columbia have sought certification under four organizations:¹²

- International Organization for Standardization, 14001 Environmental Management Series (ISO 14001)
- Canadian Standards Association (CSA) Z809-96, Sustainable Forest Management System
- American Forest & Paper Association, Sustainable Forestry Initiative (SFI)
- Forest Stewardship Council (FSC).

ISO

ISO 14001, a process-based certification scheme, requires an applicant to abide by local laws and regulations, and internally developed environmental management system. For tree improvement, a forest land manager can meet these requirements by committing to use only tree seed and vegetative material that is collected, registered, and deployed in accordance with the *Forest Practices Code of British Columbia Act* and its regulations and guidebooks. Appropriate records must also be maintained.

CSA

The CSA scheme is both process- and performance-based. CSA standards require a forest land manager to develop, for a defined forest area (DFA), a set of values and goals that are consistent with the Canadian Council of Forest Minister's criteria and indicators for sustainable forest management (CCFM C&Is), and that are derived from a public consultation process.

Subsection 1.3 of the CCFM C&Is states that: "...genetic diversity is the ultimate source of biodiversity at all levels. It is the material

Some B.C. forest lands have already been certified or registered under one or more certification systems.

¹² For more information on certification schemes and a list of certified B.C. forest land managers see: <http://www.for.gov.bc.ca/het/certification/>

upon which the agents of evolution act. Loss of variation may have negative consequences for fitness and prevent adaptive changes in populations.”

The CCFM suggested indicator for maintaining genetic diversity is: “Implementation of an *in situ/ex situ* genetic conservation strategy for commercial and endangered forest species.”

In responding to public concerns about genetic diversity, the use of “improved” seedlings, non-local provenances, and exotic species, forest land managers may refer to provincial tree improvement activities and regulatory requirements, or may seek the assistance of tree improvement and other specialists.

SFI

The SFI is a process- and performance-based scheme. A forest land manager may apply directly or seek second- or third-party verification under this system. Verifiers must demonstrate that the voluntary indicators established by the applicant are consistent with the principles, objectives, and performance measures of the SFI and the checklist of the certifying agency.

Under SFI’s Sustainable Forestry Standard, Objective 4.1.2 states that members must: “Promptly reforest harvested areas to ensure long-term forest productivity and conservation of forest resources.” Voluntary indicators suggested for this objective include:

- quality seed and seedlings that are locally adapted are readily available for reforestation
- genetically improved stock is appropriately deployed to achieve SFI reforestation requirements.

SFI applicants must describe how they intend to obtain and deploy seed and seedlings in a timely manner. These indicators could be satisfied by referencing seed procurement plans and inventories (including seed supply agreements), and seedling supply contracts. A commitment to using seed and vegetative materials in accordance with provincial regulations

should also serve as a commitment to meet these indicators.

FSC

The FSC scheme is primarily a performance-based system. FSC standards are developed locally based on 10 pre-defined forest management principles. Principle 6 (Environmental Protection) and Principle 10 (Plantations) relate to specific aspects of tree seed and seedling production and use, including: maintaining genetic diversity, restricting use of chemicals, prohibiting use of GMOs, controlling use of exotics, and ensuring ecological adaptation.

FSC regional standards are developed by chapters with representation from environmental groups, forestry-dependent communities, forest worker unions, and First Nations. Second-draft FSC Regional Standards for British Columbia were released in June 2001 for public review and comment.¹³ Once regional standards have been established, organizations accredited by the FSC can assess a forest land manager’s ability to meet the standards.

While awaiting approval of a B.C. standard, forest land managers can apply for certification through organizations with FSC-approved “checklists.” Because applicants certified under checklists will have to re-apply for certification under the new standards, many B.C. forest land managers are awaiting approval of regional standards before seeking FSC certification.

Certification Implications

Some B.C. forest lands have already been certified, suggesting that tree breeding, seed production, seed registration, and seedling production practices in the province are acceptable to certifying agencies at this time.

Verification and monitoring of genetic diversity in seedlots, seedlings, and forests may become more comprehensive over time. As certification schemes evolve, scrutiny of tree improvement and seedling production activities may increase.

¹³ MOF has been providing information on tree improvement and seedling production and use to demonstrate that the province’s regulations and practices are consistent with FSC principles.

As certification schemes evolve, scrutiny of tree improvement and seedling production activities may increase.

“Select” Lodgepole Pine Seed Availability to 2010

submitted by Michael Carlson

British Columbia has, over the past 25 years, invested substantially in genecological research and selective breeding of its major commercial species. This investment has produced biologically based seed transfer guidelines and genetically selected “select” seed—both of which have contributed significantly to regeneration success.

Under the *Forest Practices Code of British Columbia Act*, licensees are required to use seed of the best genetic quality available for planting on Crown lands. However, supplies of orchard-produced select seed for lodgepole pine (Pli) will be scarce in most SPUs for some time. This article outlines current and future sources of select seed and estimated demands through 2010. Superior provenance select seed sources are also identified to assist clients in planning future cone collections.

Lodgepole Pine Selective Breeding Program

Selective breeding of lodgepole pine for increased wood volume production began in 1976. From 1976 to 1986, several hundred trees from wild stands in eight distinct geographic areas, referred to as seed planning zones (SPZs), were selected, seed and scion collected, and gene archives and breeding orchards established. Between 1984 and 1988, thirteen progeny test series were planted across six SPZs with three sites per unit, and approximately 300 selected trees progeny tested per unit. Seven seed orchards have been established based on 10-year progeny test rankings of selected trees for six SPZs. By 2010, about half of all Pli planting stock (currently approximately 80 million per year) will come from orchard-produced (Class A) select seedlots. The remainder will come from superior provenance (Class B+) select seed sources, where available, and natural stand (Class B) standard sources.

Lodgepole Pine Select Seed Orchards

The first table on the following page lists the estimated genetic worth and production targets for each of the 17 Pli seed orchards.

Six of the seven progeny-tested lodgepole pine orchards are beginning to produce seedlots with expected genetic worth values ranging from 8 to 16% for rotation-age wood volumes. These orchards are privately owned/managed with owner companies using most of the first small seedlots produced. The seventh orchard (EK low elevation) is only two years from grafting and will not begin producing seed for 4–5 years.

Ten other Pli seed orchards have been planted at various times since 1974. One is privately owned and nine are MOF owned. These orchards have not been progeny tested and are producing seedlots with expected genetic worth values ranging from 2 to 6%.

Orchard Seed Availability

Many companies are planning wild cone/seed collection projects and need to know roughly when orchard seed will be available. The second table shows estimated percentages of current and future (2004, 2007) planting stock needs to be met by seed orchard seedlots by SPU. Percentages of planting stock needs to be met by MOF-managed orchards, and thus available for licensees not having their own orchard, are also shown. Except for the relatively small seedling requirements of the NS SPU, no unit will have more than two-thirds of its planting stock needs met by 2007, with an average of only 39% across seven units. MOF orchard seedling production by 2007 will average 19% across these same units—about one-half of the total produced. By 2010, with all orchards at full production, approximately 65% of the seed needs in all SPUs which have seed orchards will be satisfied, with about one-third of the total coming from MOF orchards.

By 2010, about two-thirds of the needed select seed of interior lodgepole pine will come from seed orchards.

The remainder will come from superior provenance (B+) and natural stand sources.

Lodgepole pine seed orchards expected genetic worth and production targets.

Seed planning unit (SPU)	Annual seedling demand ^a (millions)	Orchard #	Owner/ agency	Progeny tested?	Seedlot GW (%)	Production target (millions seedlings)	Full production
NE low < 1400 m	5.1	307	MOF	No	6	2.6	2004
		313	PRT	Yes	16	1.6	2008
TO low < 1400 m	6.3	308	PRT	No	6	1.9	2005
		311	PRT	Yes	16	1.5	2008
TO high 1400–1600 m	6.5	310	RIVER	Yes	11	1.0	2004
PG low < 1200 m	13.4	203	MOF	No	2	1.0	2001
		220	MOF	No	6	2.2	2004
		222	VSOC	Yes	8	6.6	2008
BV low < 1200 m	17.6	204	MOF	No	2	1.2	2001
		228	MOF	No	6	2.4	2004
		219	VSOC	Yes	10	8.8	2008
CP low < 1100 m [<56°N] <900 m [>56°N]	12.3	201	MOF	No	2	1.0	2001
		202	MOF	No	2	1.0	2001
		223	MOF	No	6	1.5	2006
		218	VSOC	Yes	10	6.5	2010
EK low < 1500 m	2.4	TBA	TBA	Yes	~ 10	2.4	2010
NS low < 800 m	1.0	230	MOF	No ^b	2	1.0	2001

MOF Ministry of Forests

RIVER

Riverside Forest Products

PRT Pacific Regeneration Technologies Inc.

VSOC

Vernon Seed Orchard Company

^a Seedling demand is based on average number of Pli seedlings planted annually from 1994 to 1998 in each SPU.

^b A progeny test has been planted (2000) to rogue this orchard and increase genetic worth in about 2006.

Estimates of select orchard Pli seedling supply in 2001, 2004, and 2007 compared with SPU seedling demands
(Source: Species Plans, Forest Genetics Council of B.C. Business Plan 2000–2001).

Seed planning unit (SPU)	Annual seedling demand ^a (millions)	Today (2001) million seedlings (% of needs)		3 yrs (2004) million seedlings (% of needs)		6 yrs (2007) million seedlings (% of demand)	
		All orchards	MOF orchards	All orchards	MOF orchards	All orchards	MOF orchards
NE low < 1400 m	5.1	2.8 (55%)	2.6 (51%)	3.1 (61%)	2.6 (51%)	3.4 (67%)	2.6 (51%)
TO low < 1400 m	6.3	0.9 (15%)	0	2.7 (43%)	0	3.3 (52%)	0
TO high 1400–1600 m	6.5	0.5 (8%)	0	1.0 (15%)	0	1.0 (15%)	0
PG low < 1200 m	13.4	1.6 (12%)	1.5 (11%)	4.6 (34%)	3.2 (24%)	5.5 (41%)	3.2 (24%)
BV low < 1200 m	17.6	2.6 (15%)	1.8 (10%)	5.6 (32%)	2.5 (14%)	6.9 (39%)	2.5 (14%)
CP low < 1100 m [<56°N] <900 m [>56°N]	12.3	0.74 (6%)	0.74 (6%)	2.3 (19%)	1.1 (9%)	3.6 (29%)	1.5 (12%)
EK low < 1500 m	2.4	0	0	0.12 (5%)	0.12 (5%)	0.72 (30%)	0.72 (30%)
NS low < 800 m	1.0	1.0 (100%)	1.0 (100%)	1.0 (100%)	1.0 (100%)	1.0 (100%)	1.0 (100%)

^a Seedling demand is based on average number of Pli seedlings planted annually from 1994 to 1998 in each SPU.

Filling the Shortfall in Select Seed

The production of select seed orchard seedlings will gradually increase from an average 16% of SPU needs today to 39% in 2007 and 65% in 2010 with current orchards at full production. Thus, a licensee may choose to buy select orchard seed from a private orchard company or MOF, buy superior provenance select seed, or make superior provenance cone collections.

Some SPUs now have an abundance of superior provenance seed in “surplus” status and seed inventories on SPAR should be checked before planning further cone collections. For other SPUs, superior provenance cone collections should be considered.

The following table lists eight superior provenance Pli seed source locations identified from long-term Pli provenance testing. Seed collected within an 8 km radius of the provenance origin and within 50 m up or down in elevation is considered acceptable. Appropriate zones for use of a particular provenance’s seed are listed along with elevational transfer limits. MOF Research Branch is considering additional superior provenance locations, particularly in the central Interior. Information on these sites will be available in July 2001.¹⁴

¹⁴ Contact Ron Planden, MOF Tree Improvement Branch.

Some SPUs have inventories of superior provenance seed to address shortfalls in orchard-produced seed.

In other SPUs, it may be necessary to collect cones from superior provenance sources.

Origins for lodgepole pine superior provenances (from Forest Practices Code, *Seed and Vegetative Material Guidebook*, update #5, September 18, 2000)

Location	Origin			Seed planning zones (SPZs) for use	Elevation transfer limit	
	Elevation (m)	Latitude ° ’	Longitude ° ’		Upwards (m)	Downwards (m)
Jackfish Creek	457	58 32	122 42	DK, FN	200	200
Telkwa Low	518	54 39	127 03	BLK	300	200
Larch Hills	777	50 42	119 11	BSH, E, SA, TOD, WK	400	200
Innonoaklin	579	49 54	118 12	BSH, EK, SA, WK	300	200
Champion Lake	998	49 11	117 35	BSH, EK, TOD, WK	300	200
Udy Creek	1100	53 01	123 14	CHL, CT, MRB, NCH, QL	300	200
Wentworth Creek	1059	50 58	120 20	TOA, TOD	300	200
Rocky Mt. Trench	Source is continuous from 50 30 and between 900 and 1200 m along the Columbia River Valley.			BSH, EK, MRB, SA, WK TOD	300	200

Future Seed Orchard Expansion

Six of the seven progeny-tested lodgepole pine orchards are being expanded to meet increased seed needs identified in a five-year survey of interior planting trends. Regrafting of high-ranking tested parent trees for orchard expansions began in 1999 and will continue until about 2002. A new source of select seed orchard parents has been identified from our 1985/86 progeny test series in the PG and BV SPUs.

Progeny tests rank selected natural stand parents according to the performance of their offspring across several test sites over 10 or more years. Exceptional parents often produce exceptional offspring (no surprise—genetics works!). This outcome, combined with our environmentally uniform progeny test sites, allows for a high level of confidence in selecting new orchard parents from among progeny test tree arrays.

Orchard expansions will have no impact on select seed availability until after 2010.

In March, some 5000 scion pieces were collected from 75 to 80 selected offspring trees in the PG and BV SPZ test series (see photo). Orchard expansions will have no impact on select seed availability until after 2010.

Lodgepole pine tree breeding technician John Murphy at the 1986 Gramophone Creek progeny test site selecting outstanding parents for expansion of the Bulkley Valley seed orchard.

Photo: M. Carlson.



Enhancing Seed Production in the North Okanagan Lodgepole Pine Seed Orchards

submitted by Joe Webber

This article presents some highlights of a report of the same name by Joe Webber, Clint Hollefreund, Mark Griffin, available from the senior author or Roger Painter, Tree Improvement Coordinator.

Experimental plots were established in two North Okanagan seed orchards to test the effect of improved irrigation and crown cooling through misting on enhancing seed production of lodgepole pine.

Poor seed set in north Okanagan lodgepole pine seed orchards has been chronic. The solution to improving orchard yields has several approaches. Assuming that the seed bug (*Leptoglossus*) can be controlled and that pollen supply is not limiting, then we contend that higher seed set can be attained through better cultural techniques, in particular irrigation (both the amount and distribution of water delivered). We also believe that high temperatures ($> 25^{\circ}\text{C}$) during critical stages of reproductive development may be limiting further development.

Methodology

With funding from Forest Renewal BC in 2000/01, Ministry of Forests Research Branch implemented a study to investigate means of enhancing seed production of lodgepole pine at two north Okanagan seed orchards.

The orchards used for this study were the Ministry of Forests Kalamalka Seed Orchard 307 in Vernon (KAL) and Pacific Reforestation Technologies Seed Orchard 308 near Armstrong (PRT).

In each orchard, four experimental plots were established to test the effect of improved irrigation, crown cooling through misting, the interaction between misting and irrigation, and a control block. To determine treatment effects, we measured:

- the amount of ambient orchard pollen and its synchrony with receptive female cones in each treatment plot
- the effect of treatments on second-year seed cone survival, cone size, total seed per cone, and filled seed per cone.

Supplemental mass pollination was carried out on a subsample of trees to determine if ambient orchard pollen supply was limiting. Pollen monitors were installed in each of the four blocks to determine the level of ambient orchard pollen supply and the synchrony between orchard pollen shed and seed cone receptivity. Meteorological data

(temperature and humidity) were collected in each block to determine the extent of high temperature (> 25°C) and low humidity on cone development and seed set (second-year cones). On sample trees within each block, we assessed the phenological development

of pollen and seed cones, counted the number of first- and second-year cones, sampled both first- and second-year cone mass, determined seed yields and seed weight in second-year cones, and assessed tree vigour by treatment block.

Seed yield mean values (\pm standard errors) for each orchard.

KAL 2000				
	Control	Irrigation/Mist	Irrigation	Mist
Cone yields				
Total seed per cone	22.4 (2.4)	23.3 (2.2)	23.3 (1.9)	25.1 (2.5)
Filled seed per cone	9.7 (1.6)	13.0 (1.5)	11.9 (1.4)	15.9 (1.9)
Seed weight (mg)	4.1 (0.14)	4.2 (0.16)	4.6 (0.24)	4.4 (0.10)
PRT 2000				
	Control	Irrigation/Mist	Irrigation	Mist
Cone yields				
Total seed per cone	20.4 (2.3)	16.1 (2.0)	16.2 (2.1)	18.2 (2.0)
Filled seed per cone	8.1 (1.1)	5.2 (0.67)	6.4 (1.1)	7.5 (1.1)
Seed weight (mg)	3.9 (0.19)	3.9 (0.14)	3.6 (0.17)	4.0 (0.18)

Note: Misting treatment at PRT was not tested because of low line pressure; it will be tested for year 2001.

In the second year of the project, treatments will be repeated to compare the effects of irrigation and mist treatments on seed set in second-year cones that were treated and not treated in the first year.

Highlights of the Findings

- Pollen supply and viability were both high.
- Treatment had no effect on **seed or pollen cone development** (phenology) and synchrony between pollen shed and seed cone receptivity was good.
- **Spring and fall counts of first- and second-year seed cones** showed no significant effects to treatment but showed variation between orchards. KAL showed higher average pollen cluster counts per main whorl branch per sample tree, higher spring counts of first- and second-year seed cones, and higher cone retention for first-year seed cones.
- **Cone mass** for first- and second-year seed cones varied by block and by orchard site. At KAL, misting significantly increased first-year dry cone mass but treatments had no effect on second-year cone mass. At PRT, no irrigation effects were observed and the misting system was not tested due to poor line pressure. The dry cone weight between orchards for first-year cones showed little difference but at PRT, second-year dry cone weight was about 20% less.

Initial results suggest that crown misting had a significant effect on second-year cone development.

- **Seed yields**, expressed as the number of seed per cone with a mature embryo, varied by treatments at KAL but not at PRT (see tables). Results from 2000 treatments suggest that crown misting had a significant effect on second-year cone development. Since crown misting did not begin until after the pollination period (April 27), this treatment likely was affecting ovule fertilization and early embryo development, which occurs in June. Due to equipment failure, misting in the irrigation block (Irrigation/Mist) did not occur for most of June. This may explain the small but non-significant increases in seed yields.
- **Irrigation effects** on seed yields were not significant (yields improved somewhat at KAL; no effects at PRT). We believe that irrigation water uptake is limiting seed yields but we do not expect yields to improve due to irrigation until root volume has expanded to increase water uptake (1–2 more years).

Conclusions

The first results from the KAL misting block provide an important clue to one possible cause of the chronic poor seed yields in north Okanagan lodgepole pine seed orchards. Misting during June and July led to significant increases in seed yields. However, we cannot rule out the possibility that wetting the crowns during periods of high temperature (and low humidity) allowed the crowns to take up more water through the foliage. It is likely that both crown cooling and increased water uptake are contributing. We can speculate that misting is effectively helping the reproductive development of second-year cones (June) when pollen germination, fertilization, and early embryo development resume. Our objectives for the second year of this project (2001) are to repeat this experiment and compare the effects of irrigation and mist treatments on seed set in second-year cones that were either treated in the first year or not.

SPAR Web Application

submitted by Susan Zedel

The FGC and MOF are sponsoring the SPAR project for which Forest Renewal BC is providing funding. Susan Zedel, MOF Tree Improvement Branch is leading the project. Pangaea Systems Inc., Victoria, B.C., is undertaking systems development.

The Seed Planning and Registry system (SPAR) is an information management system that provides ministry and non-ministry tree improvement clients with on-line access to current information on seed and vegetative lots and an on-line facility for entering seedling requests.

The SPAR Web application development project will convert the existing MOF IBM VM mainframe application and database to a Web-based application and Oracle database. The new application will provide a more intuitive and user-friendly interface to SPAR

functions. Users will access the system through Web browser software such as Internet Explorer. Reporting capabilities will also be improved—enabling users to receive output in various reporting formats. A direct link to the new SeedMap application is also planned.

The first phase of the project, scheduled for completion in 2001, includes conversion of the SPAR data model to an Oracle Designer format, the VM database to Oracle 8I, and all functionality related to seedlot and vegetative lot, including on-line screens and reports.

The second and third phases will handle conversion of the seedling request process, cone/seed service requests, and all remaining functions. The project is scheduled for completion June 30, 2002.

This upgrade will simplify access to SPAR, allow users to better screen seed availability, and help MOF to track seed use across the province.

New “SeedMap” System

submitted by Leslie McAuley

The FGC and MOF are sponsoring the SeedMap project. Forest Renewal BC is funding Phase 1 development. The ministry project lead is Leslie McAuley, MOF Tree Improvement Branch. GDS & Associates Limited, Victoria, B.C., is developing the software.

SeedMap, a new Web-based mapping system, will provide tree improvement clients (ministry and non-ministry) with direct access to seed planning maps and associated spatial and attribute data summary reports that were previously unavailable or available only in limited formats.

Access to this new information will give clients the tools to assess current and projected seed needs, develop appropriate cone collection and seed supply access plans, identify areas for orchard expansion, and carry out sound forest practices. SeedMap will also make it possible for clients to integrate seed planning and tree improvement information (spatial and other) with resource management initiatives such as land use planning, timber supply reviews, integrated silviculture planning, and forest certification programs.

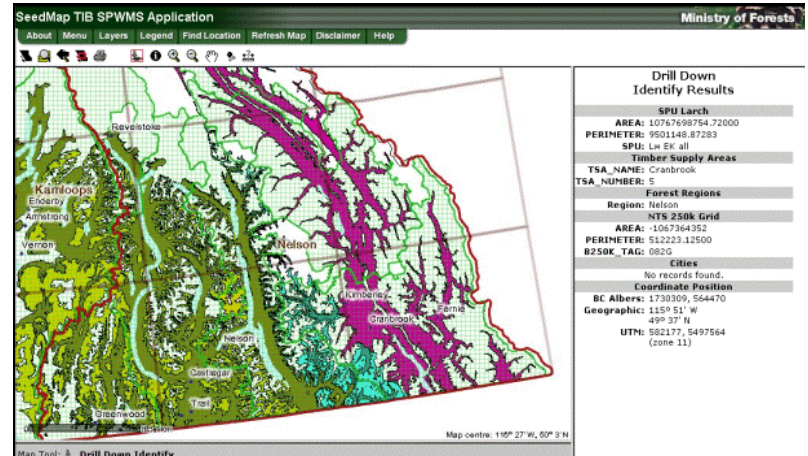
SeedMap will enable clients to select multiple reference map layers (e.g., seed planning zones/units, biogeoclimatic ecosystem classification, management unit¹⁵ boundaries, forest region/district boundaries, TRIM¹⁶ data) and view them on-line or as printed 8½" x 11" maps.

Clients will be able to query spatial polygon information, search locations/features, and measure distances. Non-spatial summary reports (e.g., Species Plan¹⁷ timelines, seed use, genetic gain, and inventory/production)

based on current (SPAR/ISIS)¹⁸ and projected (Species Plan) data will also be available through a report menu option or as a spatial query detail report.

SeedMap is being developed using ARC IMS, ESRI Canada Limited software, and client server-based technology. The SeedMap application will be accessed directly through a client's Internet browser without the need for additional desktop software or plug-ins. Non-ministry clients will access SeedMap via an Extranet User ID. A pilot of SeedMap is planned for spring 2001. A direct link to the new SPAR Web application is also planned (SPAR Web, July 2002).

¹⁸ SPAR is the MOF Seed Planning and Registry system; ISIS is the MOF Integrated Silviculture Information System.



¹⁵ E.g., tree farm licence or timber supply area.

¹⁶ Terrain Resource Inventory Mapping (TRIM)

¹⁷ Species Plans are 10-year projections of orchard production and genetic gain.

2000 Seed Orchard Crop Information

submitted by Spencer Reitenbach

The following tables summarize the 2000 cone crop for British Columbia's interior and coastal seed orchards as of June 18, 2001.

2000 Interior Seed Orchard Crop Summary

Species	Orchard #	Agency	Seed planning zones	Seedlot	Genetic worth	Cone vol. (hL)	Seed (kg)	Potential seedlings (000s) ^a
Lw	332	MOF	NE, NEK	60732	2	18.00	17.56	1 421.8
Lw	333	MOF	EK, NEK	60733	2	38.40	43.23	4 321.4
Lw	Total					56.40	60.79	5 743.2
Pli	310	Riverside	TO, TON	60151	10	15.80	2.24	269.8
Pli	307	MOF	NE, PGN, TON	60731	6	74.60	16.33	1 716.6
Pli	219	VSOC	BV, BVC, BVP	61033	10	39.80	5.54	554.6
Pli	222	VSOC	PG, BVP, CPP, PGN	61034	8	7.75	0.61	60.0
Pli	220	MOF	PG, BVP, CPP, PGN	61049	6	13.36	4.82	615.7
Pli	223	MOF	CP, BVC, CPP	61050	6	12.13	4.75	573.1
Pli	228	MOF	BV, BVC, BVP	61051	6	25.65	10.97	1 324.1
Pli	203	MOF	PG, BVP, CPP, PGN	61052	2	11.40	4.06	525.1
Pli	308	Weyer	TO, TON	61123	6	36.80	4.62	595.4
Pli	311	Weyer	TO, TON	61124	15	7.60	0.95	96.6
Pli	Total					244.89	54.89	6 331.0
Pw	609	MOF	KQ	60293	n/a	20.00	3.38	48.7
Pw	335	MOF	KQ	60734	2	19.00	9.62	212.7
Pw	Total					39.00	13.00	261.4
Sx	306	MOF	NE, NEK, PGN, TON	60735		10.00	1.71	217.5
Sx	Total					10.00	1.71	217.5

^a Potential number of seedlings is calculated using the 1999 Ministry of Forests Sowing Guidelines.

2000 Coastal Seed Orchard Crop Summary

Species	Orchard #	Agency	Seed planning zones	Seedlot	Genetic worth	Cone vol. (hL)	Seed (kg)	Potential seedlings (000s) ^a
Ba	129	TFL	M	61069	2	3.00	8.96	30.7
Ba	Total					3.00	8.96	30.7
Cw	139	Canfor	M	61062	2	0.06	0.10	19.5
Cw	140	TFL	M	61067	4	13.75	6.18	1 100.8
Cw	140	TFL	M	61068	4	2.25	1.67	275.1
Cw	128	WFP	M	61130	2	8.95	0.62	107.1
Cw	128	WFP	M	61131	2	1.00	0.02	4.2
Cw	128	WFP	M	61132	2	3.34	0.08	11.5
Cw	155	WFP	M	61135	2	0.79	0.18	36.2
Cw	155	WFP	M	61136	2	15.05	4.51	963.5
Cw	139	Canfor	M	61137	2	0.60	0.78	157.2
Cw	Total					45.79	14.14	2 675.1
Fdc	169	WFP	M, GL	61090	15	2.60	0.52	12.3
Fdc	134	TFL	M, GL	61119	11	12.00	3.39	100.4
Fdc	134	TFL	M, GL	61120	9	15.50	4.10	122.8
Fdc	154	TFL	M, GL	61121	6	15.50	5.73	161.4
Fdc	154	TFL	M, GL	61122	9	32.00	12.09	393.3
Fdc	166	WFP	M, GL	61127	10	10.86	3.06	98.1
Fdc	166	WFP	M, GL	61128	13	2.55	0.80	21.9
Fdc	169	WFP	M, GL	61129	10	10.62	2.46	71.2
Fdc	177	Canfor	M	61146	17	n/a	0.18	5.2
Fdc	Total					101.63	32.33	986.6
Hw	127	WFP	M	60400	4	0.21	0.43	74.2
Hw	126	WFP	M	61133	11	7.35	12.25	1 910.0
Hw	126	WFP	M	61134	9	29.87	32.97	5 187.3
Hw	133	Canfor	M	61138	10	1.40	0.10	10.9
Hw	133	Canfor	M	61139	4	n/a	0.33	39.2
Hw	Total					38.83	46.08	7 221.6
Pw	175	MOF	M, GL, SM	60676	n/a	19.20	10.64	215.3
Pw	174	Canfor	M	61058	n/a	n/a	1.29	19.5
Pw	174	Canfor	M	61063	n/a	n/a	0.62	8.0
Pw	403	TFL	M	61070	n/a	-	2.39	30.6
Pw	Total					19.20	14.94	273.4

^a Potential number of seedlings is calculated using the 1999 Ministry of Forests Sowing Guidelines.

Forestry and Forest Genetics in the Food and Agriculture Organization of the United Nations

submitted by Alvin Yanchuk

From June 2000 to January 2001, Dr. Alvin Yanchuk, B.C. Ministry of Forests Research Branch, worked on secondment with the Food and Agriculture Organization (FAO) in Rome, Italy, under the FAO/Canadian Government Partnership Agreement with Research and Academic Institutions (PARAI). This article highlights some of Dr. Yanchuk's experiences while working in the FAO Forest Genetic Resources Program. For more information, see <http://www.fao.org/forestry/fo/subjects/subject-e.stm>.

FAO participates in many complex political, biological, and ethical issues, including the development, ownership, and rights to genetic resources in agriculture and forestry.

The PARAI agreement stipulates that FAO and the sponsoring agency agree on a work program that benefits both organizations. The PARAI is an important means to maintain technical competency in FAO programs, and to expose scientists and academics from Organization for Economic Cooperation and Development (OECD) countries to important technical and political issues around the globe.

I was overwhelmed to see the many complex forestry problems worldwide, and those specific to forest tree genetic resources. Technical staff at FAO are highly experienced—many come to the head office in Rome after gaining experience in developing countries in regional FAO offices.

With its 180 supporting member countries, which pay annual dues directly to FAO, FAO works with governments and non-government organizations, international organizations, financial institutions, the private sector, and various community and interest groups for sustainable conservation and use of forest and tree resources. Imagine trying to do all that with a total staff of about 200 spread around the world!

Forestry is one of the four main departments in FAO, along with crops, and animal and fish resources. Forests are critically important to the welfare of many people in

developing countries, who depend on them for much of their food, non-wood forest products, and fuel for heat and cooking. All four main departments serve member countries and relevant institutions in information, policy, and planning, and offer a neutral forum for discussion of complex international issues.

The forestry department has specific programs in forest management and conservation, forest utilization, and technical co-operation. The last program is essentially FAO's consultancy role to specific short-term projects in member countries. The dedication of FAO forestry staff impressed me, especially considering the sensitive and difficult political and climatic environments in which they work.

I found the issues in forest management, use, and conservation in British Columbia almost trivial compared with elsewhere. This is especially true in many of the tropical, or very arid, forested areas and particularly in forest ecosystems close to high population densities. North America is viewed as being rich, featuring forest environments that are ecologically robust and under little serious ecological threat, and having ample infrastructure and expertise to deal with forestry issues. Yet we are seen as unsure of our direction despite spending a lot of money on forestry management and research. Our concerns about many of the issues we take so seriously are viewed somewhat skeptically and are certainly not a luxury afforded most other places.

FAO is asked to participate in many highly complex political, biological, and ethical issues. One such issue was the worldwide concerns over who is developing and claiming ownership and rights to genetic resources in agriculture and forestry. Within this are specific concerns over the development, use, and control of genetically modified organisms (GMOs). Either rightly

or wrongly, GMOs are considered substantially different than traditionally bred varieties that currently make up our food supply. This topic has centralized much of the debate about the rights of farmers, country of origin of germplasm, and the re-analysis of various articles in the Convention on Biological Diversity. Ethics is one of the main issues—who has the moral authority to develop and control the global food supply.

All these issues are highly relevant to forestry as well, and we can learn from the issues in agriculture. Clearly, the use and development of transgenic crops and trees will continue, and will be considered useful and valuable technology for some situations, but they cannot replace traditional breeding programs. More importantly, however, there is now an acknowledged need to limit exclusive development and ownership rights of private corporations. Great resistance will continue to world food and fibre security being left in the hands of a few large companies. Governments will have to deal with biotechnology development to maintain certain aspects of it in the public domain.

My specific projects dealt with reviewing the developments in biotechnology related to forestry,¹⁹ analyzing an e-mail conference on the suitability of biotechnology for developing countries, reviewing a past *ex situ* conservation initiative for three central American pines, reviewing a global database of forest genetic resources (REFORGEN), and helping to write and edit a series of guidebooks on the conservation of forest genetic resources for developing countries. These guidebooks were produced with staff from the International Plant Genetic Resources Institute and the DANIDA Forest Tree Seed Center.

The FAO experience was a unique opportunity to learn about global issues in forest genetics research management (FGRM). My wider appreciation of breeding and conservation problems in forest ecosystems around the world allowed me to evaluate how British Columbia's programs

and technical approaches to FGRM differ. With most species, conservation of forest resources will primarily occur within natural forest management systems where local peoples must strongly accept and buy in. In many ways, then, gene conservation will largely move from a genetic and ecological issue, to a social issue. Our situation in British Columbia is substantially different, although we may think it isn't so.

The largest reality check I experienced was from an e-mail that was circulated around FAO, from FAO representative Carlos Caseras in West Timor during the period of violence associated with the East Timor vote for independence from Indonesia. In the e-mail, sent from his office on September 6, 2000, Mr. Caseras described his situation:

"...I was in the office when the news came out that a wave of violence would soon pound Atambua. We sent most of the staff home, rushing to safety. I just heard someone on the radio saying that they are praying for us in the office. The militias are on the way, and I am sure they will do their best to demolish this office..."

You should see this office. Plywood on the windows, staff peering out through openings in the curtains hastily installed a few minutes ago. We are waiting for this enemy, we sit here like bait, unarmed, waiting for wave to hit. I am glad to be leaving this island for three weeks. I just hope I will be able to leave tomorrow.

As I wait for the militias to do their business, I will draft the agenda for tomorrow's meeting on Kupang. The purpose of the meeting: to discuss how we are to proceed with this operation."

Mr. Caseras was brutally executed two hours after sending the message.

When we get hung up on what we think are complex forest management issues and think times are tough because of political decisions, bureaucracy, and different ideologies, we should try to remember people like Carlos and put things in context. We do have our own set of challenges here in North America, Canada, and in particular British Columbia, but relatively speaking they should be biologically and politically easy to resolve compared with other places on the planet.

Working with the FAO was a unique opportunity to learn about global issues in forest genetics research management.

While B.C. has its own challenges, in comparison with other places, these should be easy to resolve.

¹⁹ Yanchuk, A.D. [2001]. The use and implications of biotechnological tools in forestry. Unasylva. In press.

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