TICtalk

FGC Forest Genetics Council of British Columbia

Information for and from the tree improvement community of British Columbia

Volume 5, Number 1, January 2003

Fifth Edition

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

The past year has been rich with results from Council member efforts over the last five years.

Most notable has been the "takeoff" of the Centre for Forest Gene Conservation, established in 2000 at the University of British Columbia. This issue of TIC*talk* contains an overview of the Centre and five articles on studies underway in 2002/03.

Another remarkable achievement is the completion of SelectSeed's first phase in expanding British Columbia's seed production capacity. Twelve new orchards have been established, and two more will be planted in spring 2003.

Dr. John Barker, recipient of the second FGC Achievement Award, submits this issue's personal experience article—*Reflections on 50 Years of Tree Improvement in Coastal British Columbia.*

We hope you will enjoy these and other features in this issue.

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

Barker Receives FGC Achievement Award

Dr. John Barker, Forest Renewal BC Chair in Silviculture at the University of British Columbia (retired), is the second recipient of the FGC Achievement Award. FGC co-chair Dale Draper presented the award at the June 2002 FGC meeting in Vernon.

Much of John's career has been dedicated to tree improvement in coastal British Columbia, including work at Western Forest Products' Lost Lake Seed Orchard. He helped establish the Coastal Tree Improvement Council and Coastal Technical Advisory Committee, and has been a long-serving member of the Forest Productivity Council. John was appointed to the Interim Tree Improvement Council in 1996/97, and has been an FGC Councillor since the FGC's inception in 1997.

Council established the FGC Achievement Award in 1999 to recognize outstanding contributions to forest gene resource management in British Columbia.

INSIDE

Forest Gene Resource Management Program Update

FII Funding

The tree improvement community has been very pleased that the provincial forest gene resource management program was eligible for funding under the Forestry Innovation Investment (FII) program. Without this support, the important work being carried out in forest gene conservation, seed production, and tree breeding was at risk after the termination of the Forest Renewal BC Tree Improvement Program. Fortunately, the program activities have carried on with little interruption despite the major shift in funding source. It remains to be seen whether the program will be affected by the change to an annual, rather than multi-year, commitment.

Annual FII funding replaces Forest Renewal BC's multi-year commitment.

Change in Secretariat Services

As part of its efforts to reduce operational costs, the Forest Genetics Council (FGC) has decided to forego the services of a secretariat. Beginning in fiscal year 2003/04, the secretariat's responsibilities will be shared between the FGC Program Manager and the Ministry of Forests (MOF) Tree Improvement Branch. Jack Woods, FGC's Program Manager, will take on some of the duties of the executive secretary, including maintenance of the FGC Web site. Council meetings will be organized by Roger Painter, the MOF Tree Improvement Coordinator. Tree Improvement Branch Extension Services will produce TIC*talk* and other program-level communications.

SelectSeed Enters New Phase

By spring 2003, SelectSeed will have completed the first phase of its primary mandate—the expansion of seed production capacity.

Fourteen new orchards will have been established at five private facilities: Kettle River Seed Orchard Company (Pli PG low, Pli CP low); Pacific Regeneration Technologies (Fdi NE low, Pli NE low, Pli TO low); Riverside Forest Products Ltd. (Sx TO high, Sx TO low, Pli TO high); Sorrento Nurseries (Pli CP low, Pli BV low); and Vernon Seed Orchard Company (Fdi QL, Fdi PG, Pli PG low, Pli BV low).

These orchards bring the total provincial orchard complement to the level needed to meet the FGC objective of supplying select seed for 75% of total provincial sowing needs.

Future SelectSeed activities will focus on managing and maintaining the new orchards. The first crops are expected in 2007.

SelectSeed has established 14 new seed orchards for interior Douglas-fir, lodgepole pine, and spruce.

MOF Seed Orchards

The MOF recently announced that despite considerable interest in its request for proposals (RFPs) to lease six of the ministry's tree seed orchards, no proposals were received by the closing date of October 31, 2002. The ministry plans to continue to operate the six seed orchards on a cost-recovery basis, and to close its two economically non-viable orchards (Cobble Hill and Campbell River) by March 31, 2003.

Many Councillors were concerned about the outcome of the RFP. At its last meeting (December 9, 2002), Council asked the chief forester to re-examine the MOF mandate related to the seed orchard business.

Gene Resource Information Systems

Much progress has been made in the technology behind gene resource information systems available to the tree improvement community. Most notable are SeedMap and SPAR Web, the MOF's newly released Web applications. Both applications are accessible from the Tree Improvement Branch home page (*www.for.gov.bc.ca/TIP*).

FGC Extension

FGC cooperators undertake a range of extension, communication, and education activities based on an annual plan and call for proposals.

Council's Extension and Communication Technical Advisory Committee (ETAC) funded four types of extension and communication activities in 2001/02:

FGC cooperators completed 20 extension and communication projects in 2001/02.

Workshops (5)

Three one-day seed workshops examined how to order and acquire select seed and new nursery technologies. Two one-day workshops focused on provincial seed planning, policy, and programs in British Columbia. About 200 people, representing MOF regions and districts, consultants, and forest licensees, participated in the five workshops.

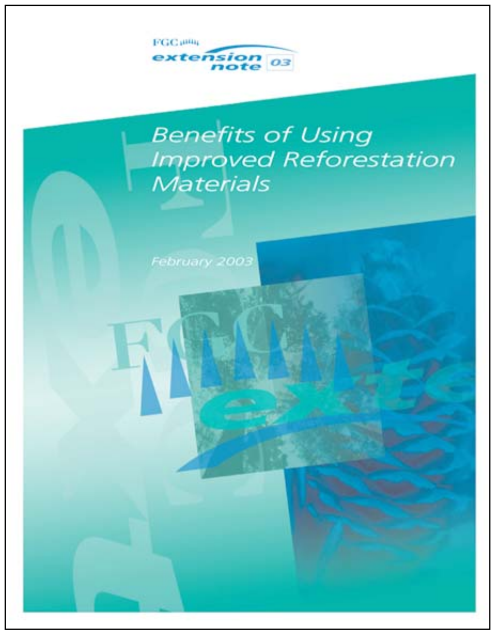
Select seed is produced in seed orchards throughout the province, and represents about 43% of provincial sowing needs. These workshops promote a better understanding of select seed use and advantages, especially with respect to AAC and forest productivity.

Tours and Related Reports (3)

A cross-section of 31 seed users attended a one-day field tour of research and demonstration installations; a report summary of tour questions, answers, and discussion was produced. A study investigating operational plantations to demonstrate the coastal Douglas-fir breeding program recommended establishment of a program of operational trials.

Extension Materials (9)

- Outreach materials for use by Timber Supply Area committees: *Delivering Genetic Gain*, and a prototype *Seed Supply Profile for Golden TSA.*
- Extension note, article, and frequently asked questions on *Benefits of Using Improved Reforestation Materials.*
- Contribution to production of the *Seed Handling Guidebook.*
- Contribution to *Field Guide to Reproductive Biology for Western White Pine.*
- First draft booklet on *The Reproductive Biology of Western White Pine.*
- Display kiosk on tree improvement activities at the Cowichan Lake Research Station.



Benefits of Using Improved Reforestation Materials discusses how improved reforestation materials are developed and used in British Columbia, and what types of benefits are associated with their use.

Technical Reports (3)

Technical reports were produced on the topics of incorporating genetic gain in timber supply analysis, assessing investments in tree improvement activities, and characteristics of inventoried seed for seed planning units.

Extension materials are available on request from Tree Improvement Branch Extension Services, or as downloadable PDFs from the FGC Web site (www.fgcouncil.ca).

Centre for Forest Gene Conservation at UBC

submitted by Sally Aitken

It's easy to support a motherhood statement like "genetic diversity should be conserved." After more than a decade of attention to this topic, most of us realize that genetic variation provides the raw material for future selection in tree improvement programs for new traits (e.g., resistance to new insects or diseases, or changes in fibre quality to meet new industrial demands). We also realize that natural populations require genetic diversity to adapt to new environmental conditions, to allow evolution to proceed. But how do we go about conserving genetic diversity, and how can we rigorously assess whether we are meeting this goal?

Three years ago, the Forest Genetics Council realized that, while gene conservation continued to be a high priority, this objective was not being met in a strategic and rigorous manner. As a result, the Centre for Forest Gene Conservation (CFGC) was established in the Department of Forest Sciences at the University of British Columbia (UBC). The CFGC has a mandate from the FGC, developed by the Gene Conservation Technical Advisory Committee (GCTAC), to:

- inventory and catalogue forest tree gene resources
- support information and policy requirements related to forest gene conservation
- provide gene conservation expertise to support and integrate with other biodiversity and forest ecosystem conservation efforts in British Columbia
- develop and advance gene conservation theory through research and collaboration with other agencies worldwide
- support FGC objectives by improving the efficiency of gene conservation in seed planning units (species, seed zone, elevational band) where genetic improvement is being actively carried out or where forests are being managed using natural regeneration
- carry out communication and extension on gene conservation to the forestry community and public
- assess risks related to biological, policy, and administrative factors, and provide recommendations to FGC on mitigating these risks.

Gene conservation is accomplished primarily in two ways: *in situ* and *ex situ*. *In situ* conservation is the long-term maintenance of genetic diversity in wild populations, typically in conservation reserves. These populations can continue to adapt and evolve, and to self-regenerate, in these reserves. The primary concern for *in situ* conservation is that population sizes are large enough for the long-term maintenance of genetic diversity (5,000 individuals of reproductive age is a good target) and that reserves are located in different geographic areas to maintain populations adapted to different environmental conditions. In the article *Cataloguing* in Situ *Gene Conservation in Protected Areas*, Dr. Andreas Hamann, Research Associate with the CFGC, describes how we are using geographic information systems (GIS) and spatially explicit databases to catalogue the degree of protection of 48 tree species in British Columbia in reserves that fall under the provincial Protected Areas Strategy.

Ex situ conservation maintains genetic diversity in seed banks, clone and tissue banks, breeding populations, and arboreta. It typically provides a back-up to *in situ* conservation, but often has smaller sample sizes. One of our graduate students, Washington Gapare, is developing efficient sampling methods for *ex situ* conservation, focusing on the ability to capture rare alleles (genetic variants). Rare alleles are those most likely to be missed when sampling for gene conservation. Some rare alleles may be vital for meeting future genetic needs, such as

In its first two years, the CFGC has initiated 8 projects investigating:

- **whitebark pine genetics**
- **protected areas and gene conservation**
- **capture of rare genetic variants**
- **genetics and certification**
- **research needs for minor species**
- **genetic issues with climate change.**

those conferring resistance to the white pine shoot tip weevil in Sitka spruce, or blister rust resistance in the white pines.

The role of maintenance of genetic diversity in third-party forest product certification was the focus of a project involving Dr. Justin Stead, Director of the Global Forests and Trade Network of the World Wildlife Fund, and Graeme Auld and Dr. Gary Bull of the Department of Resource Management in the Faculty of Forestry at UBC. This project investigated the role of genetic criteria and indicators in forest certification. A workshop held at UBC in January 2002 discussed the results of and solicited feedback on this project. The resulting report, summarized in the article *Forest Certification and the Management of Forest Genetic Resources*, shows the need to develop robust indicators of the maintenance of genetic diversity to back up vague objectives relating to genetics.

Developing strategies to meet the specific gene conservation needs of species often requires species-specific information on patterns of genetic variation. We have sound data on genetic variation for B.C. species of major economic interest, but know very little about genetic variation in other tree species in the province. Part of our mandate is to determine patterns of variation for these so-called minor species. Our approach to this problem was (1) to initiate a project on genetic diversity in whitebark pine, a species previously found to be at risk, and (2) to prioritize other species for attention.

The article *Genetic Diversity and Mating System in Whitebark Pine* describes the interesting results of Jodie Krakowski's MSc research. Her work has contributed greatly to the development of a gene conservation strategy for this high-elevation, keystone species, and raised additional questions leading to the current PhD research of Andy Bower at UBC.

To prioritize remaining species for gene conservation research, we used three approaches. First, we surveyed foresters, botanists, and naturalists in the province to collect field observations on the current status of these species. Second, Dr. Pia Smets reviewed the literature of what is know in terms of the genetics and ecology of all of these species. Third, we compiled the results from the project cataloguing *in situ* protection of these species. Finally, we convened an expert workshop at UBC in March 2002, to discuss the results of all of these approaches and to rank species for attention by the CFGC. This effort is summarized in the article *Prioritizing Minor Species for Gene Conservation Research.*

For more information and reports, visit the CFGC Web site:
www.genetics.forestry.ubc.ca/cfgc.

Work in 2003 will include:

- **initiating a project on genetics and climate change**
- **completing projects on *ex situ* conservation of rare alleles and *in situ* maintenance of genetic diversity**
- **continuing a genecological study of adaptive variation in whitebark pine.**

Cataloguing *in Situ* Gene Conservation in Protected Areas

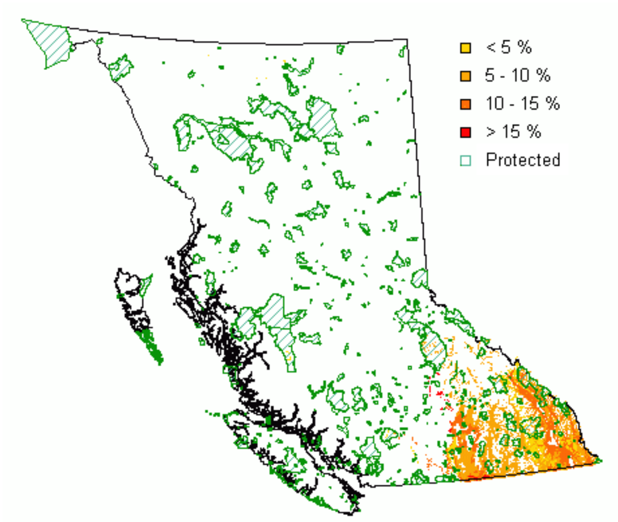
submitted by Andreas Hamann

Loss of genetic diversity in wild populations can have a variety of causes and might take place unnoticed even in species that seem to be in no danger. Establishing *in situ* reserves is an efficient method of protecting genetic diversity in tree species with populations that are sufficiently large and well distributed spatially. A common approach to assess the level of protection needed is to collect census information on the population size and distribution for tree species of concern. Geographic information systems (GIS) can then be used for analysis of spatial threats (such as habitat destruction), gap analysis (such as lack of protection in a particular region), and reserve evaluation (based on the redundancy or uniqueness of genotypes they contain).

Range Maps

Some tree species in British Columbia are common and virtually ineradicable, while others exist only in a few populations. In a first assessment, undertaken in cooperation with the B.C. Ministry of Forests and B.C. Ministry of Sustainable Resource Management, we determined where species fall along this risk continuum. This information will help to assess the types of data needed and efficiently allocate resources for subsequent analytical work to species. We used existing records on percentage cover of species in vegetation plots by biogeoclimatic ecological classification (BEC) variant from the provincial ecology program to map the distributions of 48 tree species, and combined these data with the current protected areas in the province. The map shows an example of the distribution of western larch and the locations of protected areas. As can be seen, only the protected areas in the southeast quadrant of the province may be important reserves for this species.

Range and expected percentage cover of western larch



Establishing *in situ* reserves is an efficient method of protecting genetic diversity in tree species with populations that are sufficiently large and well distributed.

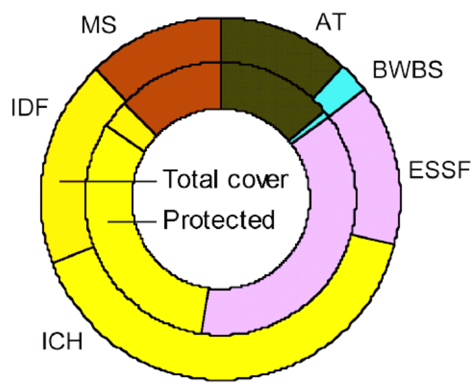
Gap Analysis

The estimation of the species range and expected coverage can be used to extract a variety of useful measures of genetic diversity protection through GIS queries:

- How common is the species?
- How large is the natural range of the species?
- In what regions and BEC variants does the species occur?
- How well are different regions covered by protected areas?

The following figure shows cumulative cover for western larch by BEC zone, in the province (outer ring) and in protected areas (inner ring). Larch is under-represented in protected areas in the IDF and BWBS zones, compared with its provincial occurrence.

Cumulative cover of western larch by BEC zone



Next Steps

In a landscape-level analysis of *in situ* protection of genetic resources, we assume that genetic differentiation has tracked geographic, climatic, and ecological variation. The idea behind this "coarse filter" approach to gene conservation is that by providing spatial coverage of ecological and landscape-level units, we will automatically cover the range of genetic variation as well. However, unusual genotypes may be located in outlying populations or at the fringe of the species range. These populations are of special interest to tree breeders but are likely to fall through a coarse filter approach. Genetic information may lead us to using a regional stratification other than BEC zones as in this first analysis. Our initial estimates need to be refined further by incorporating other factors including non-forested areas, stand age, and population sizes.

Prioritizing Minor Species for Gene Conservation Research

Submitted by Andreas Hamann

While our understanding of genetic structure of major conifer species is extensive, we know relatively little about other tree species. Studies of the genetic structure of some minor tree species will be useful for investigating the current degree of protection of genetic resources, for selecting insect or disease resistance in species that may be affected by introduced pests, and for developing seed transfer guidelines for restoration plantings.

Prioritizing Tree Species

Because not every species can be investigated, we need to focus on trees that are representative of a larger group of species with similar distribution (e.g., widespread or narrow, and rare or common) and life history attributes (e.g., wind or insect pollinated, wind or animal dispersed seed, early or late successional), or for species that are likely to experience loss of genetic diversity due to reductions in population size.

We used several sources of information to prioritize minor tree species for further genetic research and conservation: (1) a literature review on species-specific issues such as pests, regeneration capacity, and economic, ecological, and cultural values; (2) first results from the GIS survey for the extent of current *in situ* protection; and (3) a survey soliciting field observations of professionals who work with particular species.

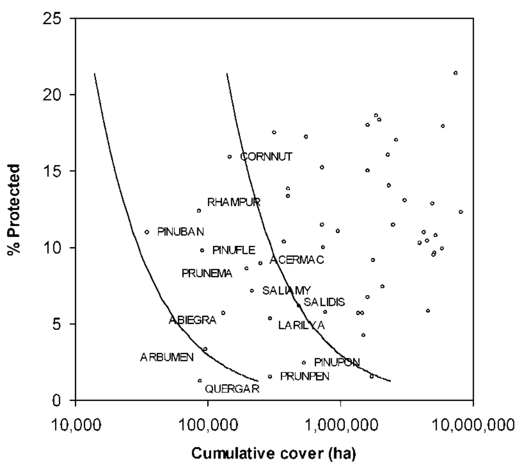
Results of the GIS survey for all three species in British Columbia are displayed in the following figure for comparison. Species that are located in the lower left corner of the graph are least abundant (x-axis) and least protected (y-axis). Examples are arbutus (ARBUMEN) and Garry oak (QUERGAR). Curves indicate an equal area protected. For example, Pacific dogwood (CORNNUT) and bigleaf maple (ACERMAC) have equal *in situ* protection. However, dogwood has a larger percentage of a smaller total area protected. This information can also be used to assess the feasibility of additional conservation efforts. For example, reserves for species that fall into the lower right

Experts ranked species for attention based on:

- **a literature review of species-specific issues**
- **first results from the study on the *in situ* protection of these species**
- **a survey soliciting field observations from professionals.**

corner of the graph may easily be found if necessary.

Current status of *in situ* protection. Cumulative cover is calculated as range (ha) x average cover (%). Curves indicate an equal area protected.



The results were presented to an expert panel in a workshop at the University of British Columbia in March 2002. The panel ranked minor species for further research in consideration of this new information and projects that have already been initiated (see table). Although whitebark pine and Garry oak are high priority species, as indicated by the survey, they received fewer expert votes at the workshop than some other species. This result reflects the recognition of the research currently underway by the Centre for Forest Gene Conservation (CFGC) and the Garry Oak Task Force. Over the coming months, we will begin projects on some of the high-ranking species.

The top 10 ranking species for genetic research or conservation activities based on votes from an expert panel

Scientific name	Common name	Abbreviation	Expert votes	Survey replies
Arbutus menziesii	Arbutus	ARBUMEN	13	4
Cornus nuttallii	Pacific dogwood	CORNNUT	8	1
Pinus flexilis	Limber pine	PINUFLE	7	1
Salix scouleriana	Scouler's willow	SALISCO	6	4
Quercus garryana	Garry oak	QUERGAR	4	10
Crataegus douglasii	Douglas hawthorn	CRATDOU	4	2
Juniperus scopulorum	Rocky Mountain juniper	JUNISCO	3	3
Populus tremuloides	Trembling aspen	POPUTRE	2	4
Malus fusca	Pacific crab apple	MALUFUS	2	2
Pinus albicaulis	Whitebark pine	PINUALB	1	12

Genetic Diversity and Mating System in Whitebark Pine

Submitted by Jodie Krakowski

Obtaining baseline data and conserving genetic variation are critical to the long-term survival of whitebark pine. This tree provides important non-commercial attributes including wildlife food, slope stability, hydrological modification, and aesthetic quality.

While other studies have focused on the United States and along the B.C.–Alberta border, this study evaluates population genetic diversity of whitebark pine in British Columbia, which encompasses a huge proportion of the species' natural range and will be of critical importance as rapid climate change affects temperate high-elevation ecosystems. This is also the first study to quantify the amount and type of inbreeding in the species, key information for sound long-term management, where inbreeding depression and disease resistance both affect the fitness and resilience of this species.

Identifying populations harbouring genetically unique trees may enable managers to incorporate genetics via visual screening in the field for disease resistance.

Methodology

This study was conducted throughout British Columbia (see map), and included one population from northern Washington and three from the Alberta Rockies. Seeds were collected from two populations in the B.C. southern Interior (Manning Park, #18, and Mount Baldy ski area, #19) to assess the mating system, and buds and needles were collected from all other populations.

Seeds were germinated and genetic diversity parameters were measured using protein electrophoresis of the maternal tree seed tissue and embryos. This technique enables detection of some selectively neutral genotypic differences based on protein alleles from the mother and father passed down to the embryos.

It also gives insight into the nature and magnitude of genetic diversity found within individuals, and provides an index for comparing populations based on the amount of genetic differentiation. Vegetative tissue was also assessed using protein allozymes, and population genetic parameters were determined.

This study is the first to quantify the amount and type of inbreeding in whitebark pine.

Collection sites

The mating system was determined based on differences between the genotypes of the embryo and maternal trees, and the potential pollen donors. If the genotypes of the pollen and maternal seed tissue were the same for all loci, then the embryo was the product of self-pollination (selfing). If the seed and pollen came from different trees, then the embryo was produced by outcrossing, which may include mating among relatives (e.g., siblings, where the trees had the same mother but different fathers).

Findings

Inbreeding, and even some selfing, was frequent in this species. Individual trees varied considerably in their tolerance of selfing (i.e., some trees produced selfed seeds but others did not, implying that selfed seeds may abort in some trees due to their low fitness). However, both populations had a widely spread outcrossing rate distribution (see graphs), implying that some trees within each population were highly tolerant of inbreeding, while others were generally outcrossers, requiring unrelated individuals for successful mating. The size of the differences between single-locus (for each individual protein assayed) and multi-locus (effects of all genes combined) outcrossing rates revealed that at Mount Baldy, most inbreeding was due to self-pollination, whereas at Manning Park, inbreeding was more often caused by mating among relatives.

Whitebark pine had heterozygosity (different genetic contributions from each parent, therefore definitely not a result of self-pollination) within the expected range for similar species, and comparable with levels found in other studies of this species. Observed heterozygosity (levels counted from genetic analysis) was generally lower than expected heterozygosity (calculated under ideal assumptions), especially in the northwest (north Coast Mountains). This heterozygote deficiency was statistically highly significant, and decreased towards the southeast (southern Rocky Mountains), the area in which pine blister rust was most prevalent and caused the greatest mortality.

A strong pattern of increasing genetic diversity was observed to the south and east, with heterozygosity much lower than that which would be assumed under ideal conditions in the north and northwest.

This pattern likely reflects whitebark pine's gradual range expansion from a few glacial refugia in the Washington and Oregon Cascades, and many refugial populations in the more topographically complex Rocky Mountains.

Within-population inbreeding was substantiated by high F_{IS}, an index of inbreeding within populations determined by allele frequencies. Whereas 94% of the total genetic variation was partitioned among individuals within populations, 6% of the genetic variation accounted for most population-level differences.

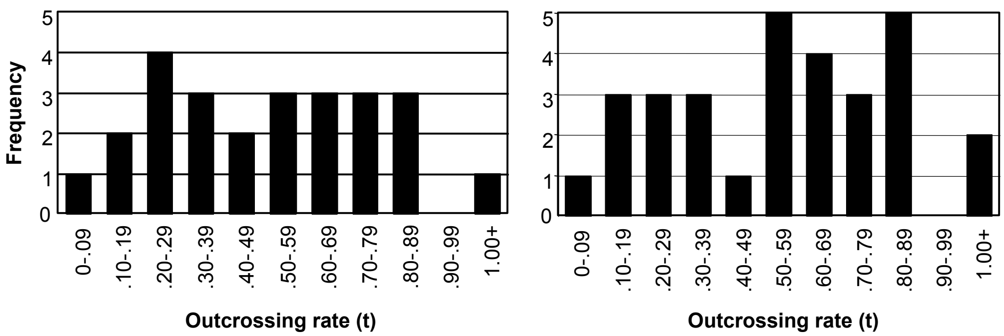
Bird seed caching is clearly responsible for the strong population genetic structure, reinforcing family patterns as related trees within a clump respond similarly to environmental cues and would be more likely to have synchronous reproductive phenology. While individual trees vary in their selfing tolerances, the differences between the populations were striking. A possible reason for this is that following glaciation, the species recolonized its range from several isolated refugia containing populations adapted to different mating system dynamics. The widespread distribution of outcrossing rates could reflect the historical introgression of two mating system modes, selfing and outcrossing, as the populations expanded northwards and merged following post-glacial recolonization.

The high heterozygosity, decreasing to the north and west, could also reflect this same range expansion. The relative homogeneity of populations, their lack of private alleles, and their decrease in observed heterozygosity with increasing latitude might be due to successive founding of populations by bird caching with accompanying founder effects and subsequent gene flow.

Inbreeding, and even some selfing, was frequent.

A strong pattern of increasing genetic diversity was observed to the south and east.

Outcrossing rates for whitebark pine at Manning Park (left) and Mount Baldy (right).



One other possible influence is the white pine blister rust pathogen. While it is most virulent and frequent in the southern Rockies, population genetic diversity (observed heterozygosity) is highest in these areas—there is a heterozygote excess compared with statistical expectations under random mating assumptions. The pathogen could be exerting selection pressure favouring heterozygous genotypes that may harbour a mechanism (or a greater potential to adapt one) for blister rust tolerance or resistance. There may only be an indirect relationship between heterozygosity and blister rust tolerance/resistance: genetic variability is the underlying means by which species evolve. Higher heterozygosity thereby implies a higher likelihood that new combinations of alleles (through recombination, as trees produce offspring) may result in some physiological mechanism that assists trees in staving off disease.

Implications

The implications of this study for gene conservation focus on the ability of whitebark pine trees to withstand blister rust. Conserving sufficient numbers of individual trees within extant populations is a key first step to ensure that outcrossing is maximized to maintain an adequate seed supply and that new genetic combinations are created.

While whitebark pine is protected in parks throughout much of its native range in the Rocky Mountains and is buffered from direct human influence in the Coast Mountains due to its remote and rugged habitat, some human management activities may be desirable. Allowing wildfires to burn in whitebark pine habitat will decrease ecological competition from other species, reduce the presence of the blister rust host plant (*Ribes* species), and provide ideal seed caching sites for the Clark's nutcracker. Collecting seeds of putatively resistant trees (i.e., those that appear rust-free in the midst of a heavy infection) and planting seedlings in heavily rust-affected areas are other options. These strategies are especially important in the southern Rockies, where mortality is very high and there is little or no recruitment.

Other more expensive and labour-intensive options also exist, such as establishing a breeding program for whitebark pine to facilitate deployment of rust-resistant seedlings, or testing for a major resistance gene such as has been found in the related western white and sugar pines. These possibilities require years of intensive work and costly equipment. Taking the initial steps to minimize fire suppression in high-elevation areas and collect seed from putatively resistant trees are sure to enhance the success of whitebark pine where it is threatened by blister rust.

Conserving sufficient numbers of individual trees within extant populations will help to ensure maximum outcrossing to create new genetic combinations.

Minimizing fire suppression in high elevation areas, and collecting seed from resistant trees will enhance whitebark pine success.

Forest Certification and the Management of Forest Genetic Resources

Submitted by Graeme Auld and Sally Aitken

Since the early 1990s, certification—the independent assessment of forestry operations against a set of standards—has gained international attention as a new mechanism for assessing and encouraging responsible forest management practices. With interest in certification growing in the province's international markets, B.C. forest managers, the provincial government, and other stakeholders are wondering how British Columbia practices measure up.

Recently completed research at the Centre for Forest Gene Conservation (CFGC) examined the B.C. government's standards and requirements specific to forest genetic resources to determine how they might be assessed under four initiatives for certifying forest lands that could be applicable in British Columbia (see table). By analyzing documents and interviewing individuals involved in these certification initiatives, the research investigated how the standards and field audits assess the maintenance and conservation of forest genetic diversity. The findings were then compared with provincial standards and requirements specific to genetic diversity, to determine if or where conflicts exist.

General description of examined certification initiatives

Canadian Standards Association (CSA)
Non-profit, membership-based organization with volunteer, associate, and supporting members.
Managed development of the CSA Sustainable Forest Management system and controls the CSA mark.
Based on the criteria and critical elements in the Canadian Council of Forest Ministers (CCFM) standard. Companies seeking certification must localize these criteria and elements through public consultation.
Forest Stewardship Council (FSC)
Non-profit, membership-based organization with no governmental affiliations. Members split into social, economic, environmental chambers with voting equally divided between northern and southern interests.
Managed the development and now controls the international FSC principles and criteria (P&C) that outline the initiative's broad requirements.
Controls the development of nationally specific interpretations of the P&C through a network of endorsed national initiatives.
Accredits companies and organizations that wish to certify against the FSC P&C.
Pan-European Forest Certification (PEFC)
Non-profit, membership-based organization comprised of national members from 19 countries (mostly European, but includes the United States and Canada).
Provides a framework for certification based on the Pan-European criteria and indicators and operational level guidelines.
Sets requirements for members who want to receive endorsement for their national certification initiative.
Sustainable Forestry Initiative (SFI)
Conceived by the American Forest and Paper Association (AF&PA) as a code of conduct for its members, but has developed to offer members and non-members the opportunity to undertake third-party verification.
Controlled the AF&PA and the Sustainable Forestry Board (SFB) (a group of 40% industry CEOs and 60% outside interests) that watch over the implementation of and improvements to the SFI standard and deal with conflicts over non-compliance.

Sources: *www.pefc.org*, *www.fscoax.org/principal.htm*, *www.afandpa.org*, and *www.csagroup.org*

Results

Forest genetic resource policy in British Columbia addresses:

- genetic diversity (the variability within a species in a natural or artificially regenerated stand compared with the baseline)
- adaptation (the ability of trees to grow in local conditions)
- quality (the beneficial character of traits that bred trees are selected for)
- the use of genetically modified (GM) trees.

The different certification initiatives touch on some of these aspects of genetics, but not consistently or comprehensively. While the variability among and within the initiatives makes it hard to generalize about differences, two important differences between standards are noted.

First, the FSC is the only initiative that prohibits the use of genetically modified organisms (GMO) in certified forest operations and for research on these lands. While one national member of the PEFC initiative (France) also restricts GMO use, for the most part PEFC, CSA, and SFI place no restrictions on GMO use or research. These initiatives appear to less clearly prohibit any specific forest management tool.

The second difference is the extent to which the initiatives advocate management that mimics natural processes. The FSC and, to a lesser extent, the PEFC encourage management practices such as natural regeneration and emphasize preserving phenotypic variation in set-asides and reserves to ensure that endemic levels of genetic diversity are conserved.

In addition, and specific to the FSC, the assessment of an operation differs based on whether management is considered "plantation" or "natural" in character. Within natural forests, the emphasis on natural processes guides certification assessments, meaning natural regeneration and set-asides are required. Planting is mostly acceptable only where justifiable on ecological grounds. For plantation forest management, genetic diversity is promoted to reduce the risk of disease and pest outbreaks; the standards encourage planting genetically appropriate seed or vegetative material. In general, origin should be documented wherever planting is used.

The FSC is the only initiative that prohibits the use of genetically modified organisms (GMOs) in certified forest operations and for research on these lands.

The CSA and SFI make no distinction between management occurring in natural systems and plantations, allowing similar practices to occur in all forests. Overall, their standards and certification procedures focus broadly on biodiversity, rather than specifically on genetic diversity.

Requirements for CSA certification state that managers are to address the conservation of genetic diversity. How this is implemented, however, varies between companies, as specific indicators are set locally through a required public consultation process.

The SFI pays little attention to genetic diversity for conservation purposes. SFI requirements focus more on planting high quality genetic stock or vegetative material, and genetic diversity as a resource for ensuring the future productivity of managed forests.

Conclusions

Existing B.C. standards and requirements specific to forest genetic resources are not in conflict with the standards and requirements of the certification initiatives reviewed. However, each of the initiatives recognized a need to improve its standards on genetics. Highlighted were four issues that British Columbia's forest genetics community should be ready to address:

- generally increasing levels of scrutiny of seed selection and tree breeding programs
- higher thresholds set for minimum effective population sizes

Each certifying organization recognized a need to improve its standards on genetics.

- increased scrutiny of planting select seed in relation to declining ingress of natural regeneration
- attention to the genetic diversity of all forest flora and fauna.

Actively pursuing these issues and positioning British Columbia to meet certification requirements may become increasingly important to maintain the province's rich diversity of forest ecosystems and competitiveness in international markets. Research at the CFGC is addressing some of these issues. [*Editor's note: See, for example, Hamann's article* Cataloguing *in Situ* Conservation in Protected Areas.] These and other research efforts present an opportunity for British Columbia to lead the development of best practices for forest genetic resource management that other forested regions can emulate.

Adapting Forest Gene Resource Management to Climate Change

submitted by Sally Aitken

The importance of using appropriate populations as seed sources for reforestation has long been recognized, based on observed differences among populations within species for survival, growth, and resistance to biotic and abiotic stresses. Over 200 years ago, Linnaeus observed that yew trees from France were less cold hardy than those from Sweden, with obvious implications for reforestation.

Geographic patterns of genetic variation for traits related to adaptation to climate (e.g., timing of initiation and cessation of growth, cold and drought hardiness, and growth rates) are associated with climatic gradients in temperature and moisture. These observations have led to forest policies that legislate the use of relatively local seed sources for reforestation, particularly on publicly owned lands. However, the "local is best" approach assumes that offspring planted locally for reforestation will experience a similar climate to that experienced by their parents, grandparents, and more distant ancestors. We now know that this assumption is unlikely to be correct.

Substantive evidence that we are in a period of rapid global climate change is accumulating for both weather data and for biological responses to increased temperature over the past 30 years. Plant phenology, particularly the timing of growth onset in the spring, has advanced during this period of warming. Altitudinal ranges of some plant species are rising, and are predicted to climb an average of 400–600 m over the next century. This distance exceeds current allowable seed transfers for reforestation of almost all species in British Columbia.

Considerable uncertainty exists around future rates of climate change.

Strategies for reducing risk or mitigating effects of climate change need to take this uncertainty into account.

If global climate change results in even a small decline in growth rates of these forests, the net effect on long-term wood and fibre production nationwide could be substantial. This could have a negative impact on Canada in two ways. First, it could reduce the total resource available to the forest industry. Second, it could reduce the net amount of carbon fixed in Canada's forests. Severe maladaptation could result in Canadian forests becoming a net source rather than a sink for carbon.

Conversely, if the existing genetic variation in major forest tree species is selected from and vigorous genotypes are redistributed across the landscape, matched to environments for traits relating to adaptation to climate, the result could be a substantial increase in carbon fixation and a positive impact on Canada's carbon budget.

If predominantly local populations are used for reforestation, and climate warms rapidly (as predicted), forest productivity will likely decline in the short term for at least some species due to maladaptation of local populations to new climatic conditions.

For example, the work of G.E. Rehfeldt at *www.forestry.ubc.ca/schaffer/rehfeldt/index.htm#3* predicts responses to climate change based on analyses of the extensive B.C. lodgepole pine provenance trials. However, if stands are planted with non-local populations and climate change predictions are wrong, similar problems will result.

By deploying intimate mixtures of seed from select genotypes from disparate regions (and environments), the effects of climate change over a wider range of potential future conditions could be mitigated. As many more trees are planted per hectare than are harvested, the system has room to increase the adaptive diversity of seedlots without necessarily reducing stand productivity. The use of higher than current initial planting densities may also provide more opportunity for selection of the best-adapted individuals through intraspecific competition.

Forested areas where management activities include tree planting hold opportunities to match genotypes with environments as climate changes. In areas where natural regeneration is used following harvest, or in *in situ* gene conservation reserves where trees are not cut, populations will have to adapt to new conditions. The ability to evolve sufficiently rapidly to adapt to a changing environment is a function of the rate of environmental change per generation, the amount of genetic diversity, and the strength of natural selection on traits conferring adaptation to changing environmental conditions.

Relatively little attention has been paid to the potential role of adaptation in response to climate change.

The CFGC is exploring:

- **genetic strategies to mitigate the effects of climate change**
- **the potential for natural populations of forest trees to adapt to new climates without human intervention.**

Differences in adaptation to climate among populations in a trial at Red Rock, B.C.:

(a) a well-adapted lodgepole pine provenance from ~1° latitude south of the test site

(b) a poorly adapted provenance from ~6° latitude north of the test site

The CFGC was recently awarded a grant funded jointly by the NSERC Strategic Grants Program and the BIOCAP Canada Foundation. This grant will be used to explore genetic strategies to mitigate the effects of climate change, and the potential for natural populations of forest trees to adapt to new climates without human mitigation. The research team for this 4-year project includes Sally Aitken, Alvin Yanchuk, Rob Guy, Tongli Wang, incoming PhD student Kirstin Campbell, and one additional graduate student.

The project has three primary components:

1. Evaluation of the potential for mixtures of improved and unimproved genotypes from different provenances to buffer some effects of climate change and future climatic uncertainty. The responses to temperature of lodgepole pine populations inferred by Rehfeldt in simulations run using the TASS computer model under varying future climatic scenarios will be used.
2. Investigation of the underlying physiological responses of genotypes from different populations to both temperature and carbon dioxide to better understand and predict population responses to climate change. A series of growth chamber experiments with lodgepole pine and possibly one additional species will be undertaken.
3. Prediction of the ability of naturally regenerated populations of forest trees, in conservation reserves or in operational forest areas, to adapt to a rapidly changing climate by combining information from existing provenance and new genecological trials, for species to be determined.

Genetic Data Centre

submitted by Carol Ritland

History

The Genetic Data Centre (GDC) at the University of British Columbia is an inter-faculty facility set up to advise biologists on the relative advantages, precision, and costs of alternative techniques for molecular applications in population, quantitative, and conservation genetics, and provide space and equipment for their research. It is particularly valuable to people who have not invested in the equipment for molecular marker work, but who have research problems for which molecular genetics can provide new insight, direction, and results. The GDC's two state-of-the-art laboratories are located in the UBC Forest Sciences Centre.

Mandate

One of the GDC's mandates is to strengthen the training of graduate students, postdoctoral fellows, and faculty members in the use of molecular tools, data collection, and data analysis. The GDC infrastructure promotes and encourages collaborations within the University, and the extension of possible molecular genetic applications to workers throughout the province, Canada, and the rest of the world.

Forestry

Forestry projects undertaken by the GDC include paternity identification, pollen treatment, and seedlot analysis. The GDC has also invested labour and material in the development of microsatellite markers, which are ideal co-dominant markers for many conifer species including western redcedar, yellow-cedar, and western hemlock.

For more information visit
www.forestry.ubc.ca/gdc/index.htm
or contact Dr. Carol Ritland at critland@interchange.ubc.ca.

The GDC has undertaken forestry projects involving paternity identification, pollen treatment, and seedlot analysis.

Western Larch Crown Pruning Methods

submitted by Joe Webber, Clare Hewson, Chris Walsh, and Gary Giampa

This article highlights effects of several crown-pruning techniques on western larch cone production for both soil-based and container orchard stock.

Efficient management of western larch crops in older seed orchards is hampered by tree height. As tree height approaches 5–7 m, cone crops become inaccessible and management activities such as supplemental mass pollination, insect control, and cone collection become impractical and costly.

Two general approaches are used for crown management: topping and forming. Topping, used primarily for trees taller than 5–6 m, removes 25–50% of the crown. Crown forming, through pruning, begins on younger material (2- to 3-year-old grafts) to enhance the number of potential flowering sites, and create a more compact crown.

Western larch is an unusual conifer, and traditional pruning techniques may not apply. Larch seed and pollen cones are produced on short-shoots greater than 2 years old, and rarely on the current year long-shoots. The objective of pruning must focus on increasing production of long-shoots but not at the expense of cone (seed) production.

Two soil-based seed orchards (Kalamalka, Vernon) and one container orchard (Research Branch Laboratory, Victoria) were used to study the effects of pruning techniques on western larch cone production.

Soil-Based Stock (Kalamalka Seed Orchards 332 and 33)

The following table summarizes seven pruning regimes initiated in both orchards in 1997 as part of the FGC Operational Tree Improvement Program (OTIP).

Summary of the treatments applied during the 2001 field season

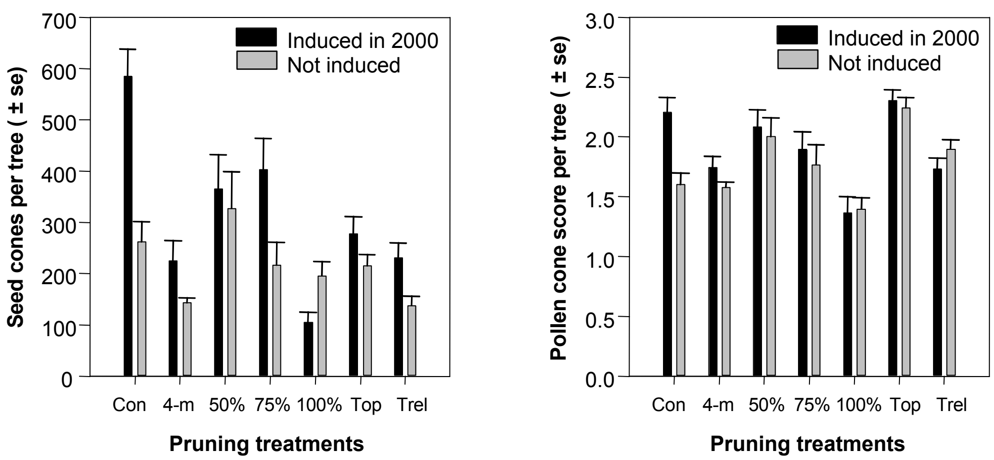
#	Description	Prune leader	Prune branches	Train
1	Height control, necessary branch training	Prune back any material > 4 m in height. To be done after cone collection.	No pruning of trained branches unless, after bending, limbs extend > 1.5 m into rows. In this case, prune to 1.25 m.	Attach branches to other branches using ties. Train only branches impeding row access.
2	Moderate pruning and branch training	Pruning by removal of 50% of all current leader growth until height reaches 4 m, then control height at 4 m.	Maintain hedge effect by discretionary pruning. Remove no more than 25% of the length from current year's lateral shoot growth.	Train all lateral branches that may impede row access.
3	Severe pruning	Pruning by removal of 75% of all current leader growth until height reaches 4 m, then control height at 4 m.	Maintain hedge effect by discretionary pruning. Remove no more than 50% of the length from current year's lateral shoot growth.	Train all lateral branches that may impede row access.
4	Complete pruning, no branch training	Pruning by removal of 100% of all current dominant leader growth until height reaches 4 m, then control height at 4 m.	No pruning of lateral branches unless extending > 1.5 m into row. In this case prune to 1.25 m.	None.
5	Severe crown top	Prune to 3 m once a height of 5 m is exceeded. To be done after cone collection.	No pruning of lateral branches unless extending > 1.5 m into row. In this case prune to 1.25 m.	Train all lateral branches that may impede row access.
C	Control	None, free to grow	None, free to grow. Prune only if branches impeding row progress.	None, free to grow.
T	Trellised rows. Max height 4 m. Crowns extend into rows a max of 1.25 m with full crown closure within rows.	Any branches or leaders > 4 m in height to be pruned to 4 m. To be done after cone collection.	Only in situations where training is not feasible and the branches extend into rows > 1.5 m. Prune these branches to 1.25 m extension.	Whenever possible bend or tie branches along trellis wires.

Pruning was done throughout the summer prior to cone collections. Flower induction was imposed annually on one-third of the orchard ramets. All induction trees of sufficient size and not carrying a heavy cone crop were girdled shortly after bud flush (about halfway through the pollen flight or short-shoot flush) by making two hand pruning saw cuts, each about 60% of the circumference of the tree, spaced at about a tree diameter apart and aligned 180° opposite each other.

The following charts show the mean (± standard error) seed and pollen cone responses for induced and non-induced trees treated in 2000. Results are based on yearly flowering counts for all treated ramets. Seed cone response is expressed as mean total counts (± standard error) and pollen cone response is expressed categorically (1 = light and 4 = heavy). Seed cone response was heaviest for induced control (not pruned) trees. However, these trees were about 6–7 m tall and if adjusted for height, the differences would be more equitable. The pruning regimes that removed 50% and 75% of the shoot produced the best seed cone response, which was similar to the control response in the non-induced group.

There was less response of pollen cones to induction but pruning treatments were effective in improving overall pollen production. This was most evident in the topping treatment.

Mean (± se) year 2001 seed and pollen cone response to year 2000 girdling treatments in two Kalamalka western larch seed orchards by seven crown-pruning treatments



Container Stock (North Road Lab)

In the container stock seed orchard, four crown pruning treatments were initiated 2 years after grafting: control, terminal bud removal (10%), 50% of the current year's shoot removed, and 75% of the current year's shoot removed.

All pruning was completed in early spring before reproductive bud flush. The following spring, the number of long shoots was counted as terminal long shoots (TLS), lateral long shoots (LLS), or main stem long shoots (MSLS). To determine the effect on flower production, all pruning treatments trees were induced (root pruning) 3 years after the initial pruning treatments.

The following table shows 1994 long-shoot response (mean ± standard error) to 1993 pruning of grafted 2-year-old western larch container stock.

While the number of long shoots did not increase with the pruning treatments, the form of the crown was more compact with the potential flowering sites closer to the stem than the controls.

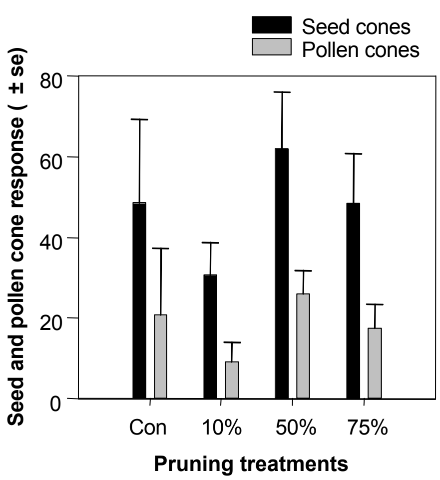
Mean (± se) long shoot response in western larch container stock to four pruning treatments counted on terminal, main stem, and lateral pruned shoots

Western larch container stock: grafted 1990 and pruned 1993					
Pruning treatment	**LBP**	**TLS**	**MSLS**	**LLS**	**TotLS**
Control	0	9.9 (0.67)	4.9 (0.48)	4.0 (0.40)	18.8 (0.91)
10%	3.0 (0.29)	8.5 (0.63)	4.8 (0.47)	2.0 (0.30)	18.3 (0.95)
50%	3.1 (0.31)	6.5 (0.41)	4.6 (0.40)	2.0 (0.39)	16.2 (0.86)
75%	2.4 (0.22)	5.0 (0.31)	5.5 (0.46)	1.3 (0.24)	14.2 (0.72)

LBP: number of mainstem lateral branches pruned in 1993
TLS: number of 1994 terminal lateral shoots responding to 1993 pruning
MSLS: number of 1994 mainstem long shoots responding to 1993 pruning
LLS: number of 1994 lateral long shoots responding to 1993 pruning
TotLS: total number of 1994 long shoots responding to 1993 pruning

In 1995, about 2–3 weeks prior to short-shoot bud flush, all trees within each of the four pruning regimes were induced by root pruning (removing the outer 3–5 cm of the root ball). The following chart shows the mean (± standard error) seed and pollen cone response to induction.

Mean (± se) seed and pollen cone response to root pruning induction in 5-year-old western larch container stock pruned to three levels of shoot removal 2 years earlier



Shoot pruning increased the number of seed and pollen cones responding to root pruning treatments, but the difference was not likely significant (statistical test not completed). The pruned trees were much more compact.

Recommendations

Results from the soil-based and container studies suggest that the best shoot pruning regimes for western larch crown management are removal of 50–75% of the current shoot while maintaining top height to 4–5 m. These regimes produce a more compact crown while maintaining flower production. As the treatments continue, the study will determine whether shoot pruning is required to maintain the augmented flowering or if a simple topping will suffice.

Results suggest that the best shoot-pruning regimes for western larch crown management are removal of 50–75% of the current shoot, while maintaining top height to 4–5 m.

Paper Birch Population Variation in Root Reinforcement, Growth Rate, & Phenology

submitted by Kirstin Campbell and Nicole Wilder

Studying the genecology of paper birch (*Betula papyrifera* Marsh.) allows the development of seed zones, seed transfer guidelines, gene conservation programs, and viable seed orchard growing stock. As a fast growing pioneer species, birch is also an excellent candidate species for use in slope stabilization projects.

Interest in birch as a commercial species is growing in British Columbia. Birch is used to produce quality magazine paper, as a specialty wood for furniture and cabinetry, and for non-timber forest products such as birch syrup.

A variable species with a wide geographic distribution, birch is found at low to mid-elevations in the ICH, IDF, and SBS biogeoclimatic zones. The ability of a population to move across elevational, latitudinal/longitudinal, and environmental gradients depends on its adaptive strategy. Identifying the adaptive strategy of birch aids in the development of operational reforestation guidelines.

Little is known about the effect of seed source on the operational performance of this species. Genecological research into birch began in 1994, with two seed source collections to date. Trials are underway to determine whether the phenotypic variability of birch is due to genetics, the local environment, or an interaction between the two. Trials comparing sources collected in British Columbia and northern Idaho were established in the spring of 1996 (B.C.) and in 2000 (B.C. and Idaho).

In 2000, four birch populations growing at Red Rock (Prince George, B.C.) were uprooted to gain insight into the physiological differences of the seed sources tested, and to identify candidate seed sources for slope stabilization projects. The seed sources had been collected from the Skeena, Lee Creek, Eaglet, and Porcupine regions in British Columbia.

The Skeena source had the most resistance to uprooting, as well as the greatest height, diameter, and root biomass compared with the other seed sources tested. Skeena trees exhibit a generalist adaptive strategy, which suggests that the trees can be grown in a variety of soil types, temperature, and moisture regimes, and provide superior root strength and slope stability compared with local populations. The adaptive strategies of the other three seed sources in this study were not as clearly defined. The overall conclusion is that trees from the Skeena source are an ideal population for use in terrain stabilization projects.

In the evaluation of phenological and morphological differences, 20 seed sources of birch were assessed for bud flush in 2001. Preliminary results indicated that sources grown at Skimikin (Salmon Arm, B.C.) required greater accumulation of degree-days than those grown at Sandpoint, Idaho. The same sources flushed much later at Red Rock, but required fewer degree-days than those grown at Sandpoint. These results suggest that day length may be influencing bud flush at Red Rock. Generally, northern, interior, and high-elevation sources flush

Results of this study indicate that trees from the Skeena seed source are ideal for use in terrain stabilization projects.

Results also suggest that growth rate, rather than growing season length, determines paper birch height growth.

before southern, coastal, and low-elevation sources, respectively, when grown in a common garden environment.

Sixteen seed sources were assessed for leaf drop at Red Rock in the fall of 2001. Leaf drop followed the same pattern as bud flush, with northern, interior, and high-elevation sources losing their leaves before southern, coastal, and low-elevation sources, respectively. Height increment in 2001 was not significantly different even though growing season length was different among sources. There does not appear to be a relationship between growing season length and height increment. These preliminary results suggest that growth rate rather than growing season length determines paper birch height growth. Birch exhibited no difference in height increment along elevational and latitudinal clines. These preliminary results support earlier findings that paper birch demonstrates a generalist adaptive strategy.

For more information, contact Kirstin Campbell (kcampbell@cortex.ca) or Nicole Wilder (wildern@unbc.ca).

Genetic Resistance of Lodgepole Pine to Comandra Rust

submitted by Sally John

This is a follow-up to the article on comandra rust in the Spring 2000 issue of TIC*talk*.

Background

The Morice & Lakes IFPA genetics project was carried over from the Babine Forest Products Enhanced Forest Management Pilot Project (EFMPP) in 2001. Initiated in 1998, this project investigates two distinct topics: the effect of stand density on genetic ranking, and the genetics of susceptibility to comandra rust (*Cronartium comandrae*). An earlier TIC*talk* article (Spring 2000) documented the first component of this project; here, we report on the second.

Lodgepole pine hosts the largest array of fungal pathogens of any timber species in British Columbia. In some areas of the province timber losses to comandra rust are large; survival and growth of young lodgepole pine are severely reduced locally. In one study, trees with bole infections of comandra suffered 87.2% mortality. The Lakes TSA is one of the most heavily affected areas of the province.

The B.C. Ministry of Forests (MOF) breeding program for lodgepole pine in this area includes progeny tests, planted in 1985 and 1986, and seed orchards. Predicted gains in individual tree growth rates are substantial and verifiable.

Study Questions

Two questions form the basis for this study.

- Are some pine trees "naturally" resistant to comandra rust?
- Is there a geographical seed source basis to genetic variation in rust resistance?

The degree of genetic control of disease resistance can only be estimated in stands with a known genetic structure, such as progeny tests. Assessments can reveal whether certain families and provenances are more susceptible to a given disease than others. Progeny tests established by the MOF provide an excellent opportunity, and we assessed one Bulkley Valley progeny trial site for comandra rust incidence in 2000.

Analyses and Results

Infection rates among 309 families ranged from 0 to 69%; these differences were statistically highly significant. We then investigated the possibility of a geographic basis for observed family variation in infection rates. Initial regression analyses attempted to relate variation to latitude, longitude, and elevation, both singly and in various linear combinations. The highest R^2 value was obtained by regressing infection rate on latitude alone; however, this value was only 0.070. For infection rate and elevation, the calculated R^2 was a surprisingly low 0.00013. We concluded that no strong linear relationship exists between infection rate and geographic variables.

Cluster analyses were then performed, assigning tested families into logical geographic groups, and examining whether variation in infection rates could be explained by these clusters. A number of iterations were run, with numbers of clusters ranging between 5 and 100.

The objectives of the iterations were to:

1. find a reasonably small number of clusters that would separate the families into distinct groups; and
2. find a clustering that explains a reasonable amount of the variation in infection rate.

Results suggested that nine clusters most reasonably explained observed variation in infection. The R^2 value from an analysis of variance (ANOVA) was used as an indication of the gain in value from separating data points into more clusters. A large gain (0.280–0.318) in the R^2 value was noted in increasing from eight to nine clusters. With more than nine clusters, R^2 values increased very slowly up to 100 clusters ($R^2 = 0.560$).

It was concluded that infection rate is strongly influenced by geographic source, with the highest infection rates occurring in provenances clustered in southeast British Columbia, and the lowest infection rate in a cluster from intermediate latitude and longitude.

Conclusion

Genetic variation exists in susceptibility to comandra rust infection. This variation has a geographic basis, and can be exploited in two distinct ways to produce resistant seedlots for deployment in high-risk areas:

1. resistant provenances can be identified as desirable sources for wild-seed collections; and
2. resistant genotypes established in seed orchards can provide custom orchard seedlots.

Based on results from this project, both of these options are being implemented by the MOF and the forest industry.

Based on results from this project, the MOF and forest industry have identified resistant provenances for wild-seed collections and are collecting custom seedlots from resistant families already established in orchards.

Next Steps

A new field trial is being designed specifically to test comandra resistance of genotypes established in the Bulkley Valley seed orchard, and to allow accurate ranking of families. Open-pollinated family collections were made in the orchard in 2001 and 2002, and seed will be sown in spring 2003. Seedlings will be established in 2004, in a tightly spaced (1 m × 1 m) trial replicated on three sites, chosen for high likelihood of comandra rust exposure. The results will be used to tailor orchard seedlots for deployment in high-risk areas.

More information on this project is available on the Morice & Lakes IFPA Web site at: www.moricelakes-ifpa.com/.

Alberta Forest Genetic Resources Council Shifts into High Gear

submitted by Cliff Smith

Established in April 2000, the 13-member Alberta Forest Genetic Resources Council (AFGRC) is now into its third term. Similar to British Columbia's FGC, the AFGRC advises the provincial Minister of Sustainable Resource Development and the forestry community on policy and regulation related to managing the gene resources of Alberta's forests.

Most of the Alberta Council's energy in 2001/02 has focused on three areas of forest genetics policy development: the Alberta Forest Genetics Framework, a Forest Genetics Resources Conservation Plan, and the use of non-native and GMO trees in reforestation.

Alberta Forest Genetics Framework

Several AFGRC members participated in development of the Alberta Forest Genetics Framework (AFGF) policy for public lands within Alberta's Green Area—an effort involving over 40 scientists and resource management experts from government and industry. The Green Area represents the majority of Alberta's public forest lands (53% of the provincial land area). It is protected from indiscriminate agricultural settlement and development, and is available for sustainable forest management activities.

The purpose of the framework is to provide direction on the management of the province's coniferous and deciduous forest genetic resources programs. The AFGF involves four major policy streams: deployment; breeding, testing, and verification; materials collection, handling, registration, and storage; and production of seed and vegetative materials of controlled parentage.

Technical task groups comprising 8–12 members representing Alberta's forest companies and the Department of Sustainable Resource Development (DSRD) developed each policy stream with support from an expert committee of forest geneticists. A Primary Task Group coordinated each policy stream.

The involvement of experts and practitioners from both the private and public sectors in balancing conservation and tree improvement imperatives means that the framework should carry a high degree of credibility and support for years to come.

The draft policy, entitled *Management and Conservation Standards for Forest Tree Genetic Resources in Alberta*, was presented to the June 2002 Council meeting for input and advice. Council endorsed the Standards at its September 2002 meeting. Following interdepartmental review, the policy will be presented to Alberta's Standing Policy Committee early in 2003. Workshops will be conducted with practitioners prior to final adoption and implementation in spring 2003.

The AFGRC advises the Minister of Sustainable Resource Development and the forest community on policy and regulation related to managing Alberta's forest gene resources.

Provincial Forest Genetic Resources Conservation Plan

Council regularly reviews development of a provincial Forest Genetic Resources Conservation Plan. Implementation activities in 2001 included:

- completion of digitized draft seed zones, which are to act as the spatial and ecological units for *in situ* conservation
- development of a list of native tree species of Alberta in consultation with Parks and Protected Areas staff
- creation of linkages between the conservation plan and *in situ* conservation standards in the AFGF draft *Management and Conservation Standards for Forest Tree Genetic Resources in Alberta*, and linkages with the protected areas program through an agreement with Parks and Protected Areas to work jointly on tree genetic resource conservation

- prioritization of the conservation effort, and significant advances in developing partnerships, linkages with forest genetic resource management policy, background material, and information required for gap analysis and prioritizing of species.

Reforestation with Non-native Trees

At the request of the Alberta DSRD, Council reviewed the report *Implications of the Use of Non-native Trees for Reforestation of Public Lands in Alberta*. Council subsequently recommended that the government proceed with an assessment of the ecological and biodiversity impacts of using non-native trees for reforestation. DSRD presented a preliminary draft discussion paper on this topic to Council at its March 2002 meeting. The draft is being revised on the basis of substantive input from Council.

Alberta's Position on GMO Trees

In developing its position statement on GMOs, Council reviewed the status of GMO tree development in Canada and the opportunities and threats it may pose. Similar to the stance taken by British Columbia's Forest Genetics Council, the AFGRC recognizes the theoretical potential of GMO trees, but does not recommend use of GMOs for reforestation at this time.

Forest Genetic Resources Benchmarking Program

Early in its mandate, the AFGRC committed to provide objective quantification of how Alberta's forest genetics programs are performing relative to similar programs in Canada and elsewhere. The intent was to generate clear and measurable evidence of program performance on a periodic basis, while retaining flexibility to adjust programs in response to new knowledge and evolving environmental and social needs.

Work during the past year identified four areas for benchmarking and the means by which they will be measured:

- *Conservation of Forest Genetic Resources: in situ* conservation, *ex situ* conservation, tree species and populations of concern, and policy and restoration activities for populations of concern
- *Tree Improvement:* improved stock production and usage, involvement and commitment of stakeholders, enhancement of forest productivity and tree health, and maintenance of genetic diversity
- *Education:* formal education, continuing education, extension and outreach, and public awareness
- *Administration and Management:* planning, implementation, monitoring, policy framework, and research.

Council will choose an independent agency to undertake the benchmarking project once terms of reference for project implementation have been developed. Spring of 2004 is the preliminary target date for the first benchmarking reports.

The Alberta government has funded the operation of the Council to date.

For more information, or a copy of the 2001/02 Annual Report, contact Council Chair Cliff Smith (csmith@compusmart.ab.ca).

Like British Columbia's Forest Genetics Council, the AFGRC does not support use of GMO trees for reforest-ation at this time.

Reflections on 50 Years of Tree Improvement in Coastal British Columbia

submitted by John Barker

Fifty years ago, give or take a bit, tree improvement began in British Columbia.

In the latter half of the 1940s, the Sloan Commission report set in motion British Columbia's move towards sustained yield and more intensive forest management practices. Area-based tenures were created, amalgamating existing private tenures with adjacent Crown land. The main emphasis at the time was on inventory and regeneration practices.

During the 1950s, Dr. Alan Orr-Ewing of the B.C. Forest Service (BCFS) Research Division began work on genetic improvement of Douglas-fir at the Cowichan Lake Research Station (CLRS). Working essentially on his own, he began selecting quality phenotypes to breed for improved yield. With a very limited budget and a small field crew of summer students, progress was slow.

Plus Tree Board

The success of cooperative tree improvement programs in the southeastern United States stimulated interest in British Columbia. In 1959, Gerry Burch—then a forester with B.C. Forest Products (BCFP)—got together with Alan Orr-Ewing to form the cooperative Plus Tree Board. The Board's purpose was to coordinate and implement a selection program in second-growth Douglas-fir forests for the B.C. coast. Chris Heaman, Orr-Ewing's assistant, was responsible for the field selection program, working with Sven Rasmussen and Dick Kosick from Tahsis Company, Dave Handley and Don Schon of MacMillan Bloedel (MB), Doug McLeod from Rayonier, Bill McGhee from Crown Zellerbach (CZ), and Web Binion from BCFP.

Plus Tree Weeks

This enthusiastic group became impatient with the slow progress in selecting breeding stock and felt that common training would enable cooperators to expand the selection effort. "Plus Tree Weeks" were organized to facilitate training and concentrate selection efforts. Candidate stands were identified on all tenures. Following a training day on criteria and methodology, staff from companies and the BCFS working in crews of 2–3 would 100% cruise a sizeable second-growth stand (40–100 years old) of Douglas-fir, evaluating straightness, volume, branching habit, and health to identify and map potential candidate trees. At the conclusion of the field evaluations, the entire group would revisit the selected candidates, argue (sometimes quite spiritedly) as to whose tree was best, and make a final selection.

Inspired by cooperative tree improvement programs in the southeastern United States, Gerry Burch and Alan Orr-Ewing formed B.C.'s cooperative Plus Tree Board in 1959.

Using this approach, cooperators were able to expand coverage of the species range. Scion material was then collected and grafted into clone banks at the CLRS and into the first seed orchards of the cooperators. Between 1959 and 1965 over 400 parents were selected. The Douglas-fir field program was essentially phased out by 1968, but selections were beginning in other species such as Sitka spruce and western hemlock.

Establishing Orchards on the Coast

By 1968 the clone banks and first orchards were starting to produce flower buds and emphasis shifted to controlled pollinations and mating designs. There was considerable debate about whether to carry out progeny testing of parents followed by roguing, or whether to select new parents within the tests. In 1970 the

BCFS retained Gene Namkoong to provide advice in this area. His suggestion of a diallel design was adopted and the first major plus-tree crossing took place in 1973, with field testing starting in 1975 and continuing into the 1980s. Breeding and progeny testing became the responsibility of the BCFS Research Branch, with seed production handled by Reforestation (Silviculture) Branch and the forest companies.

During the mid to late 1960s, several companies established clone banks and seed orchards using material from these selected parents. It became evident that climatic conditions at some of these orchard sites were not conducive to seed production and that high sunshine hours and some drought were essential ingredients in enhancing seed production.

These factors prompted several companies and the BCFS to re-establish their orchards in the drier Saanich Peninsula (BCFP/CZ at Mount Newton, BCFS at Puckle Road, Tahsis at Hovey Road, and Pacific Forest Products at Saanichton); near Duncan (BCFS at Koksilah); near Nanaimo (MB at Yellow Point); and on the Sunshine Coast (Canfor at Davis Bay). Each company and the BCFS attempted to provide for its own needs—a cooperative approach to seed orchard production was yet to be born.

During the early 1970s, interest in species such as western hemlock, Sitka spruce, and western redcedar grew. ITT Rayonier (later Western Forest Products [WFP]), Canfor, and Tahsis (latterly Pacific Forest Products and then WFP) began selecting these species and incorporating them into clone banks. Rayonier purchased the Lost Lake Orchard property for use with these species and abandoned Douglas-fir. Parental selections, however, were restricted generally to areas within company holdings, which led to a fragmented effort during this period.

Section 88 and Formation of the Coastal Tree Improvement Council

Following the Pearse Royal Commission in 1975, efforts to establish a cooperative approach between government and industry were renewed. Government support through Section 88 funding offered a financial incentive to companies that would amalgamate their orchard parents with other material to better represent seed zones (rather than just company tenures). This idea was facilitated by formation of the Coastal Tree Improvement Council (CTIC) chaired by Don McMullan of BCFP. Roy Collins and Bill McMullan at WFP, Ralph Bower at MB, Tim Crowder at BCFP/CZ, and Sally John at Canfor were instrumental in establishing Section 88-funded orchards and Mike Crown of the BCFS administered the program. Seed from these orchards was allocated through the Ministry Seed Planning and Registry (SPAR) system.

During this period, the question arose as to how many seed orchards were needed to service the range of recognized seed zones. The patterns of geographic variation observed in research trials with Douglas-fir, western hemlock, and Sitka spruce showed that the detailed biogeoclimatic subzones did not correlate well with genetic performance. In other words, there appeared to be little genotype–environment interaction. This simplified the seed orchard situation considerably and made it possible to consolidate orchards, with companies and the Ministry agreeing on developing coverage for different seed zones within the existing orchards.

From 1975 to 1987 cooperative tree improvement flourished under the Coastal Tree Improvement Council and support from Section 88 funding.

In 1988, the government abandoned Section 88 and transferred financial responsibility for seed production to the forest companies. This created a major break in the cooperative tree improvement effort and caused problems with seed pricing and equitability since government facilities would now be competing with private orchards. To encourage operations managers to buy improved seed, the Ministry set its price for orchard seed at only 1.5 times that of wild seed, which under-represented actual production costs. While the low price increased demand, it discouraged seed producers from increasing supply. Orchards producing seed for other users were placed in the awkward position of subsidizing their competitors’ seed needs.

The absence of a need for financial coordination reduced the scope of the CTIC, but technical coordination among the breeders and various orchards continued. However, ongoing issues regarding incentives and seed pricing led to concerns about the viability of the CTIC.

By the late 1980s, progeny test data were becoming available and the time was right for establishing improved orchards through roguing older orchards and establishing new ones. From the size of the program, it was evident that a cooperative effort was necessary.

The Cooperative Provincial Program Comes of Age

With the advent of Forest Renewal BC in 1994, funding for enhanced forestry activities once again became available. The Interior and Coastal TICs struck a committee to draft a provincial tree improvement strategy. The resulting draft strategy was well received, but lacked both the funds and cooperative governing structure to be implemented. In 1997, the provincial chief forester replaced the existing TICs with an appointed transitional Council whose mandate was to recommend an organizational structure with government, industry, Forest Renewal BC, and university representatives that could efficiently deliver a provincial tree improvement program.

The transitional Council met eight times over the next 12 months, debating several controversial issues at length. One of these was the future role of the Ministry in operating seed orchards. An understanding was reached that the Ministry would phase out its involvement in seed production, while continuing its important role in selection, testing, and breeding. Where no private sector organization was willing to invest in establishing an orchard for a particular seed zone, the Ministry retained the option of doing so. Industry would concentrate on the production of quality seed to approved standards and the integration of improved selections into the seed production phase.

The progress made by the transitional Council attests to the diligence, persistence, and cooperation of its members. At the urging of the Council, the Ministry raised the price it charged for surplus seed to reflect the true cost of seed production. After heated debate, the Council agreed to establish an independent company—SelectSeed—to act on its behalf to expand orchard capacity. Eventually, profits from seed sales were to provide the operating funds for SelectSeed's continued operation. Jack Woods was instrumental in developing the Council's strategic and business plans and in bringing SelectSeed from concept to reality.

Forest Renewal BC funding in 1994 led to a draft provincial tree improvement strategy.

The outcome of the transitional Council's efforts was the preparation of the 1998 10-year Strategic Plan, which became the basis for the Forest Renewal BC Tree Improvement Program. The Council's Business Plan, produced with the involvement of the Coastal and Interior Technical Advisory Committees, fundamentally changed the way that tree improvement activities were funded. In a systematic, objective, and transparent process, it allocated funds to projects based on their contribution of benefits to the cooperators. The transitional Council also expanded the scope of the program to include forest gene conservation and maintained a highly effective working relationship between Ministry breeders and cooperating orchardists.

In the summer of 1998, the chief forester accepted the transitional Council’s recommendations, and in the fall appointed the Forest Genetics Council of British Columbia. However, the recent disappearance of Forest Renewal BC is once again testing the resolve of the tree improvement community to weather the ups and downs of the "yo-yo" of B.C. forest policy.

In the fall of 1999, the chief forester appointed the Forest Genetics Council of British Columbia to guide a provincial forest gene resource management program.

Cuttings

No Change in Seed Use Requirements to March 31, 2003

Amendments to the *Forest Practices Code of BC Act* and its regulations came into force on December 17, 2002. These changes provide for a transition period, December 2002–April 2005.

Seed use requirements under the transition period remain as they were under the Forest Practices Code, and are described in section 38 of the Timber Harvesting and Silviculture Practices Regulation.

MOF Tree Improvement Web Site

Check out the newly designed MOF Tree Improvement Branch Web site at *www.for.gov.bc.ca/TIP/index.htm* and send your comments via the FEEDBACK menu option.

Contributors

Sally Aitken, PhD
Univ. of British Columbia
Faculty of Forestry
(604) 822.6020
aitken@interchange.ubc.ca

Graeme Auld
Yale University
School of Forestry &
Environmental Studies
(203) 436.3978
graeme.auld@yale.edu

John Barker
jebarker@telus.net

Kirstin Campbell, MSc
Cortex Consultants Inc.
(250) 360.1492
kcampbell@cortex.ca

Gary Giampa
Ministry of Forests
Kalamalka Seed Orchards
(250).549.5576
gary.giampa@gems8.gov.bc.ca

Melissa Hadley
Cortex Consultants Inc.
(604) 885.4050
mjhadley@cortex.ca

Andreas Hamann, PhD
Univ. of British Columbia
Forest Sciences Department
(604) 822.4124
hamann@interchange.ubc.ca

Clare Hewson
Seed Orchard Forester
(retired)
Ministry of Forests
Kalamalka Seed Orchards

Sally John, PhD
Isabella Point Forestry Ltd.
(250) 653.2335
ipf@saltspring.com

Jodie Krakowski, MSc
Univ. of British Columbia
Forest Sciences Department
(604) 822.4124
jodiek@interchange.ubc.ca

Carol Ritland, PhD
Univ. of British Columbia
Genetic Data Centre
(604) 822.8101
critland@interchange.ubc.ca

C.B. (Cliff) Smith
Alberta Forest Genetics
Resource Council
(780) 449.5626
csmith@compusmart.ab.ca

Jordan Tanz
Forest Genetics Council
Executive Secretariat
(250) 360.1492
jtanz@cortex.ca

Chris Walsh
Ministry of Forests
Kalamalka Seed Orchards
(250) 260.4777
chris.walsh@gems4.gov.bc.ca

Joe Webber
Ministry of Forests
Research Branch Laboratory
(250) 952.4123
joe.webber@gems3.gov.bc.ca

Nicole Wilder
Forestry Extension Officer
University of Northern BC
(250) 960.5778
wildern@unbc.ca

Editor: Melissa Hadley

Subscribing to TIC*talk*

The Forest Genetics Council is reviewing its policy regarding posting TIC*talk* to its Web site. If you wish to receive TIC*talk* by post, please send your request to:

Roger Painter, MOF Tree Improvement Branch
Tel: (250) 356.9276 Fax: (250) 356.8124
E-mail: roger.painter@gems8.gov.bc.ca