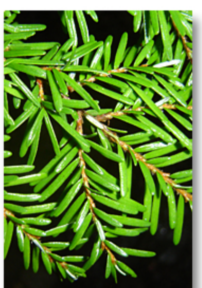
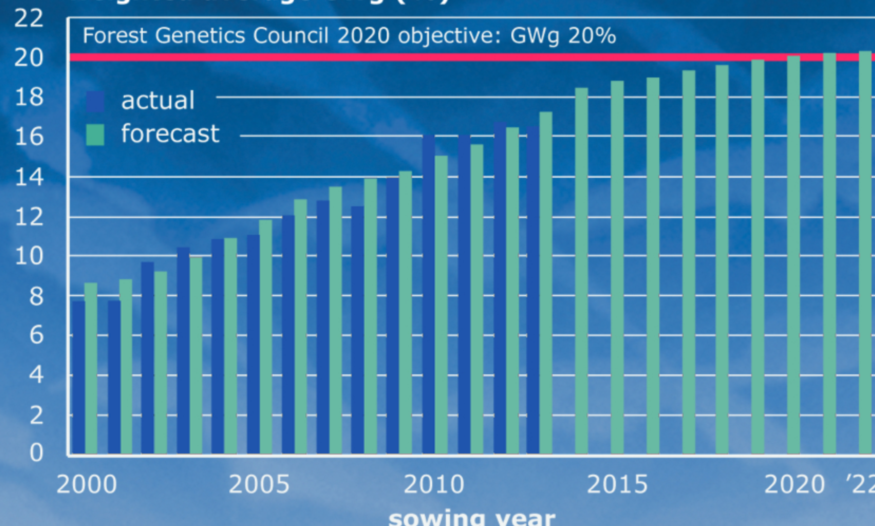


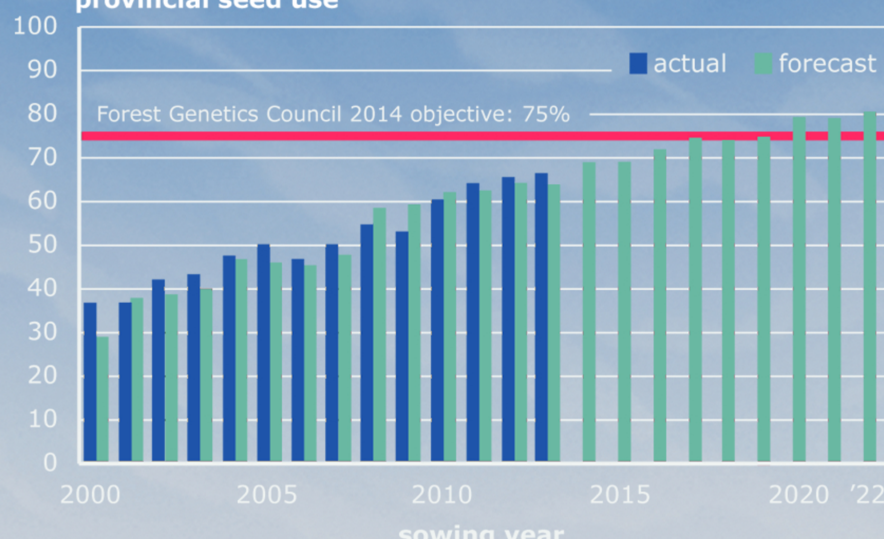
FGC Forest Genetics Council of British Columbia

ANNUAL REPORT 2012/2013

weighted average GWg (%)



percentage of total provincial seed use



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Canadian Cataloguing in Publication Data

Forest Genetics Council of British Columbia

Annual report. -- 2000/2001

Annual.

Title from cover

Issuing body varies.

ISSN 1499-125X = Annual report – Forest Genetics Council of British Columbia

1. Forest Genetics Council of British Columbia – Periodicals.

2. Trees –

SD399.5.B74 634.9'8'09711'05 C2001-960195-6

Cover graphic: Provincial performance indicators for select seed use and average genetic worth

This cover figure shows progress for two of the primary objectives of the Forest Genetics Council of BC; the use of select seed as a percentage of total seed use provincially, and the average genetic worth for growth of class A (orchard) seed used.

The combined work of all co-operators over many years has resulted in the achievements summarized in these graphs. Underlying these simple statistics is a complex system of tree breeding and testing, over 100 seed orchards, seed management, and research that have combined to advance tree improvement to the level where significant gains in provincial timber supply are being realized.

Not represented in these graphs is work in the areas of genetic conservation, extension, record maintenance, decision support tools for seed users, and the highly effective provincial system for seed extraction, testing, registration, and storage led by the Provincial Tree Seed Center.

Overview and acknowledgements

This 12th consecutive FGC Annual Report presents provincial-level performance indicators for the 2012/13 fiscal year and financial summaries for spending under the Land Based Investment Strategy (LBIS) Tree Improvement Program. Further details are available in the FGC Business Plan for 2012/13, and the Tree Improvement Program Projects Report for 2012/13.

After the period of this report, the tree improvement community in BC was shocked with the sudden passing of Tim Lee, Manager of the Vernon Seed Orchard Company, Chair of the Interior Technical Advisory Committee, and a member of Council. Tim was highly respected and is mourned by all who knew him. His cooperation, support, and contributions are greatly missed.

During the 2012/13 fiscal year about 242 million seedlings were sown for Crown and private lands in BC, down from 253 million in 2012. Over this same period select seed use increased to 66.4% of total sowing (Figure 2). The average genetic worth for growth was unchanged, but continues to be on track to meet Council's 2020 target of 20% on average. While it is unlikely that Council's 2014 target of 75% select seed use will be met, substantial progress was made over the previous decade.

Early in 2013, FGC Industry Co-Chair Kerry McGourlick retired from Western Forest Products Inc. and from his position as FGC Co-Chair. Kerry ably served Council as Industry Co-Chair for 3 ½ years, during which time Council introduced a new 5-year strategic plan, and implemented several key policy positions. Kerry's leadership will be missed, and he is wished all the best in his retirement.

The success of this program is due to the skills and work of the many people involved, all of whom are thanked for their contributions and support. In particular, I would like to thank Interior and Coast TAC chairs Tim Lee and Annette van Niejenhuis, Genetic Conservation TAC chair Dave Kolotelo, Pest Management TAC chair Jim Corrigan, Extension TAC chair Diane Douglas, Seed Transfer TAC chair, Lee Charleson, and Decision Support TAC chair, Guy Burdikin. Also thanked for their ongoing support and guidance are Assistant Deputy Minister Tom Ethier and Deputy Chief Forester Jim Sutherland.

(Photos: D. Kolotelo, J. Woods)

JACK WOODS,
Program Manager,
Forest Genetics
Council of BC

Jim Sutherland,
Deputy Chief Forester,
BC Ministry of Forests
Lands and Natural
Resource Operations

Message from the Ministry of Forests Lands and Natural Resource Operations

I would like to congratulate the Forest Genetics Council of BC (FGC) for producing their 12th consecutive annual report. This series of reports show the substantial progress made in forest genetics research and tree improvement in B.C. over the past dozen years. They also demonstrate that the FGC has remained focused on its objectives and maintained a well-organized business planning process. The results of this collaborative program have significantly enhanced the value, resilience and conservation of our forests.

About 5% ($3 million) of the provincial Land-Base Investment Strategy (LBIS) budget supports FGC's annual business plan. Tree improvement activities, however, account for approximately 50% of the ministry's performance measure for timber volume gains for silviculture investments[1]. This impressive ratio is feasible because of other investments made by government and the private sector in seed orchards (which are operated on a cost-recovery basis through seed sales) and by universities in forest genetics research. This collaborative investment model has supported the achievement of FGC's long-term goals and objectives, and I'm pleased to note (in figures 1 and 2 of this report) that the use and genetic quality of select seed continues to rise.

Timber supply in management units impacted by the mountain pine beetle remains an important issue. The use of select seed is one of the few options available to mitigate projected mid-term timber supply fall downs. FGC presented this case to the Special Committee on Timber Supply, and it was subsequently acknowledged in their action plan released on October 9, 2012. This communication was successful because of credible work undertaken by FGC and its long history of cooperation between government, industry and academia.

Our forests, and the way we manage them, continue to evolve. Government recently reorganized how it manages the land-base through the creation of the Ministry of Forests, Lands and Natural Resource Operations, and many aspects of Ministry business are under review. It is, therefore, timely for the FGC and SelectSeed Ltd. (its wholly owned company) to examine their roles and update their respective strategic plans.

I would like to thank members of the Forest Genetics Council and its affiliated technical committees for their contributions. I encourage you to continue working together to advance our collective interests in forest genetic resource management.

[1] Ministry of Forests, :Lands and Natural Resource Operations, Revised 2013/14-2015/16 Service Plan http://www.bcbudget.gov.bc.ca/2013_June_Update/sp/pdf/ministry/flnr.pdf

Message from Forest Genetics Council Co-Chairs

It is with great sadness that we mourn the passing in July 2013, of a good friend and colleague, Tim Lee, Manager, Vernon Seed Orchard Co. Tim served as a valued member of the FGC and as chair of the Interior Technical Advisory Committee. He is missed. Please read a tribute to Tim on page 10.

In this report, we are pleased to note that total use of select seed continues to rise and the average genetic gain for growth (GWg) of select seed sown remained at 16% (see Figures 1 and 2). Although we are on target to achieve our GWg goal of 20% by 2020, we will not meet the select use goal of 75% by 2014 due to lower than anticipated lodgepole pine seed production.

Higher select seed use (and genetic gains) will be realized when the new high-gain interior Douglas-fir and lodgepole pine seed orchards mature and reach full production. We anticipate that some of the lodgepole pone seed set issues will also be resolved, which may include re-establishment of orchards outside the hot and dry Okanagan. These challenges remain priorities and we're pleased that researchers, orchard managers, and pest specialists are giving them substantial attention.

The use of seedlings grown from seed with higher genetically-based resistance to pests, notably western white pine and Sitka spruce, is also increasing. We note, however, barriers to using these species remain despite availability of resistant seed and management benefits (e.g. increased species and product diversity). We therefore encourage silviculturists to take advantage of pest-tolerant seedlots where the species is ecologically suitable.

In the coming year, we'll begin discussion on a new 5-year strategic plan that considers existing trends and future needs. The development and implementation of climate-based seed transfer systems will likely result in substantial changes to our existing breeding program and seed orchards. Seed demand in some management units will also change as harvest levels decline. With change, however, also comes opportunity. In the long term, we're confident that our program will continue to make valued contributions.

We would like to thank all those who have contributed to FGC's goals and activities over the past year; in particular those who participate on Council and its technical committees. These people are key to the continued operation and advancement of this important cooperative program.

We encourage readers of this annual report to also review the 2012/13 FGC Tree Improvement Program Project Report for further information and details about FGC projects and people.

BRIAN BARBER and LARRY GARDNER,
Co-Chairs,
Forest Genetics
Council of BC

1.0 Introduction

The FGC Annual Report presents provincial-level performance indicators for genetic resource management.

This Annual Report presents provincial-level performance indicators outlined in the FGC Strategic Plan for 2009 to 2014. It also summarizes outcomes from projects funded through the Land Based Investment Strategy (LBIS) Tree Improvement Program. These projects are outlined in the Forest Genetics Council of BC (FGC) Business Plan for 2012/13. Performance indicators reported here represent results from both LBIS investments and the investment of other cooperators.

1.1 Tree improvement and forest genetic resource management in British Columbia

Tree improvement and forest genetic resource management (GRM) includes increasing value through tree breeding and seed production, conservation of the genetic diversity of indigenous forest tree species, and enhancing forest resilience through scientifically-based seed transfer standards and the maintenance of genetic diversity. Support activities including research, extension, and records management also advance provincial GRM initiatives.

1.2 About the Forest Genetics Council of British Columbia

The FGC represents stakeholders in the management and conservation of the genetic resource of indigenous tree species.

The FGC is a multi-stakeholder group representing government agencies (Ministry of Forests Lands and Natural Resource Operations -MFLNRO), the forest industry, universities, the Canadian Forest Service, and small private companies. The mandate of the FGC is to champion forest GRM, to oversee strategic and business planning for a cooperative provincial GRM program, and to advise the provincial Chief Forester and the Assistant Deputy Minister Resource Stewardship on GRM policies.

The FGC leads program development and business planning for provincial investments through the LBIS, and seeks efficiencies for all investments, including those by industry and university cooperators.

1.3 FGC vision and objectives

Council set the following vision statement and objectives in its five-year Strategic Plan (2009-2014), and annually develops a Business Plan outlining activities to meet these objectives.[2]

Vision

BC's forest genetic resources are diverse, resilient, and managed to provide multiple values for the benefit of present and future generations.

Objectives

- *Increase the average volume gain of select seed used for Crown land reforestation to 20% by the year 2020*
- *Increase select seed use to 75% of the provincial total sown by 2014*
- *Adequately conserve the genetic diversity of key populations of all forest tree species native to BC by 2015, through a combination of in situ, ex situ, and inter situ conservation*
- *By 2020, high-quality genecology research information will guide operationally efficient climate-based seed transfer policy and practice for all trees planted in BC*
- *Coordinate stakeholder activities and secure the resources needed to meet Business Plan priorities*
- *Monitor and report progress in genetic resource management activities*

Chris Walsh

Seed orchard manager with the MFLNRO at the Kalamalka Seed Orchards from 1981 to 2013.

David Reid

Manager of MFLNRO seed orchard operations provincially from 1991 to 2013.

Dawn Stubley

Cone and Seed Operations officer technician at the MFLNRO Provincial Tree Seed Center from 1989 to 2013.

Garry DeBoer

Manager of EagleRock Nursery and Seed orchard operations, where he worked from 1983 to 2012.

Chuck Woodward

Facilities and Site Operations Officer at the MFLNRO Provincial Tree Seed Center from 1979 to 2013.

Retirements during 2012/13

[2] For more information on the Forest Genetics Council, see *http://www.fgcouncil.ca*.

2.0 Budget and Expenditures

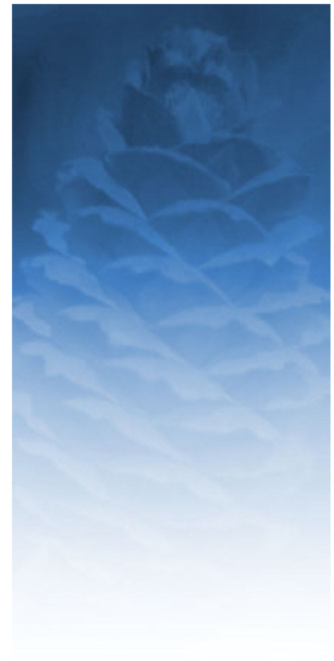
Land Based Investment Strategy Tree Improvement Program allocations and expenditures for the 2012/13 fiscal year are shown in Table 1. The table does not include in-kind costs, staff salaries, and other substantial inputs by industry, MFLNRO, and university cooperators that contribute to the success of GRM activities in BC.

Table 1
Summary of Forest Investment Account Tree Improvement Program budgets and expenditures for the period April 1, 2012 through March 31, 2013 ($ x 1000).

Subprogram	**Budget ($)**	**Expenditures ($)**
Genetic Conservation	220	206
Tree Breeding	1,062	1,032
Operational Tree Improvement Program (OTIP)	584	594
Extension and Communication	28	5
Genetic Resource Decision Support	90	90
Cone and Seed Pest Management	113	92
Applied Tree Improvement and Biotechnology	289	289
Genecology and Seed Transfer	544	499
Administration	30	8
Contingency	40	0
Total	**3,000**	**2,815**
SelectSeed Ltd. orchards and FGC program management	540	543*

* SelectSeed allocation provided through the 2011/12 LBIS budget. Total SelectSeed expenditures were $741,883 with the difference supported through seed sale revenue and investment income.

Overall spending was 6% below budget due primarily to project savings or projects not proceeding in some subprograms. Non-allocated funds remained in the MFLNRO and were either re-allocated within the LBIS program or returned to provincial general revenue. An overall budget reduction of $0.5 million from the previous year was fully absorbed by an allocation to SelectSeed Ltd. at the end of the previous fiscal year. This is anticipated to be the last payment to SelectSeed Ltd. under its Multi-Year Agreement as increasing seed production and sales are now sufficient to cover business costs and some of the costs for FGC functions and management.



3.0 Performance Indicators

Progress towards objectives set out in the FGC Strategic Plan for the period 2009-2014 (summarized above) are measured and reported annually. Two of these objectives are to increase select seed[3] use to 75% and increase the average genetic worth (GWg[4]) of class A select seed to 20%. Province-wide performance on these objectives has been measured and reported since 2000 and is shown below.

3.1 Increase seedlot genetic worth

Objective

Increase the average volume gain of select seed used for Crown land reforestation to 20% by the year 2020.

Performance

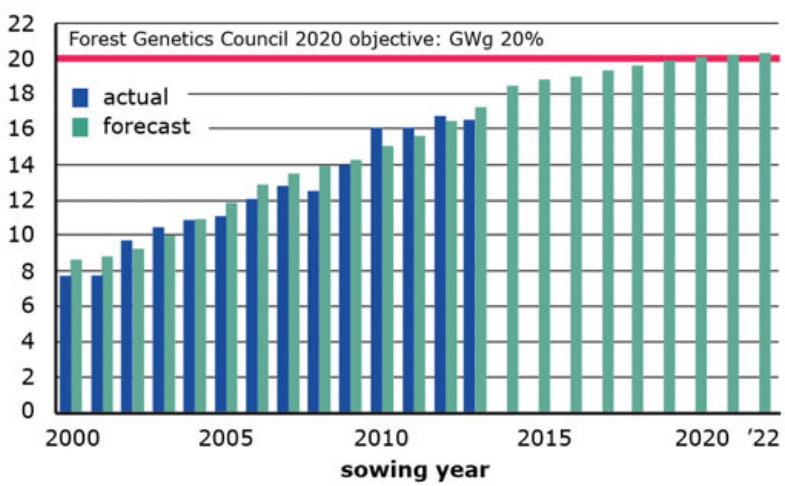


Figure 1
Actual and forecast annual average genetic worth for stem-volume growth (GWg) of select seed sown in BC.

The average GWg remained stable at 16.5% (16.7% in the 2012 sowing year), but dropped below the forecast of 17.2% (Figure 1). This drop below forecast resulted primarily from the use of lower-gain lodgepole pine seed in the Prince George and Central Plateau zones; a direct consequence of inadequate production from lodgepole pine orchards that has forced the use of seed from older low-gain orchards. GWg levels for interior spruce, western larch, interior Douglas-fir, redcedar, and western hemlock are largely at or

---

[3] Select seed includes Class A seed from seed orchards and Class B+ seed from natural stands that have been identified, through field-based provenance trials, for superior growth performance.

[4] Genetic worth is a measure of rotation-age gain in a specific trait, relative to non-selected wild seed. Genetic worth for growth (GWg) is a measure of stand-based gains in wood volume expressed as a percentage.

exceeding forecasts. Orchard upgrades, supported in part by the OTIP subprogram and using material identified in provincial breeding programs, are successfully supporting genetic gain increases.

3.2 Increase select seed use

Objective

Increase select seed use to 75% of the provincial total sown by 2014.

Performance

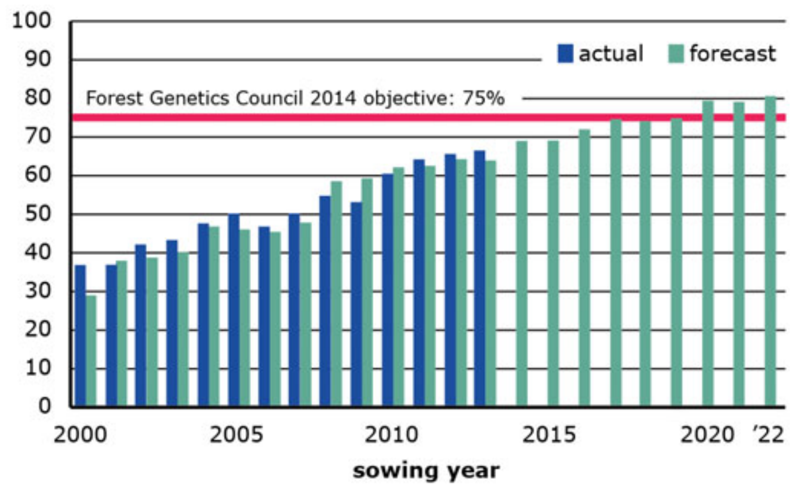


Figure 2
Actual and species-plan forecasts of select-seed use as a percentage of total provincial seed use, by year.

Select seed use as a percentage of total provincial sowing increased slightly in the 2013 sowing year to 66.4% from 65.5% the previous year (Figure 2). This increase is due primarily to a drop in overall sowing from 253 million in 2012 to 243 million, with a proportionally smaller drop in the use of class A seed from 143 million to 142 million (Figure 3). Seed from superior provenance sources (class B+), primarily Pli, was down from 19.3 million in 2012 to 17.8 million in 2013.

Class A seed use for interior spruce, western larch, coastal Douglas-fir, redcedar (coast), western white pine, Sitka spruce, and western hemlock continues to be high due to generally adequate seed supplies from orchards. Orchard seed production for lodgepole pine and interior Douglas-fir is building, but remains below expectations. Because of the large sowing demand for lodgepole pine, this species remains as the primary barrier preventing achievement of the 2014 target of 75% select seed use. Several years of moderate to poor interior Douglas-fir seed crops have prevented higher levels of class A seed use. Figures 3 and 4 provide a breakdown of annual sowing by species and genetic class.

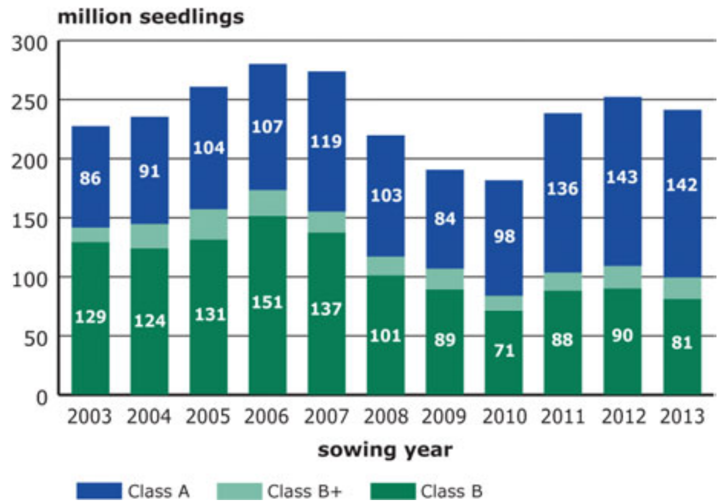


Figure 3
Provincial sowing of orchard (class A), wild-stand (class B), and superior provenance seed (class B+) from 2003 to 2013.

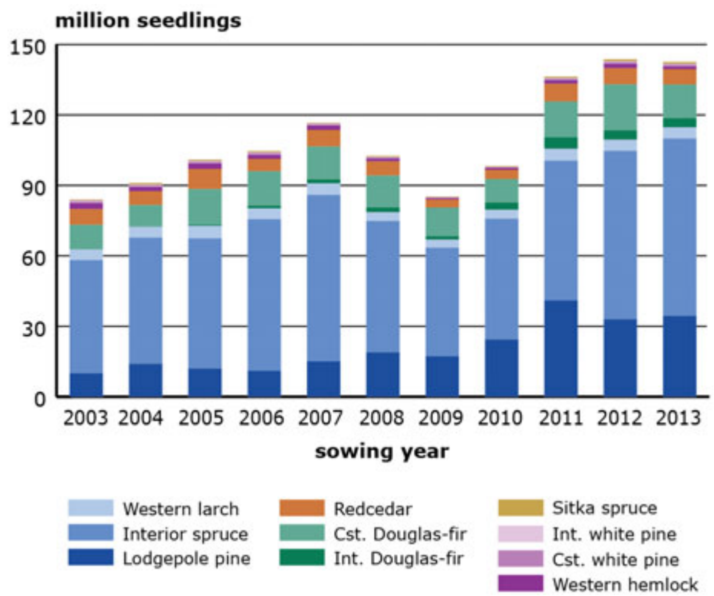
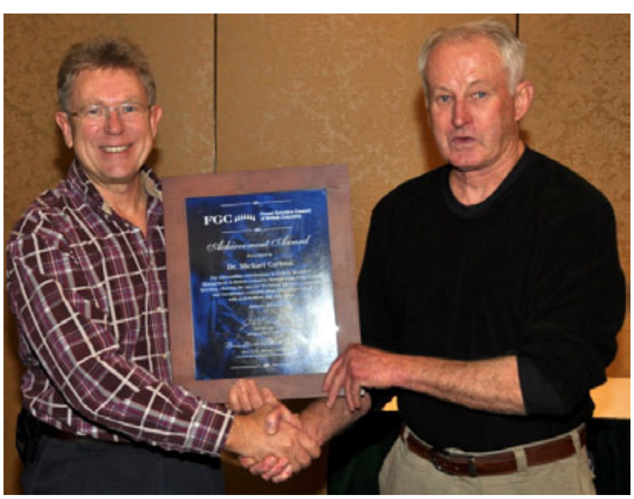


Figure 4
Provincial sowing of orchard seed (class A) by species from 2003 to 2013.



Dr. Michael Carlson (right), Emeritus Scientist and tree breeder with the MFLNRO Tree Improvement Branch received the FGC Achievement Award from Provincial Chief Forester Dave Peterson. Michael's exceptional contributions to forest genetics and tree improvement in BC are extensive and include development of lodgepole pine tree improvement programs for multiple seed zones, chairing the Interior Technical Advisory Committee, sitting as an FGC member for 11 years, and mentoring many people in both tree improvement and forestry. Michael continues to contribute on a voluntary basis.

(*J. Woods* photo)

In memory of Tim Lee

On July 7, 2013 Tim Lee passed away suddenly at the age of 58. Tim was employed by the Vernon Seed Orchard Company (VSOC) for 25 years, with over half of that time as manager. He was a leader and facilitator in the forest genetics community in BC. Tim served as Chair of the Interior Technical Advisory Committee and as a member of the Forest Genetics Council of BC. He promoted cooperation among all members of the interior tree improvement community and provided strong leadership towards common goals. Tim was a friend to all who knew him and highly respected by his colleagues. His integrity, honesty, and good cheer are missed.

A loving family man, Tim is survived by his wife Karen, four adult children, and six grandchildren.

Vernon Seed Orchard Ltd. site near Vernon, BC. VSOC also manages seed orchards near Quesnel.

(D. Reid photo)

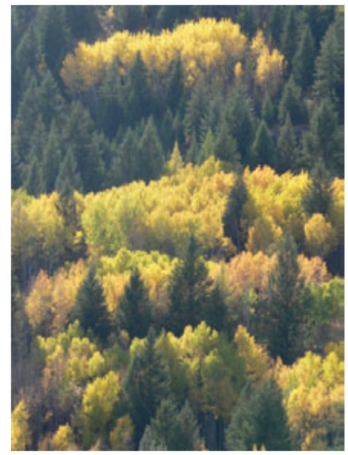
3.3 Adequately conserve genetic diversity

Objective

Adequately conserve the genetic diversity of key populations of all forest tree species native to BC by 2015, through a combination of *in situ*, *ex situ*, and *inter situ* conservation

Performance

During the period of this report 263 individual-tree seed collections from six species and 25 locations were added to the ex-situ genetic conservation seed bank maintained by Provincial Tree Seed Center (TSC). There are now 9,200 samples from 33 indigenous species in long-term storage at the seed bank. The emphasis for collection was on whitebark pine; a species listed as endangered under the Species at Risk Act. Staff at the TSC also prepared 172 whitebark pine samples for long-term freezer storage, and conducted viability tests on 63 whitebark pine family lots for a research project.



Aspen clones showing genetic diversity in fall colour and phenology near Greenwood in southern BC.

(J. Woods photo)

Projects undertaken by the UBC Center for Forest Conservation Genetics (CFCG) included enhancements to climate modeling capability with Climate Western North America (ClimateWNA). This model supports forecasts of both ecosystem shifts under climate change and where the loss of tree species or genetic diversity is most likely. It also replaces earlier forecasts[5]. Species and locations of concern are given priority for ex-situ seed collection or research. CFCG work on the hybridization patterns of white, Englemann, and Sitka spruce was completed and publications prepared. This work improves our understanding of hybridization patterns and the relationships between climate and species range. It also informs genetic conservation efforts and provides information on how breeding program selections influence species representation. The CFCG completed measurement of a Garry oak genetic trial to provide base-line information on the genetic architecture of this species, and initiated an online version of the "Big Tree Registry" of the largest trees found in BC for each native species. The registry will make information on these unique trees broadly accessible.

A plan was developed to begin genetic testing of whitebark pine to identify families that exhibit greater resistance to white pine blister rust. This plan was reviewed by the Genetic Conservation TAC and approved by the FGC. Work will begin in 2013.

Genomics work on trembling aspen was completed and provided information on genetic diversity levels and population differentiation. Threats from development to small scattered populations found in the south coast warrant the establishment of an *ex-situ* clonebank, as *ex-situ* seed storage for this recalcitrant species is not feasible. The genetic diversity of other populations throughout BC is not threatened.

[5] Andreas Hamann and Tongli Wang 2006. Potential effects of climate change on ecosystem and tree species distribution in British Columbia. Ecology 87:2773–2786.

Feature:

Choosing traits for genetic selection: economic and technical considerations

The objective of tree improvement is to select, produce, and deploy seed (or cuttings) with the genetic potential for greater economic value in a planted stand and acceptable levels of genetic diversity. This simple concept becomes complex as tree breeders attempt to choose traits and select for more than one trait.

When choosing traits for genetic selection, fast growth, straight stems, and fine branching are often a priority, as they influence timber production and saw-log value. Wood-quality traits are often of interest because wood density and fiber length influence board strength, while micro-fibril angle impacts longitudinal shrinkage and warping when drying. Other wood traits might include extractive content to increase rot resistance in a species like western redcedar, or reducing lignin content for more efficient pulping. Moreover, pest resistance is of primary importance for species like western white pine (blister rust), or Sitka spruce (terminal leader weevil).

A difficulty arises when considering different potential products. While wood density is an asset for lumber and some types of pulping, it can reduce value for other pulp and paper products due to thicker cell walls. Similarly, increasing extractive content may benefit western redcedar lumber quality for exterior uses, but reduce value for some types of fine-fiber pulp.

A biological limitation faced by tree breeders is the ability to simultaneously advance the genetic quality of multiple traits. This limit is driven by the genetic correlation among traits. For example, in many species diameter growth rate and wood density have a negative genetic correlation in the range of 0.6 (0.0 = no correlation and 1.0 = complete correlation). This implies that selecting trees for fast growth will result in a reduced genetic potential for wood density. Because this correlation is < 1.0, there are opportunities to select and increase value for both traits, but gains in stem growth are slowed when wood density is also improved.

In BC, tree breeders conduct research to understand the genetic correlations among commercially important traits. Knowing these correlations is key to selecting trees with the greatest potential to add value in planted stands. Another important consideration is the relative economic value of different traits. For example, what is the worth of greater volume production relative to an increase in wood density, resistance to a pest, or a straighter stem? Answering these questions is difficult as there are many product types, product values change over time, and some traits are better controlled through silvicultural management of a stand (i.e. branch size can be reduced by managing for more stems per hectare).

Photos

Top: Second-growth Douglas-fir logs. **Left:** Sitka spruce leader weevil attack. **Right**: Good stem form in a third-rotation Douglas-fir plantation on Vancouver Island.

(J. Woods, J. King photos)

In addition, engineering solutions at the product conversion stage may be more effective than breeding solutions for some traits. Predicting both future product type and future conversion technologies is highly speculative.

So why not select for all traits of value at the same time? This is where the genetic correlations among traits become important. In general, when selecting for more traits less genetic gain is made on any single trait. Tree breeders often solve this complex biological, economic, and silvicultural problem by using a selection index that mathematically combines available information on genetic correlations, economic values, and on the inherent degree to which a trait is passed along to its offspring (heritability), to guide tree selection.

The unfortunate reality of all breeding, whether for trees, agricultural crops, or horses, is that it's very difficult to improve more than two or three traits simultaneously. As a result, tree breeders focus on key traits of known importance and seek to understand the limitations. In BC, all programs focus on increasing the genetic potential for timber production on a per hectare basis through selection on growth rate or pest resistance. Other traits are given consideration on a species-by-species basis with the intent of maximizing future value.

3.4 Climate-based seed transfer

Objective

By 2020, high-quality genecology[6] research information will guide operationally efficient climate-based seed transfer policy and practice for all trees planted in BC.

Performance

During the period of this report the planting of the assisted migration adaptation trial (AMAT) was completed. This research comprises 48 field sites ranging from California to the southern Yukon with a range of genetic populations (seed sources) from 15 commercial, indigenous species. AMAT will provide important information for the ongoing refinement of climate-based seed transfer standards for many years.

Interior spruce seedlings at the PRT Growing Services Ltd. Armstrong nursery. All seedlings planted in BC come from registered seedlots with known and recorded origins. Standards set out by the MFLNRO ensure all planted seedlings originate from seedlots that are genetically adapted to the planting site.

(*J. Woods photo)*

New analytical methods were used to improve future projections of biogeoclimatic ecosystem zones and species ranges using the ClimateWNA model developed and maintained by the UBC Center for Forest Conservation Genetics (CFCG). Improvements allow substantially more accurate estimates of on-the-ground biogeoclimatic ecosystem occurrence, allowing better forecasting of ecosystem changes with climate change. This model is a cornerstone to the development of climate-based seed transfer policy and is widely used for other climate-change projects in BC.

The Genome Canada and LBIS-funded AdapTree project at UBC began the second of its three year duration. Initial work included the establishment of common-garden seedling tests of lodgepole pine and interior spruce, and the sequencing of nearly 30,000 genes per species in hundreds of these seedlings. Work from previous projects included analyses of hybridization patterns among Sitka, white and Engelmann spruce, informing seed transfer standards. Results also suggest that selections for superior growth in spruce breeding programs are shifting genetic adaptation towards slightly warmer climates, providing buffering for climate change.

Maintenance, measurement, and analyses of over 60 existing long-term genecology field trials were also carried out by the MFLNRO Tree Improvement Branch. This work included label maintenance, removal of competing vegetation, and assessments.

A climate-based seed transfer framework to guide provincial policy was further developed during the period of this report. Objectives for the final approach are to integrate the best available information from genecology research into a policy framework that can be readily updated with new information with minimum disruption to operational seed use and existing seed orchard infrastructure.

[6] Genecology is the study of the geographic distribution of genetic differences among tree populations.

Feature:

Genomics in forest genetic resource management

Genomics is the science of sequencing the nucleotides that make up the DNA molecule and the genetic code it contains. Sequencing technologies and analytical methods have advanced dramatically over the last decade due to massive investments in genomics in Canada and other parts of the world. Genomics includes both sequencing and mapping entire genomes and fine-scale genetic mapping to find genes that influence an organism's specific functions.

Knowing the sequence of genes in an organism and understanding the functions of the genes are very different areas of investigation. With tens of thousands of genes producing proteins for highly complex biological functions, unraveling the contribution of any single gene or set of genes is difficult. Large investments in tree genomics have advanced knowledge a great deal, but there remains much to learn about gene function and what genes influence the complex development pathways for growth or other traits. Explaining the phenotype by knowing the genotype is still only possible for a handful of simple traits.

In BC, Genome Canada and GenomeBC have supported genomics research primarily on interior spruce (*Picea glauca* x *P. englemannii* hybrid complex[a]), Sitka spruce[b], and poplar[c]. These investigations have applied sequencing and bioinformatic assembly technologies to both sequence the genomes and to search for genes that influence key functions such as growth rate, pest resistance, or wood properties. More recently, the Genome-Canada supported AdapTree[d] project is applying genomic methods to examine natural patterns of adaptation. Knowledge from this work will inform the development of climate-based seed transfer standards.

At the present time, genomic applications to breeding in some agricultural crops are common and forestry applications are emerging. These include the use of many genetic markers to select for economic traits in trees, guiding seed transfer, and pest identification. In BC, genomics is not yet used for the selection of trees for traits of economic significance. However, with the fast pace of this research, genomics is likely to have a role in BC tree breeding programs in the near future. It is a tool that tree breeders must evaluate relative to the cost of other options. For example, using tree measurements from traditional progeny field trials allows breeders to obtain genetic gains for traits like growth rate. The application of genomic selection can shorten the time for selection of better trees, potentially increasing genetic gain per year across a breeding cycle. However, these potential gains must be evaluated with an understanding of the uncertainty of the technology, the cost, and other potential methods.

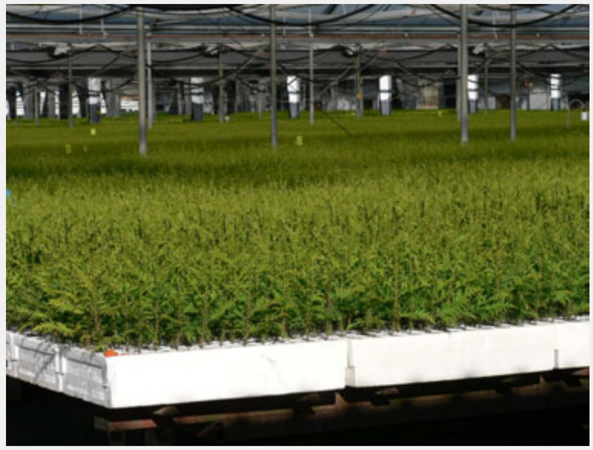


Photo: Western redcedar seedlings at Western Forest Products nursery. Genomic selection may offer a solution to the problem of selecting trees at a young age for mature traits such as wood extractive content and rot resistance.

(*J. Woods photo*)

It is not our expectation that genomics will displace long-term field testing. Genomics will, however, become one of the tools available to help breeders select trees for seed orchards.

Genomics will likely be most useful for traits that are difficult to evaluate at a young age, such as terpenoid extractive content in redcedar, a key trait for rot resistance in lumber. Resistance to some pests, such as mountain pine beetle, is also difficult or impossible to evaluate in a young tree as only larger trees are attacked. For traits of this type, genomics may be the only practical method that can be applied to select desirable trees within a practical time frame. It is also useful for understanding genetic diversity patterns and management impacts.

While the hurdles preventing full application of genomics in BC remain significant, it is likely that these will continue to drop and more opportunities will arise in the near future.

[a] **SmartForest** - project leaders Dr. John MaKay (Laval U.), Dr. Jörg Bohlmann (UBC)

[b] **Treenomix** – project leaders Dr. Jörg Bohlmann (UBC) and Dr. Kermit Ritland (UBC)

[c] **PopCan** - project leaders Dr. Carl Douglas (UBC) and Dr. Shawn Mansfield (UBC)

[d] **AdapTree** - project leaders Dr. Sally Aitken (UBC) and Dr. Andreas Hamann (U. Alberta)

3.5 Coordinate stakeholder activities

Objective

Coordinate stakeholder activities and secure the resources needed to meet Business Plan priorities.

Performance

During the period of this report, the FGC led completion of

- An activity plan and associated budget recommendations for the Land Based Investment Strategy Tree Improvement Program for 2013/14
- A published Business Plan and full set of species plans for 2012/13
- A published FGC Annual Report and Projects Report for 2011/12
- Ongoing management of committee work and collaboration on issues
- Conflict-of-interest guidelines for FGC and advisory committee members.

Council convened four times during the fiscal year. These meetings, in combination with subcommittee work done under the overall FGC structure, resulted in the efficient coordination of activities among a broad range of stakeholders, including the MFLNRO, major licensees, smaller licensees, universities, the Canadian Forest Service, other provincial ministries, and non-licensee private firms. Business planning and final budget recommendations were made for the LBIS Tree Improvement Program and subsequently accepted by the MFLNRO. Other activities included final approval of an updated genetic conservation plan and facilitating ongoing activities to ensure collaboration among stakeholders. In addition, Council provided direction to the SelectSeed Ltd. board of directors and oversaw SelectSeed operations and financial reporting.

Members of the Forest Genetics Council, breeders, and orchard managers tour tree breeding and research installations at the MFLNRO Skimikin Seed Orchard complex near Salmon Arm in south-central BC.

(J. Woods photo)

3.6 Monitor and report progress

Objective

Monitor and report progress in genetic resource management activities

Performance

This objective was met through the development and publication of a comprehensive Business Plan for 2012/13 and "species plans" that outline breeding programs, seed orchards, historic seed use and production, and other data relevant to an efficient multi-stakeholder provincial program. Performance indicators for objectives set out in the FGC Strategic Plan are reported in this document. Project level reporting is summarized in the Tree Improvement Project Report for 2012/13.

Table 2
Seed orchards in BC, summarized by site.

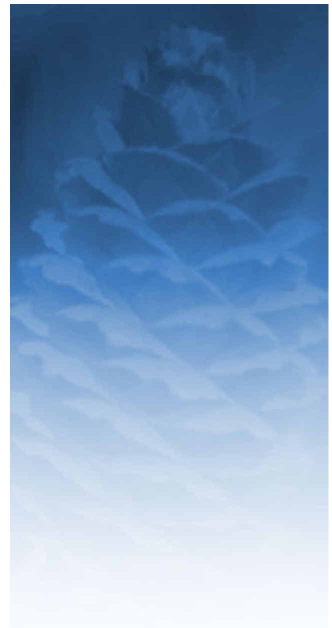
Site and owner[7]	Number of seed orchards	Total #of ramets established	Ramets under contract with SelectSeed Ltd.
Vernon Seed orchard Company Ltd. (including Quesnel orchards)	17	30,468	8,440
Kalamalka Seed orchards (MFLNRO)	17	19,594	
Skimikin Seed Orchards (MFLNRO)	15	18,516	
PRT Growing Services Ltd.	7	10,050	7,956
Kettle River Seed Orchards Ltd.	2	7,850	7,850
TimberWest Forests Ltd.	10	5,432	
Tolko Ltd.	4	5,007	5,007
Sorrento Nurseries Ltd.	2	4,835	4,835
Western Forest Products Inc.	12	3,018	
Saanich Seed Orchards (MFLNRO)	6	3,620	
Prince George Tree Improvement Stn. (MFLNRO)	3	3,212	
Small private (2 sites)	5	1,981	
Canadian Forest Products Ltd.	4	1,863	
Total	104	115,446	34,088

Lodgepole pine seed orchard operated by PRT Growing Services Ltd. in partnership with SelectSeed Ltd. This 4800 ramet orchard produces seed for lower elevations in the Thompson Okanagan seed zone.

(J. Woods photo)

[7] Excludes yellow cedar hedge orchards for rooted cutting production owned by Western Forest Products Inc. and the MFLNRO, Cowichan Lake Research Station.

4.0 2012 Orchard Seed Crops



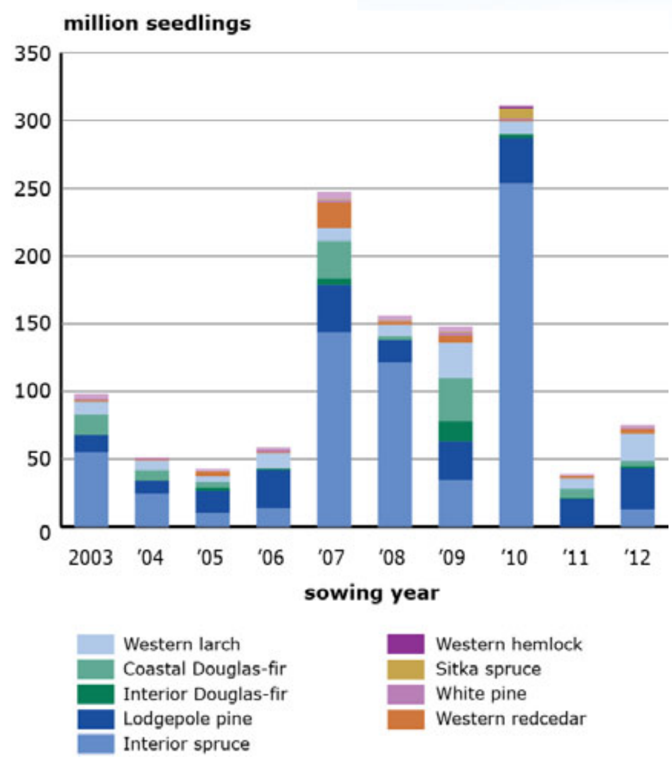
Cone and seed crops in 2012 were moderate for most species, good for western larch, and very low for interior spruce (Table 3; Figure 5). Lodgepole pine orchards had acceptable seed set (filled seeds per cone) from some orchards, but seed-set issues continue to impact production.

Overall, the total harvest of 800.4 kilograms of seed is sufficient to grow approximately 75 million seedlings, with lodgepole pine and western larch making up most of this production. Lodgepole pine and interior Douglas-fir continue to fall below expectations for seed production, limiting the use of high-genetic-worth seed in some seed zones.

Table 3
Summary of 2012 seed crops from all provincial orchards.

Species	Seed produced (kg)	Seedling equivalents (million)
Interior spruce	95.0	12.7
Lodgepole pine	250.4	30.1
Western larch	241.9	20.1
Interior Douglas-fir	61.0	2.0
White pine	26.0	0.5
Western redcedar	12.0	3.5
Sitka spruce	0	0
Coastal Douglas-fir	101.8	3.8
Western hemlock	12.3	2.6
Total	800.4	75.3

Figure 5
Orchard seed production by species and year.



Developing cones of interior spruce. These "flowers" (megasporangiate strobili) are at the end of the phenological stage where they are receptive to wind-borne pollen. They will soon become pendant on the branch as they develop into mature cones for harvest in late August.

(T. Wagner photo)