

Annual Report
2016/17



Table of Contents

1.0	Introduction.....	2
1.1	Forest Genetics Council of BC	2
1.2	Vision and Goals	3
2.0	Budget and Expenditures	4
3.0	Objectives and Performance Measures.....	5
3.1	Increase Genetic Gain for Growth	5
3.2	Increase Select Seed Use	6
3.3	Increase Pest-Resistant Seed Use.....	7
	<i>Feature: Jack H. Woods: The Face of Tree Improvement in BC 1999 to 2016</i>	<i>8</i>
3.4	Genetic Conservation.....	9
3.5	Resilience and Climate-based Seed Transfer	9
	<i>Feature: CEDaR: <u>C</u>edar <u>E</u>nhanced <u>D</u>urability and <u>R</u>esistance.....</i>	<i>10</i>
3.6	Resources and Efficiency	11
3.7	Monitor and Report.....	12
4.0	Seed Orchards and Crops	13

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

Main cover photo: Western Larch "flowers"

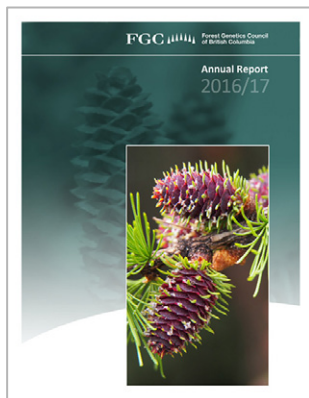


Photo: J. Woods

Developing cones of western larch (*Larix occidentalis*). This photo was taken in late April, following the period when the larch flowers are receptive to pollen and during the period of rapid cone development. These cones will change to a green colour by early summer and will begin to shed their seeds by about mid-August.

Messages

British Columbia's forests contain over 40 native tree species. The conservation and management of these important genetic resources contribute to sustainable forest management, carbon sequestration and the continued provision of ecological services.

The forest genetics activities of many organizations are coordinated under the auspices of the Forest Genetics Council of BC (FGC), a multi-stakeholder advisory established in 1999. I was fortunate to have served on FGC during its formative years. At that time, Jack Woods was the FGC Program Manager and CEO of SelectSeed Co. Ltd. In 2016, Jack announced his intention to retire.

In his dual role since 1999, Jack made tremendous contributions to the provincial forest genetics program, including the establishment and reporting of FGC's performance measures for value, resilience and conservation. He established 15 seed orchards in partnership with five private companies to increase the production of genetically selected seed. The FGC annual report is another one of Jack's enduring legacies. I would like to thank Jack for his dedication and service to this provincial program over the past 17 years.

With Jack's retirement, Brian Barber has taken the position of FGC Program Manager and CEO SelectSeed. Also, Pat Martin is the new Director, Forest Improvement and Research Management Branch, and FGC Co-Chair. I am confident the program's success will continue under their leadership and with the collaboration of all involved.

BC is blessed with invaluable forest genetic resources. With careful management these resources will continue to provide a wide range of benefits to current and future British Columbians

We are pleased to present the 16th annual report of the Forest Genetics Council. The 2016/17 fiscal year was a year of transition with Jack's departure, new roles for Brian and Pat, and the completion of the scientific foundation for new climate-based seed transfer standards.

FGC's 2020 targets for select seed genetic gain and use were almost met this year thanks, in part, to the fourth-largest seed crop in FGC's history. Additional capacity in lodgepole pine seed orchards is, however, still required, and planning is underway.

A highlight for Council was its fall field trip to Campbell River hosted by Interfor. Councillors visited a Douglas-fir realized gain trial established by Jack Woods 20 years ago, and a western redcedar field trial recently established as part of a promising genomics selection project. See the feature on the 'CeDAR' project in this report.

We are grateful to the LBIS program and others who have made financial and in-kind contributions to help us advance FGC's goals and programs. This includes the many people who serve on FGC and its various advisory committees, and SelectSeed's board of directors. We also wish to extend our thanks to Brian and Jack for their support, including the compilation of this annual report. Finally, best wishes to Jack in planning and enjoying his well-deserved retirement.



DIANE NICHOLLS RPF
Assistant Deputy Minister,
and Chief Forester,
Ministry of Forests, Lands,
Natural Resource Operations
and Rural Development



PAT MARTIN RPF
FGC Co-Chair and
Director, Forest
Improvement
and Research
Management Br.



MARK TAMAS RPF
FGC Co-Chair, and
Chief Forester,
Tolko Industries Ltd.

FGC's mandate is to enhance the conservation, resilience and value of BC's forests

1.0 Introduction

This annual report provides an overview of the Forest Genetics Council of BC (FGC), its objectives and progress towards the performance measures described in the FGC Strategic Plan 2015-2020. It also includes summaries of annual budgets and expenditures, provincial seed use and production, and BC's seed orchards. Features include retirement acknowledgements for Jack Woods and others, and a summary of a western redcedar genomics project.

1.1 Forest Genetics Council of BC

The FGC is a multi-stakeholder advisory group appointed by the Provincial Chief Forester. FGC includes representatives from the BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (Ministry), forest tenure holders, universities, and the Canadian Forest Service.

FGC's mandate is to lead and coordinate provincial forest genetics activities to enhance the conservation, resilience and value of BC's forests. FGC establishes objectives and performance measures, and provides advice to the Ministry regarding policies, practices, and the allocation of funds to research and operations.

FGC's vision, goals and objectives are described in its Strategic Plan 2015-2020. These guide the development of FGC subprograms, project plans, and annual business plans. Several technical advisory committees assist FGC in preparing these plans and their associated budgets. Hundreds of people are involved in this cooperative program which began in 1959 with the Plus Tree Board.

For more information about FGC, visit www.fgcouncil.ca

Lodgepole pine cones

Photo: B. Barber



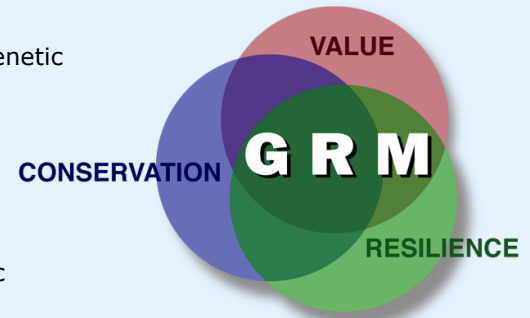
1.2 Vision and Goals

Vision

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

Goals of Genetic Resource Management (GRM)

- **Conservation** - the maintenance of natural levels of genetic diversity for all tree species indigenous to BC.
- **Resilience** - matching seed (genotypes) to planted sites (environments) and maintaining natural genetic diversity in planted populations of trees.
- **Value** - increasing the timber and non-timber economic value of planted forests.



Retirements

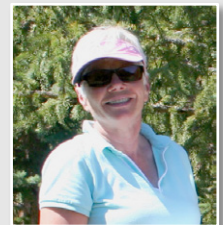
Hilary Graham

Hilary began her forestry career in 1986. She worked for several nurseries, Agriculture Canada, and as an independent consultant before serving as manager of Skimikin Seed Orchards 2012-17. She will continue working part-time between overseas travels.



Rita Wagner

Rita retired in 2016 as the site supervisor for the Ministry's Prince George Tree Improvement Station (PGTIS). She began her career with the Ministry in 1982 collecting scion from helicopters and working in PGTIS' orchards and research trials.



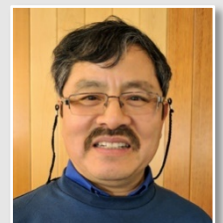
Elizabeth (Lisa) Meyer

Lisa enjoyed a 35-year career with the Ministry. She was as research field technician before serving as site supervisor at Saanich Seed Orchards from 2006 to 2016. She retired to Prince George with her husband Mark and their horses.



Cheng-Yi Xie, Ph.D., RPF

"Dr. X" worked for the Ministry from 1992 to 2017. Cheng-Yi was the Ministry's coastal hardwoods tree breeder, specializing in cottonwood, big-leaf maple and red alder. Travel, photography and gardening are on his retirement list.



2.0 Budget and Expenditures

Funding for advancing FGC's goals and objectives is derived from a variety of sources, including governments, forest tenure holders, tree seed sales, research grants and contributions. An important Ministry-funding program is its Land Based Investment Strategy (LBIS). LBIS funds are allocated to FGC's subprograms and various activities based on FGC's recommendations.

The following table summarizes FGC's recommended budget for a LBIS-allocation of \$2.5MM and actual expenditures by subprogram for 2016/17.

Table 1

Summary of Land Based Investment Strategy Tree Improvement Program and SelectSeed budgets and expenditures for the fiscal year ending March 31, 2017.

FGC Subprograms – LBIS funds	Recommended Budget (\$'000)	Actual Expenditures (\$'000)
Genetic Conservation	\$ 189	\$ 180
Tree Breeding	\$ 1,180	\$ 1,210
Operational Tree Improvement Program (OTIP)	\$ 424	\$ 380
Extension and Communication	\$ –	\$ –
Cone and Seed Pest Management	\$ 137	\$ 110
Genecology and Seed Transfer	\$ 429	\$ 460
Genetic Resource Decision Support	\$ 77	\$ 80
Applied Tree Improvement and Biotechnology	\$ 55	\$ 60
Administration	\$ 10	\$ 20
LBIS total	\$ 2,500	\$ 2,500
Additional Ministry funds (risked managed)	\$ –	\$ 180
SelectSeed Co. Ltd. expenditures supporting FGC	\$ 243	\$ 238
Total	\$ 2,743	\$ 2,918

The Ministry acquired additional funds to support tree breeding and genecology, the two largest subprograms. SelectSeed Co. Ltd., which is owned by FGC, also provided management services, and supported FGC meetings, communications, and the ministry's tree breeding program. SelectSeed generates revenue from selling seed produced in orchards operated under contracts with five private partners.

The above table does not include Ministry base-funded salaries and operating expenses (including seed registration, testing and storage), public and private seed orchards (which also operate on a cost-recovery basis), nor research grants including those provided by NSERC, Genome Canada and Genome BC.

Refer to FGC's annual business plans for additional information on its various subprograms and activities.

3.0 Objectives and Performance Measures

The FGC strategic plan includes five objectives and performance measures (PMs) for enhancing the value, resilience and conservation of BC's forest genetic resources. Two additional enabling objectives support these PMs.

The first two PM's associated with select seed use have been tracked since 1999 and combined contribute to the Ministry's annual service plan performance measure for timber volume gains from silviculture investments¹.

3.1 Increase Genetic Gain for Growth

Performance Measure

Increase the average volume gain of select seed² used for Crown land reforestation to 20% by the year 2020.

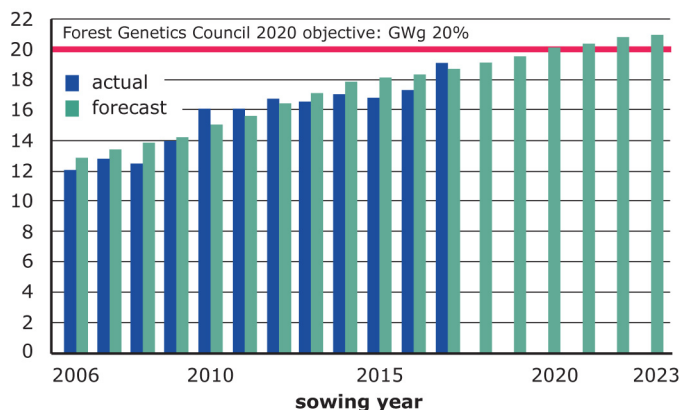


Figure 1

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

The volume gain of select seed or genetic worth for growth (GWg) is the additional timber volume estimated to be available at harvest compared to reforesting with wild stand (unselected) seed, expressed as percentage.

The average GWg of select seed used in 2017 sowing requests was 19.1, which is higher than the previous year and higher than forecast. This rise is largely attributed to the increased availability and use of high GW seedlots of interior spruce (avg. GWg 23) and lodgepole pine (avg. GWg 11.5).

¹ <http://www.bcbudget.gov.bc.ca/2016/sp/pdf/ministry/flnr.pdf>

² Select seed is seed with a genetic worth (GW) greater than zero for a specific trait such as growth (volume), wood density or pest resistance.

3.2 Increase Select Seed Use

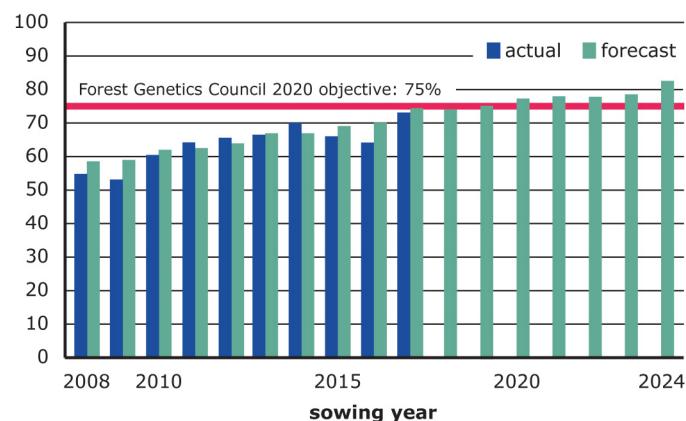
Performance Measure

Increase select seed use to 75% of the provincial total sown by 2020.

Progress

Figure 2

Actual and forecast select-seed use as a percentage of total provincial seed use, by year.

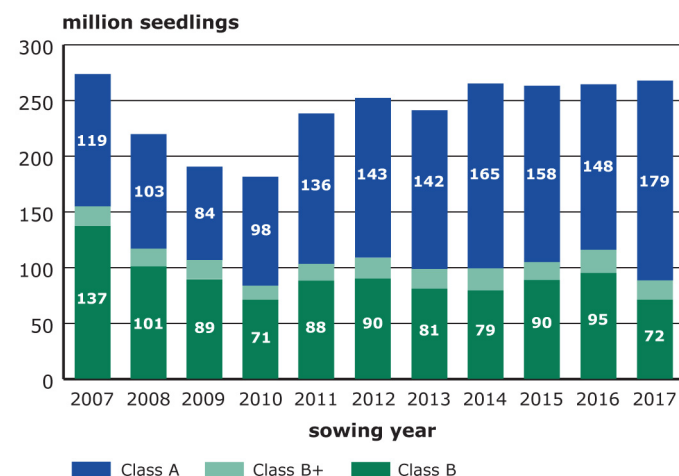


The total provincial sowing for 2017 remained high at 268 million seedlings. Class A sowing requests increased to 179 million seedlings and class B+ (exclusively lodgepole pine) was 17 million (see Figure 3). The percent of select seed (class A and B+) therefore increased to 73.1% of total sowing in 2017. This reversal of a two-year declining trend in select seed use is attributed to increased production of interior spruce and lodgepole pine class A seed.

The use of interior spruce orchard seed continues to account for over 50% of all class A seed sowing (Figure 4) and 92% of all spruce seed sown in 2017. Lodgepole pine orchard seed use increased to 22% of total class A use. However, the production of lodgepole pine orchard seed remains below annual demand and accounted for only 40% of 99 million pine seedlings requested in 2017. See Section 4.0. *Seed Orchards and Crops* for more detail.

Figure 3

Provincial sowing of orchard (Class A), wild-stand (Class B), and superior provenance seed (Class B+).



In recognition of the need to increase lodgepole pine seed production in the northern seed planning units, FGC's Interior Technical Advisory Committee developed a strategy to replace the first-generation orchards, which are mostly located in the Thompson-Okanagan region, with new second-generation orchards sited in cooler environments. Parent tree selections and the locations of these pine orchards are still to be determined, and subject to new climate-based seed transfer standards (see Objective 3.5).

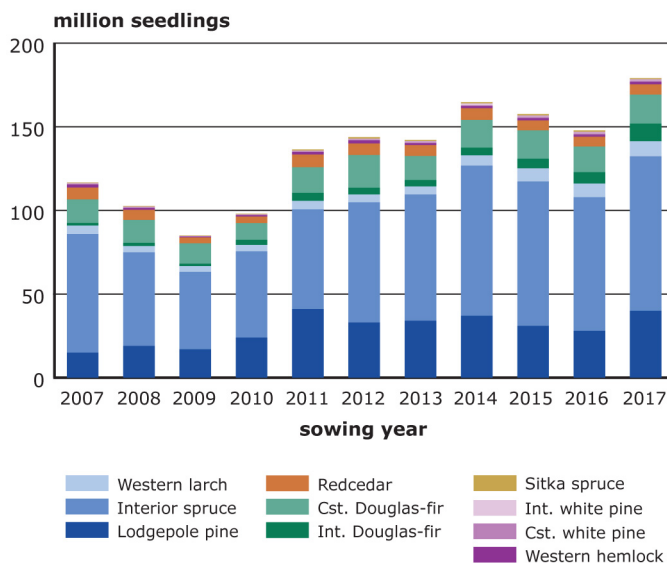


Figure 4
Provincial sowing of
orchard seed (Class A)
by species.

3.3 Increase Pest-Resistant Seed Use

Performance Measure

Increase the use of seed with a genetic gain for pest resistance to 50% of select seed sown by 2035.

Progress

This 'new' performance measure was introduced in 2015 based on stakeholder input, and the most common forest health challenges and tree breeding opportunities identified by entomologists, pathologists and geneticists.

Currently, only western white pine and Sitka spruce seed are registered with a genetic resistance to pests: western blister rust and terminal weevil, respectively. Selections and breeding values for resistance to other pests are currently underway, including: terminal weevil in interior spruce; western gall rust in lodgepole pine; root rots and swiss needle cast in Douglas-fir; and foliar diseases and ungulate browse in western redcedar.

Pest-resistant orchards will subsequently be established, and pest-resistant seed will be identified on the Seed Planning and Registry system (SPAR) in the years ahead. Future reports will include progress towards this new objective.

Jack H. Woods:**The Face of Tree Improvement in BC 1999 to 2016**

Jack Woods is a well-known leader and scientist among forest genetics communities both locally and abroad. He is recognized by many as the face of BC's forest genetics program, having served as Program Manager, Forest Genetics Council of BC (FGC), and CEO, SelectSeed Co. Ltd. from 1999 to 2016.

Jack was born and raised in the BC Kootenays where he developed his passions for the outdoors and sports. He was a member Canada's National Ski Team in the mid-70's, along with (but not one of) the "Crazy Canucks". Skiing took him south of the border where he earned a B.Sc. in forestry and M.Sc. in forest genetics at the University of Montana.

In 1982, he returned to BC for a gene archive job at the Ministry of Forests' Cowichan Lake Research Station. Living with his family in Duncan, Jack volunteered with a community school and team sports. In 1993, he took over the Coastal Douglas-fir (Fdc) breeding program from Chris Heaman and developed the advanced-generation breeding strategy, as well as research such as realized-gain trials to validate timber volume projections for reforestation with genetically-selected seed.

In 1997, Dale Draper recruited Jack to assist him with a review of the provincial forest genetics program. This review led to the establishment of the Ministry's Tree Improvement Branch, the FGC, and SelectSeed Co. Ltd, which is wholly owned by FGC. Jack was instrumental in developing the legal framework for the latter and securing a long-term funding agreement with Forest Renewal BC to expand provincial seed orchard capacity.

In 1999, he resigned from the Ministry to assume the dual-role position of FGC Program Manager and CEO SelectSeed. In these roles Jack developed and implemented strategies and business plans in collaboration with various public, private and academic agencies. He helped establish rigorous planning processes, science-based standards, criteria to guide investments, and durable performance measures and reports, such as this one.

Jack also oversaw the establishment of 15 seed orchards with five private partners in BC's interior. These orchards represent approximately 30% of BC's seed orchard capacity (see Table 2) and contribute to FGC's select-seed use objectives. SelectSeed's orchards now generate sufficient revenue to support annual operating expenses, provide management services to FGC, and contribute to the Ministry's tree breeding program. Jack views the establishment of this financially-stable business model as a career highlight.

On the side, Jack also served on Western Forest Genetics Association's executive, co-chaired an IUFRO working group, supported the Forest Science Board, and helped organize numerous conferences, workshops and tours.

In November 2016, Jack "retired" and passed his FGC/SelectSeed reigns over to Brian Barber, but continues to provide support and advice to ensure a successful transition – another demonstration of Jack's interest and dedication to the program.

Jack is proud to have worked with many intelligent and dedicated people around the world. He also feels fortunate to have had opportunity to do field research and explore BC's diverse ecosystems. He will continue to pursue travel and adventure in retirement with his partner, Dr. Sally Aitken, and his three children and grandchild.

We wish you all the best Jack!



John (Jack) H. Woods, RPF



Three generations of Douglas-fir tree breeders. Left to right: Chris Heaman, Jack Woods and Michael Stoehr.

Photo: Keith Bird



Left to right: Hilary Graham, Jack Woods, Dee Shaddock and Brian Barber at SelectSeed's lodgepole Pine seed orchards at Sorrento Nursery Ltd.

Photo: Brian Barber

3.4 Genetic Conservation

Performance Measure

Adequately conserve the genetic diversity of representative populations of all forest tree species native to BC by 2020, through a combination of *in situ*, *ex situ*, and *inter situ* conservation.

Progress

In 2016/17, the Genetic Conservation TAC updated its 5-year strategy for guiding conservation research and activities. This included updating definitions, inventories, and methodologies to estimate a tree species' *in situ* conservation status, including potential gaps in parks and protected areas.

This updated *in situ* conservation catalogue is also used to target *ex situ* seed collections from representative populations across the tree species range. In 2016/17, over 10,000 *ex-situ* seed samples representing 35 of BC's 42 native tree species were maintained at the Tree Seed Center's conservation seed bank.

These collections include representative samples of whitebark pine, a species at risk due to an introduced blister rust and climate change. Research in field testing and screening blister-rust resistant parents also continued in 2016/17.

A formal indicator for tracking progress towards this conservation performance measure will be introduced next year.

3.5 Resilience and Climate-based Seed Transfer

Performance Measure

By 2020, the selection and transfer of all tree seed used to reforest Crown land in BC will be guided by a climate-based seed transfer system that is regularly updated with new genecology and climate research information.

Progress

The development of a climate-based seed transfer (CBST) system is being led by the Ministry with input from forest professionals, academics and others.

In 2016/17, Phase 1- Scientific Foundation - of this initiative was substantially completed with the publication of Ministry's Technical Report 99: *A Proposed Climate-based Seed Transfer System from British Columbia* by O'Neill et al. This CBST system will better match seedlots to the climate of planting sites and utilize the existing biogeoclimatic classification system. It will also facilitate assisted migration, improve seed deployment, and simplify seed planning.

Phase 2 - Policy Development - was also advanced and aided by the formation of a multi-stakeholder advisory group. New tools and maps were also developed to help assess options and guide implementation of CBST. The new CBST standards are expected to be in place by 2018.



Keith Bird and Dr. Greg O'Neill collecting climate data at an assisted migration and adaptation trial (AMAT) site near Port Alberni.

Photo: Marie Vance

CEDaR: Cedar Enhanced Durability and Resistance

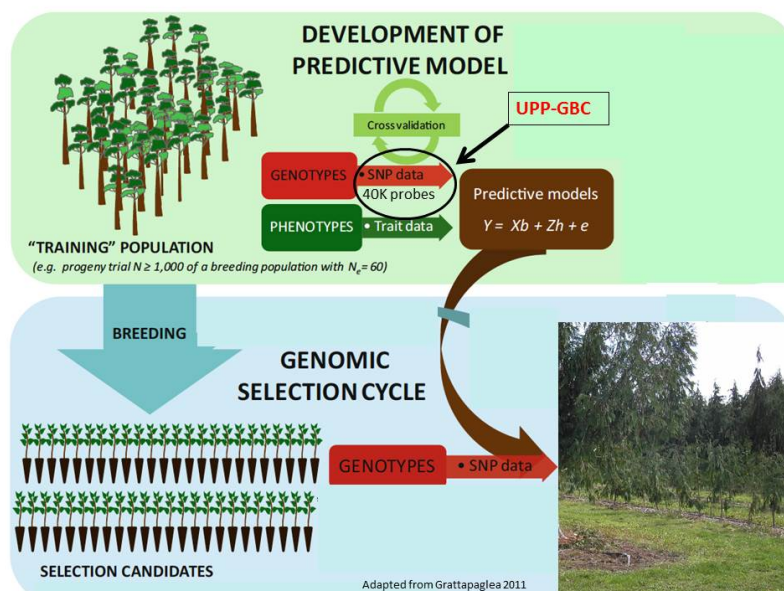
Western redcedar (cedar) is a long-lived tree species and known as the “Tree of Life” to Coastal First Nations peoples. Cedar’s unique wood characteristics, including low weight and rot resistance, make it superior for outdoor products such as roofing, decks, fences and siding. Its durability is derived from extractives deposited in heartwood, which takes decades to develop. Second-growth stands therefore contain less durable wood and less volume per hectare compared to old-growth forests. Pathogens, ungulate damage, and climate change also threaten the sustainability of cedar and the \$1.3B export industry it supports.

Dr. John Russell, the Ministry’s cedar geneticist, and Dr. Joerg Bohlmann, Professor Michael Smith Laboratories, UBC, have partnered with Genome Canada, Genome BC, Interfor, Island Timberlands, TimberWest, Western Forest Products, and FPInnovations to improve the genetic quality of the ~8M cedar seedlings planted annually on BC’s west coast.

This CeDAR project aims to develop genomic selection (GS) predictive models and apply them to the second-generation breeding population to identify trees with faster growth, more extractives, and better pest resistance. Recent advancements make GS more feasible, faster, and cheaper than traditional breeding methods – which can take 30-40 years to test and select trees for mature wood traits in large expensive field-tests.

Genomic-selected trees will be incorporated into cedar seed orchards managed by the project’s partners and used to produce seed for reforestation. Planting GS seedlings will save forest companies ~\$30M/year in browse protection and site rehabilitation costs. GS seedlings will also increase the resilience, productivity, and value of BC’s cedar forests for future generations.

For more information on the CeDAR project, visit <http://mrjeff.net/cedar/>



What is genomic selection?

Genomic selection (GS) consists of extracting and screening the DNA of 1000s of individuals in a large “training population” to identify single nucleotide polymorphisms (SNPs) associated with desired phenotypic traits observed in that population. A predictive model is developed and used to select seedlings based exclusively on their genotype in a target, related population. GS has been successfully used in animal breeding, notably dairy cattle, and eucalyptus and loblolly pine, and is under development for white spruce, Douglas-fir and other pines. (UPP-GBC = Genome BC’s User Partnership Program.)



Top left:
Heartwood rot in cedar logs.

Top right: Dr. John Russell
examining a cedar progeny trial.

Bottom: Collecting foliage for
DNA from target population
seedlings.

Photos: John Russell

3.6 Resources and Efficiency

Outcome

Secure resources and coordinate stakeholder activities to efficiently meet Business Plan priorities.

Performance

This objective does not have a performance measure but serves to support the previous five objectives and their PMs, and annual business planning. Its outcome is realized by securing and allocating resources, supporting FGC's various subprograms, and coordinating stakeholder activities.

These tasks are conducted in accordance with FGC's governance model, annual business planning processes, Ministry procurement policies and procedures, and guiding principles that include collaboration, open communication, and the use of best science and business practices.

FGC met four times during the fiscal year, including in-person meetings at Campbell River in October 2016 and at Richmond in March 2017. Conference calls were held in June and December 2016.

FGC also reviewed and approved the annual report and business plan for Select Seed Co. Ltd., which is now self-financed through seed sales to the Ministry and forest tenure holders. FGC also provided advice to SelectSeed's board of directors in their recruitment of a successor to Jack Woods.

A number of meetings were also conducted by FGC's various technical advisory committees (TACs), including the Coast TAC, Interior TAC, Genetic Conservation TAC, Genecology and Seed Transfer TAC, and Decision-support TAC. These TACs recommended activity priorities and funding to FGC.

A comprehensive analysis of future seed production and demand for the northern lodgepole pine seed planning units was also advanced by Jack Woods. This analysis considered future timber harvest, silviculture strategies, reforestation and seed orchard production forecasts, and climate-change. This analysis, despite its uncertainties and assumptions, supported the second-generation orchard replacement strategy endorsed by ITAC and FGC.

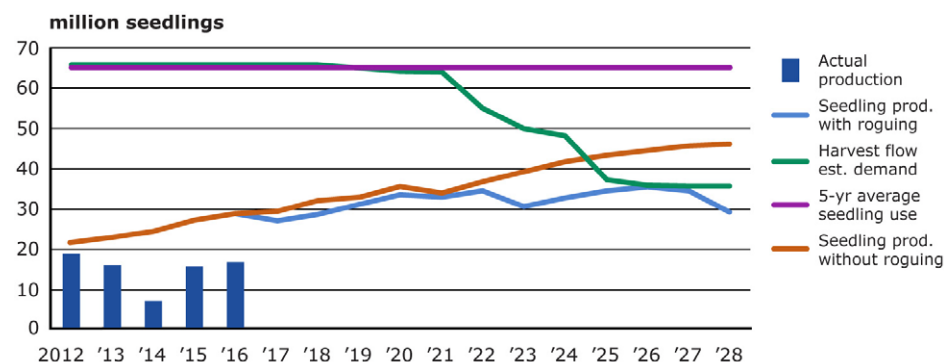


Figure 5

Projected orchard seed production and seedling demand for the three northern lodgepole pine (Pl) seed planning units: Prince George (PG), Bulkley Valley (BV) and Central Plateau (CP).

Figure: Jack Woods

3.7 Monitor and Report

Performance Measures

Annually produce a business plan, annual report and project report.

Progress

FGC's published a business plan, which outlined its subprograms, activities and recommended budgets for 2016/17 (also see Table 1). This business plan also included a comprehensive set of species plans that summarize tree breeding and conservation activities, and actual and projected seed production and use for each commercial tree species and seed planning unit.

An annual report for 2015/16 was also published in a format similar to this year's report and also included progress towards FGC's targets for value, resilience and conservation.

Since 2013/14, no tree improvement program project reports have been compiled. However, individual technical project reports are available, including those for operational research trials supported by FGC.

Extension and communication activities throughout 2016/17 also served to report advancements in forest genetics research, tree breeding, genecology, seed production, cone and seed management, CBST and decision-support. These activities included presentations at ITAC's annual extension meeting, silviculture committee workshops, and a BC Seed Orchard Assoc. meeting.

A separate series of workshops that focused on the lodgepole pine tree program was also held in 100 Mile House, Prince George and Burns Lake in October 2016. These sessions, sponsored by the Ministry, Vernon Seed Orchard Company and SelectSeed, were attended by approx. 100 persons.

BC Seed Orchard Association
meeting at the Tree Seed
Centre, Surrey, BC.
June 2016

Photo by Dave Kolotelo



4.0 Seed Orchards and Crops

There are 97 seed orchards in BC managed by the Ministry and private companies, including SelectSeed which is wholly owned by the FGC. These orchards, which contain over 116,000 parent trees, produce seed for the major commercial tree species and most areas in the province.

Seed production varies from year-to-year and species-to-species, as demonstrated in Figure 6. The 2016 cone crop was the fourth-largest crop in FGC's history. Over 2000 kg of seed, equivalent to 221 million seedlings, were collected. This large orchard crop also advanced progress towards FGC's select seed use performance measures. Seed surplus to 2017 sowing needs can be used in subsequent years, when production is also expected to be lower.

Species	Seed produced (kg)	Seedling equivalents (million)
Interior spruce	793	120.7
Lodgepole pine	210	28.5
Western larch	169	12.5
Interior Douglas-fir	306	13.3
White pine	52	0.8
Western redcedar	85	24.2
Sitka spruce	0	0
Coastal Douglas-fir	454	14.1
Western hemlock	39	6.2
Ponderosa pine	14	0.1
Red Alder	1	0.8
Total	2117	221.1

Table 3

Summary of 2016 seed crops from provincial orchards.

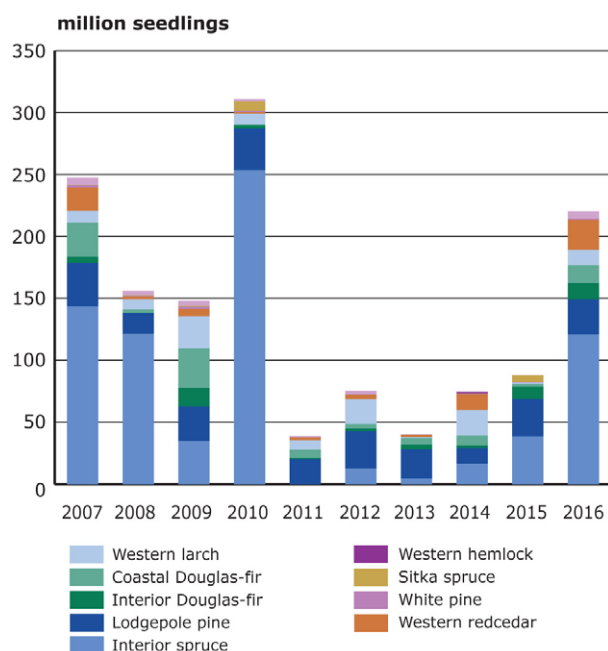


Figure 6

Orchard seed production by species and year 2007-2016.

