Table of Contents

Canadian Cataloguing in Publication Data

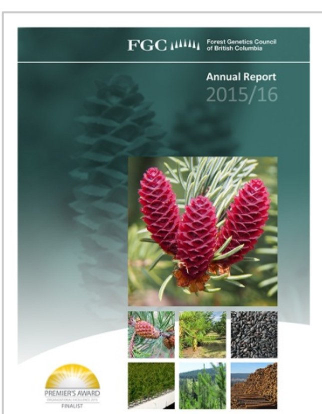
Forest Genetics Council of British Columbia

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: Interior spruce "flowers"



Photos: J. Woods

Interior spruce flowers range from green to deep shades of purple and red. These flowers are near the end of the period when they are receptive to pollen and will soon turn green and become pendant on the branch. Conifers are "wind" pollinated, meaning that pollen is airborne and not delivered by insects. Orchard flowers are pollinated by other trees from orchard. Orchard seed contains genetic gains for growth rate or other traits of economic interest, and initiates the value chain leading from seed through to harvested logs.

Messages

This report marks the 15th consecutive year in which the Forest Genetics Council of BC (FGC) has led planning and investments in provincial forest genetics and tree improvement. This program also continues to be a core category within the Land Base Investment Strategy (LBIS).

The FGC and its technical committees have maintained a healthy balance in meeting their objectives to: 1) increase timber supply and value; 2) increase resilience to climate change through the development of a climate-based seed transfer system; and 3) enhance genetic conservation. Broad stakeholder input and collaboration has kept the FGC focused on these three core objectives for many years. Although provincial Class A seed use reached a short-term plateau, continued production of high value seed will help us achieve the targets set out in our Strategic Plan for 2015-2020.

I would like to congratulate FGC and members of its technical committees for being a finalist in the 2015 Premier's Awards for Organizational Excellence. This achievement reflects their dedication, contributions, and enthusiasm. I wish you all continued success.

DIANE NICHOLLS
Assistant Deputy Minister
and Chief Forester,
Ministry of Forests, Lands and Natural Resource Operations
(FLNRO)

During the past year Council met quarterly, including a field trip to PRT Growing Services' Armstrong nursery and orchard complex. This site, which includes several orchards managed under contract with SelectSeed Ltd. (wholly owned by FGC) is an example of the excellent collaboration between the public and private sectors.

2016 was the sixth consecutive year when provincial sowing levels were above 240 million seedlings, and the third year in a row above 260 million. This high and sustained demand for seed resulted in a drop in total Class A seed use from 70% in 2014 to 64% in 2016. However, we are confident this recent trend is temporary as new orchards continue to come on-line and more Class A seed is available. Significant progress was also made towards our resilience and conservation objectives.

On behalf of Council, we extend our gratitude to the many people in government, industry and universities who contributed to our cooperative program.

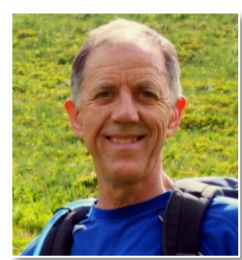
BRIAN BARBER
Former Co-Chair,
Forest Genetics Council of BC

Former Director,
Tree Improvement Branch, FLNRO

MARK TAMAS
Co-Chair,
Forest Genetics Council of BC

Chief Forester,
Tolko Industries Ltd.

I'm pleased to present the 2015/16 FGC Annual Report. With retirement looming, this is likely to be the last report prepared under my tenure. Reflecting on nearly 35 years of work in forest genetics programs in BC, I cherish most the working relationships and friendships with the many skilled and dedicated people who make this program work. It's been a long run of success, and everyone involved deserves congratulations. It's only through steady progress that the huge benefits of tree improvement are realized. BC is one of the few jurisdictions in the world that has successfully maintained such a comprehensive program. I'm very proud to have been part of it and I thank everyone involved.



JACK WOODS,
Program Manager,
Forest Genetics Council of BC

1.0 Introduction

This Annual Report presents progress using provincial-level performance indicators outlined in the FGC Strategic Plan for 2015 to 2020. Included are outcomes from Provincial investments made through the Land Based Investment Strategy (LBIS) Tree Improvement Program, as well as direct investments made through the Ministry of Forests, Lands and Natural Resource Operations (FLNRO), forest companies, SelectSeed Ltd., and the Canadian Forest Service. Specific projects are outlined in the Forest Genetics Council of BC (FGC) Business Plan for 2015/16.

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

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, conserving the genetic diversity of indigenous forest tree species, and enhancing forest resilience through scientifically-based seed transfer standards and forest health. 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 the FLNRO, the forest industry, universities, the Canadian Forest Service, and smaller forest-sector 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 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 (2015-2020), and annually develops a Business Plan outlining activities to meet these objectives.[1]

Vision

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

Objectives / Performance Measures

- *Genetic conservation: 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.*
- *Resilience and climate-based seed transfer: 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.*
- *Use of select seed for reforestation: Increase select-seed use to 75 percent of the provincial total sown by 2020.*
- *Increase genetic gain for growth: Increase the average volume gain of select seed used for Crown land reforestation to 20% by the year 2020.*
- *Use of pest-resistant seed for reforestation: Increase the use of seed with a genetic gain for pest resistance to 50% of select seed sown by 2035.*
- *Resources and efficiency: Secure resources and coordinate stakeholder activities to efficiently meet Business Plan priorities.*
- *Monitor and report progress in genetic resource management activities*

Retirements

Vicky Berger
Vicky worked for the FLNRO at the Kalamalka Forestry Center as a Research Technician with the lodgepole pine, white pine, and broadleaf breeding programs from 1993 to 2016.

Craig Ferguson
Craig worked for the FLNRO at the Cowichan Lake Research Station from 1985 to 2016, primarily as a Research Technician with the redcedar and yellow cypress breeding programs.

John Ogg
John began working for the FLNRO in Terrace in 1982 and retired in 2016 after many years leading propagation work at the Cowichan Lake Research Station.

Lisa Hayton
Lisa worked for the FLNRO in Victoria as a data management technician. Her work with the Douglas-fir breeding program extended from 1979 to 2016.

Randy Armitage
Randy worked for the FLNRO at the Kalamalka Forestry Center as a research technician leading growing and facilities management from 2007 to 2016.

[1] 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 and SelectSeed Ltd. allocations and expenditures for the 2015/16 fiscal year that were made in support of the provincial GRM program are shown in Table 1. The table excludes in-kind costs, staff salaries, and other substantial inputs by industry, FLNRO, and university cooperators that contribute to the success of GRM activities in BC.

Table 1
Summary of Land Based Investment Strategy Tree Improvement Program and SelectSeed budgets and expenditures for the fiscal year ending March 31, 2016 ($ x 1000).

LBIS Tree Improvement SubPrograms	Budget ($)	Expenditures ($)
Genetic Conservation	239	247
Tree Breeding	1,131	1,069
Operational Tree Improvement Program (OTIP)	503	418
Extension and Communication	0	0
Cone and Seed Pest Management	71	50
Genecology and Seed Transfer	361	336
Genetic Resource Decision Support	60	40
Applied Tree Improvement and Biotechnology	126	126
Administration	10	11
Total	**2,500**	**2,297**
SelectSeed Ltd. expenditures on behalf of FGC*	243	201

*SelectSeed provided program management services and paid expenses for communications (website, publications), meetings, research, and consulting on behalf of the FGC. In addition, funds were provided to the FLNRO to support a tree breeder for part of the year.

Non-allocated funds remained with FLNRO and were either re-allocated within the LBIS program or returned to provincial general revenue. Projects generally proceeded as planned. Some expected needs in the OTIP subprogram were not undertaken due to fewer orchard pest problems than anticipated. Tree Breeding and Genetic Resource Decision Support program under-spending was largely due to projects not proceeding as planned because of priorities and needs that changed during the fiscal year.

SelectSeed Ltd. (FGC owned) supported FGC activities using revenue derived from the sale of seed produced in orchards operated under contract.

3.0 Performance Indicators

Progress towards objectives set out in the FGC's new Strategic Plan for the period 2015-2020 (see section 1.3) are measured and reported annually. Two of these objectives are to increase the average genetic worth for growth (GWg[2]) of select seed[3] used to 20% by 2020 and to increase the use of select seed to 75% of total nursery sowing by 2020. Province-wide performance on these objectives is shown below.

3.1 Increase seedlot genetic worth

Performance measure

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

Performance

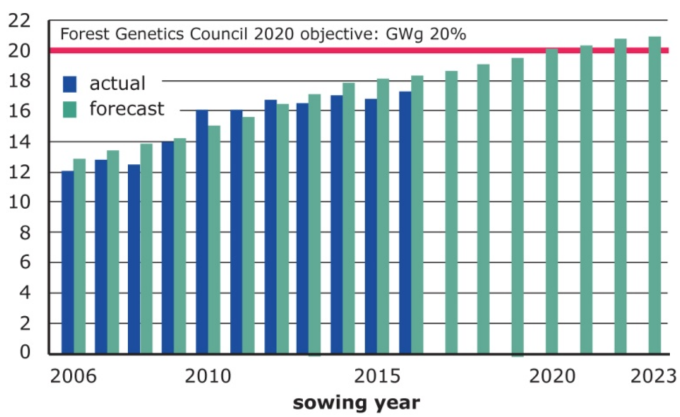


Figure 1
Actual and forecast annual average genetic worth for stem-volume growth (GWg) of select seed sown in BC.

The average GWg of select seed sown in the 2016 sowing year rose to a high of 17.3% on a forecast 18.1% (Figure 1). The increase from 2015 is due primarily to greater availability and use of very high GWg interior Douglas-fir and western larch class A seed. Coastal redcedar class A seed also showed a strong upward trend in GWg. Lodgepole pine GWg dropped due to continued insufficient orchard production and the increased use of class B+ seed during the sowing year.

[2] 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.

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

3.2 Increase select seed use

Objective

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

Performance

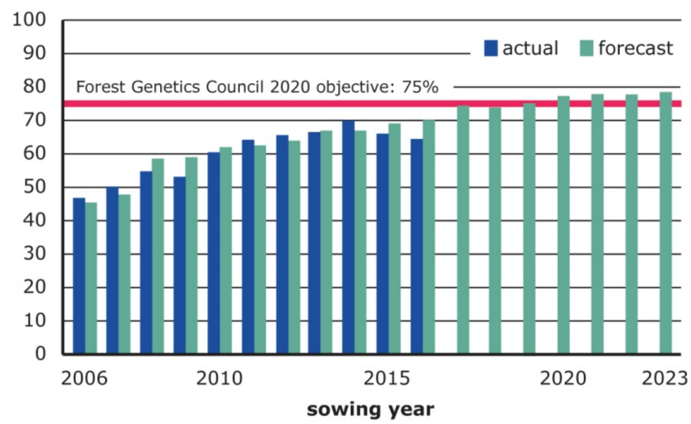


Figure 2
Actual and species-plan forecasts of select-seed use as a percentage of total provincial seed use, by year.

Select seed use as a percentage of total provincial sowing fell to 64.4% in the 2016 sowing year from 66.0% the previous year and 70.2% in 2014 (Figure 2). This downward trend is caused primarily by increased class B seed use for interior spruce and by decreased availability of class A lodgepole pine seed. Increases in orchard seed production for interior Douglas-fir are driving an upward trend in Class A seed use for this species. Western larch class A seed use also increased as a percentage of total larch sowing. Overall sowing of class A seed decreased from 158 million in 2015 to 148 million in 2016, while total provincial sowing increased slightly to 261 million (Figure 3).

In 2016 provincial sowing levels exceeded 240 million for the sixth consecutive year. Continued high seed demand is challenging provincial orchards to meet seed needs for some seed planning units (SPU). Reduced demand for central interior areas is anticipated, however, as post mountain-pine-beetle harvests drop.

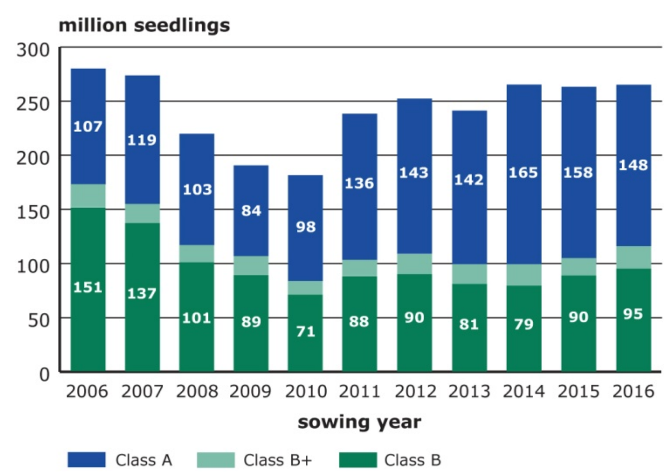


Figure 3
Provincial sowing of orchard (Class A), wild-stand (Class B), and superior provenance seed (Class B+).

Class A seed use for coastal Douglas-fir, western redcedar (coast), western white pine, Sitka spruce, and western hemlock remains high due to adequate orchard seed supplies. Orchard seed use for red alder on the coast is beginning as young orchards mature. Although somewhat reduced from previous years, interior spruce continues to account for over 50% of class A sowing in BC (Figure 4).

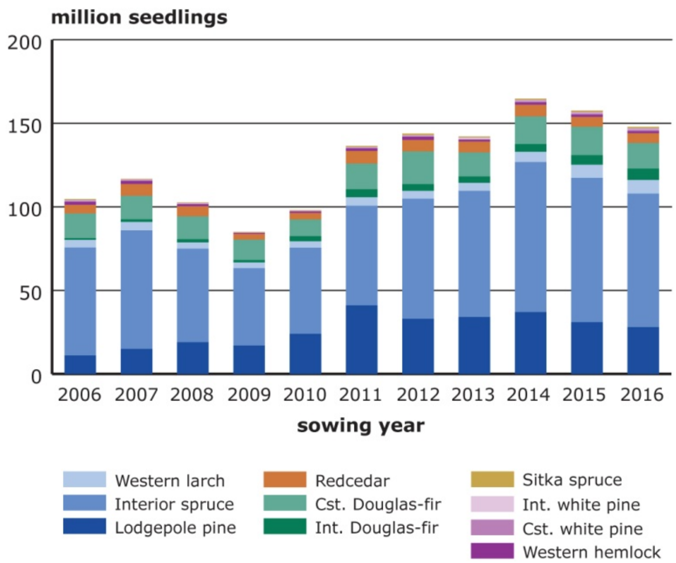


Figure 4
Provincial sowing of orchard seed (Class A) by species.

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.

Performance

The use of pest resistant seed is currently limited primarily to western white pine (blister rust resistance) and Sitka spruce (weevil resistance). For these species pests have long restricted use in operational plantations and the focus of breeding and orchard programs is on developing higher levels of resistance. Nearly all seed currently used is from genetically resistant sources.

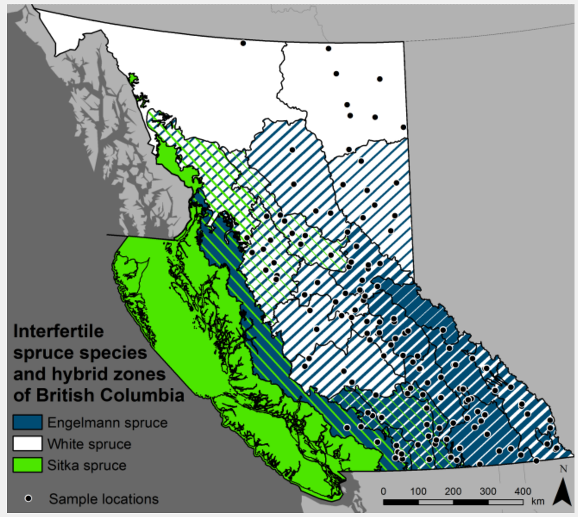
Pests such as pine rusts, interior-spruce leader weevil, and *Kethia* on redcedar are also receiving focus in breeding programs. New orchards are currently being established with varying levels of resistance for these species.

Future Annual Reports will report the proportion of class A seed used for planting that is from sources with some level of genetic resistance to a pest. In the 2016 sowing year, approximately 2% of class A seed use came from resistant seed sources.

Feature:

Spruce hybridization in British Columbia - Jon Degner (UBC)

British Columbia is home to three interfertile species of spruce; Sitka (*Picea sitchensis*), white (*Picea glauca*), and Engelmann (*Picea engelmannii*). Each has different ecological requirements, and wood qualities. For example, Sitka spruce has very low tolerance for freezing while white spruce is very frost-hardy. White-Sitka hybrids, present throughout the Nass and Skeena river systems, can tolerate conditions anywhere along that spectrum. Likewise, the cool, dry conditions of the Central Plateau are a perfect compromise between Engelmann spruce’s cool, wet habitats in the subalpine and white spruce’s cold, dry boreal habitat. As such, white-Engelmann hybrids, collectively referred to as “interior spruce (Sx)”, are present throughout much of the interior (see figure).



Map of hybridization among Sitka, white, and Engelmann spruce species in British Columbia. Relative stripe widths illustrate the average proportion of each species represented in hybrids. Pure Sitka spruce is found in coastal BC and pure white spruce occurs only in northern BC.

Following the recession of the ice sheet covering most of BC at the end of the last ice age, spruce rapidly recolonized the landscape and began hybridizing. While hybridization is common among similar species around the world, most hybrid zones consist of first-generation hybrids that may not be well-suited to their environments. In contrast, the spruce hybrids present in BC are the product of many generations of hybridization, allowing time for natural selection to favour hybrid trees that best survive and reproduce. They are able to draw from traits that evolved separately in both parent species and to thrive in new environments where either parent would quickly die off. This includes many regions of the Chilcotin Plateau that are too warm for white spruce and too dry for Engelmann. This flexibility has allowed the white-Engelmann hybrid zone to be widespread and stable for thousands of years.

While early researchers noted that pure species and hybrids could be differentiated based on cone morphology, these methods don't allow determination of the degree of hybridization. This has historically been troublesome for seedling nursery managers, as a seedlot that is 20% Engelmann and 80% white spruce will have different growing requirements than one that is 80% Engelmann and 20% white, yet these species may be indistinguishable in the field. Recent advancements in molecular genetics have allowed us to determine the boundaries of hybrid zones and to accurately categorize hybrids. For example, genetic data from the AdapTree project[1] has helped us determine that relatively few populations of pure Engelmann spruce exist in BC, and that some white spruces as far north as Fort St. John aren’t so white after all (see figure).

The easy crossability and huge range of traits among spruces in BC has given breeders an exceptional amount of genetic variation to work with, allowing the spruce breeding program to achieve high genetic gain for both growth and weevil resistance. New molecular tools will help breeders understand specific hybrids and select the best trees for seed orchards and seed production. This is particularly relevant for climate-based seed transfer policies currently being developed, as a broad range of hybrids will form the populations used for reforestation in future growing conditions. The hybrids of BC have allowed a constant spruce presence throughout every climate BC has faced since the last glaciation, and they will continue to support the productivity of BC's forests well into the future.

White (?) spruce cone. *(photo S. Aitken)*

[1] AdapTree is co-led by Dr. Sally Aitken (UBC) and Dr. Andreas Hamann (U. Alberta)

3.4 Adequately conserve genetic diversity

Objective

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.

Performance

Genetic conservation is focused on 42 tree species indigenous to BC. During 2015/16, ex-situ seed collections were completed for 6 species from 14 locations, bringing the provincial genetic conservation collection held at the Provincial Tree Seed Center to 10,007 samples representing 36 species. Moisture content testing was done for 136 family seedlots to monitor and help maintain seed quality. Species-range map updates were completed using vegetation resource inventory, cover percent, and botanical data. These maps are central to conservation cataloguing. Work with whitebark pine rust-resistance breeding included the establishment of four field trials and rust inoculations on nursery stock.

This program area partially supports the widely-used ClimateWNA model developed and maintained by the UBC Center for Forest Conservation Genetics. During the year, model upgrades continued and assistance was provided to people using the model for a full spectrum of forestry activities.

Other work included :

- upgrading of the existing genetic-conservation catalogue,
- maintenance of western yew and Garry oak genetic archives, and
- communications and extension on conservation issues.

3.5 Climate-based seed transfer

Objective

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.

Performance

Investments in the science underlying an effective climate-based seed transfer system continued in the FLNRO with field trial establishment, assessment, and data analysis for key reforestation species. Policy development work included the establishment of a Government Policy Working Group and the review of a science foundation report. Work on the UBC AdapTree genomics project continued, with completion of interior spruce hybrid zone maps, analysis of adaptive phenotypic variation and climate for B- versus A-class seed lots, and the development of SNP chips containing 50,000 markers for genotyping spruce and lodgepole pine for genocological and gemomic selection. A research project at the University of Victoria on developing western redcedar blight resistance for future climates was completed.

Feature:
Reducing early plantation costs with class-A seed

Fast early seedling growth improves stand establishment success and reduces cost. Treatments such as site preparation, larger planting stock, brushing, and fertilizing at planting are all implemented to favour early seedling growth and speed site green up. The use of class A seed that is genetically selected for growth also speeds plantation establishment when compared with non-selected wild (class B) seed, as shown in Figure A for interior spruce[1]. Similar comparative height-age relationships between class A and class B seed are found for all BC species with tree improvement programs that are focussed on growth gains.

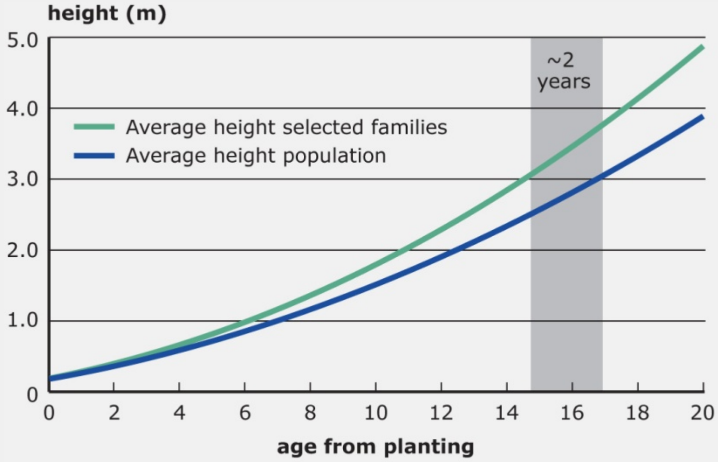


Figure A. Comparison of early height growth for selected families of interior spruce relative to non-selected wild seed.

Many factors impact early stand establishment, including pre-and post-harvest treatments, stock quality, weather, post-planting treatments, site moisture and nutrient status, etc. While class A seedlings experience all of these in much the same way as class B seedlings, the inherent ability of class A seedlings to grow faster increases the probability that brushing may be avoided on some blocks. The faster early growth also reduces the time to free-growing and crown closure.

Foresters working in interior and coastal areas have noted faster early height growth with class A seedlots and, as a result, a reduction in stand establishment costs due to the avoidance of brushing and weeding costs on some blocks. Because of the many interacting factors affecting plantation establishment, faster seedling growth will not always eliminate costly brushing and weeding treatments. However, as the cost of class A seed is, on average, about one twelfth the cost of brushing (Figure B), avoiding brushing on only one block in 12 will pay for the incremental cost of class A seed.

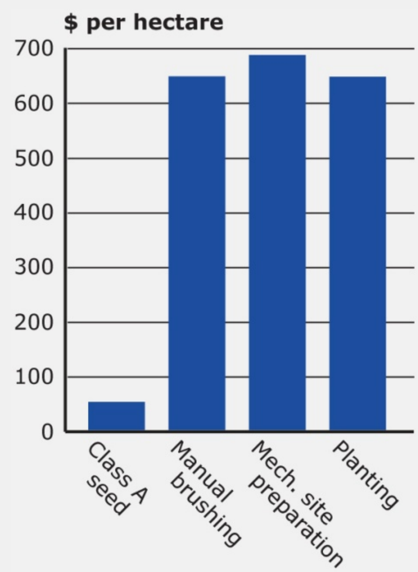


Figure B. Comparison of average silviculture costs. Costs shown for Class A seed are incremental costs relative to class B seed and represent a weighted average across species.

The many interacting variables that impact stand establishment make it difficult to quantify the benefits of any particular treatment, including class A seed. Years of observation have, however, convinced some foresters from both the interior and the coast that class A seed is reducing their establishment costs.

Faster early growth also helps young stands reach free-growing faster and full green-up sooner than seedlings from non-selected sources. Value gains can accrue through the earlier release of adjacent blocks of timber for harvest, reducing overall constraints on harvest timing. Silviculture foresters from one major interior licensee estimate their better Douglas-fir and spruce sites are achieving free-to-grow status 25 to 40% sooner in central BC.

[1] Seedlots with a positive Genetic Worth for growth (GWg) are selected primarily for growth and increasing yield at rotation. Some class A seedlots, (i.e. white pine or Sitka spruce) are selected for disease or pest resistance and may exhibit early growth rates that are similar to wild or non-selected seed).

3.6 Coordinate stakeholder activities

Objective

Secure resources and coordinate stakeholder activities to efficiently 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 2016/17,
- a published Business Plan and full set of species plans for 2016/17,
- a published FGC Annual Report for 2014/15,
- ongoing management of committee work and collaboration on issues.

Council met four times during the fiscal year, including meetings at the PRT Growing Services Armstrong nursery and seed orchard complex, the Provincial Tree Seed Center in Surrey, and the TimberWest Forest headquarters in Nanaimo. Other business included the development of a full suite of activities and accompanying budget recommendations to guide FLNRO spending under the LBIS Tree Improvement Program. During the year, Council-owned SelectSeed Ltd. supported a succession tree breeder position within the Tree Improvement Branch, and communications and business activities for the FGC.

The FGC is proud to have been recognized as a 2015 Premier's Awards Provincial Finalist in the category of Organizational Excellence.

Members of the Forest Genetics Council and associated technical committees accept the 2015 Premier's Award Finalist certificate from John Dyble, Deputy Minister to the Premier (center front) at a ceremony in Victoria.

3.7 Monitor and report progress

Objective

Monitor and report progress in genetic resource management activities.

Performance

Projects planned for the year ending March 31, 2016 were outlined in a comprehensive Business Plan for 2015/16. Also included are plans with specific information on breeding programs, seed orchards, historic seed use, and orchard production for all major seed planning units. This annual Business Plan is designed to fulfill objectives set out in the FGC Strategic Plan for the 2015-2020 period. Performance indicators for objectives set out in the FGC Strategic Plan are reported in Annual Reports. Numerous other reports are presented at technical meetings by program cooperators or are communicated through the FGC or FLNRO Tree Improvement Branch websites.

Table 2
Seed orchards in BC, summarized by site.

Site and owner[4]	Number of seed orchards	Total #of ramets established	Ramets under contract with SelectSeed Ltd.
Vernon Seed orchard Company Ltd.	17	32,784	8,359
Kalamalka Seed orchards (FLNRO)	16	17,605	
Skimikin Seed Orchards (FLNRO)	15	18,563	
PRT Growing Services Ltd.	6	11,873	9,781
Kettle River Seed Orchards	2	7,402	7,402
TimberWest Forests Ltd.	7	5,940	
Tolko Ltd.	4	5,658	4,903
Sorrento Nurseries Ltd.	2	5,036	5,036
Western Forest Products Inc.	10	3,601	
Saanich Seed Orchards (FLNRO)	6	3,844	
Prince George Tree Improvement Stn. (FLNRO)	3	3,184	
Small private (2 sites)	5	1,264	
Total	93	116,754	35,481

Transverse cuts of a lodgepole pine cone showing many healthy filled seeds. Orchard managers strive for this level of production.

(photo J. Woods)

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

4.0 2015 Orchard Seed Crops

Cone and seed crops were moderate to low for most species in 2015, with the exception of interior Douglas-fir. Lodgepole pine also had a larger crop than in most years, although still well below demand (Table 3; Figure 5). This was the fifth consecutive year with relatively poor interior spruce crops. Notable were the first small crop of red alder and the potential for quickly increasing crops of both red alder and ponderosa pine.

The total 2015 harvest of 927 kilograms of seed is sufficient to grow approximately 88 million seedlings.

Table 3
Summary of 2015 seed crops from provincial orchards.

Species	Seed produced (kg)	Seedling equivalents (million)
Interior spruce	290	38.6
Lodgepole pine	229	30.2
Western larch	12	1.0
Interior Douglas-fir	262	9.9
White pine	31	0.5
Western redcedar	0.2	0.0
Sitka spruce	32	5.6
Coastal Douglas-fir	58	2.3
Western hemlock	0.4	0.1
Ponderosa pine	12	0.1
Red Alder	0.02	0.0
Total	927	88.3

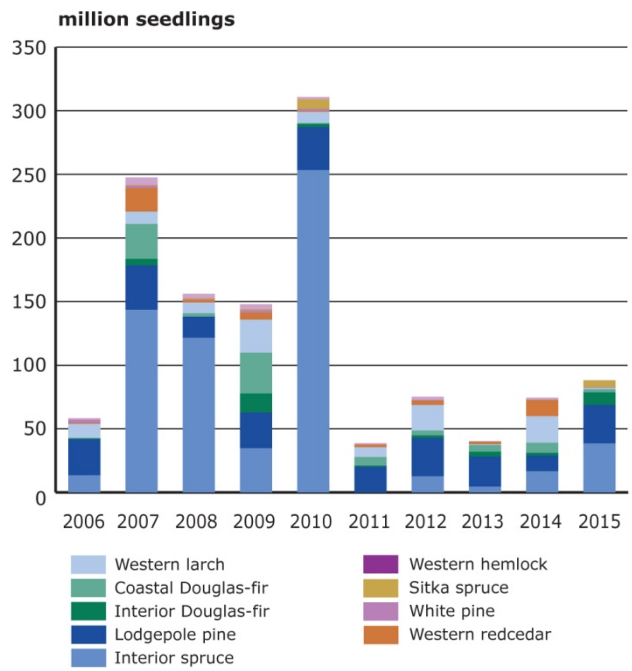


Figure 5
Orchard seed production by species and year.