2011/2012

Forest Genetics Council of BC

Tree Improvement Program

Project Report

This page is intentionally blank.

2011/2012

Forest Genetics Council of BC

Tree Improvement Program Project Report

Introduction and Acknowledgements

Objectives continue to be met by the provincial program led by the Forest Genetics Council of BC (FGC). Operating in its current structure since a major reorganization in 1998, Council has set a strategic vision and formulated objectives through strategic plans, the most recent of which is for the period 2009-2014. These plans have guided subprograms and the development of annual business plans for work that is applied and focused on clear and measurable objectives. Annual reporting provides provincial-level progress measures in FGC Annual Reports and project-level progress in this report. Senior managers in the MFLNRO and the forest industry, as well as the public, have clear measures on progress and access to information through these reports (available at www.fgcouncil.bc.ca). The rigour shown through the business planning and reporting processes has been instrumental in the ongoing support received through the Tree Improvement Program of the Land Based Investment Strategy (LBIS). Tree Improvement investments currently support fully half of the LBIS timber supply objectives through a relatively minor percentage of the overall LBIS investment.

Climate change remains a significant challenge for this program. Forest health and productivity is negatively impacted by climate change because individual trees that are genetically adapted to past climates are now becoming poorly adapted to the climate in which they are rooted. This results in stress and susceptibility to pests, diseases, and other factors. Understanding the patterns of genetic diversity for tree species and developing seed transfer standards that guide operational planting is the primary response to climate change available to forest managers. By better matching the genetic potential of seed used with changing present and future climates, the health and productivity of BC's forests can be supported. Key to this strategy is research to understand the genetic diversity patterns of commercial tree species and how these align with climate. Also key is the development of methods to interpret climates in terms of BC forest ecosystems and how these ecosystems might change over time. Changing seed transfer standards to ensure that seed used is optimally matched to future climates will allow forest managers to better ensure healthier planted forests in the future.

Research on how genetic diversity aligns with climate and on climate model interpretation is well underway in BC. Early provenance testing dating back to the 1960s, and more recent and more specific genecology research, is providing valuable information. With many long-term field trials in place and with models such as ClimateBC, new seed-transfer-standard development is underway. This will not be a one-time change, but rather a new process that will allow updated information to be utilized within a framework of seed transfer that supports operational planting. Changes to seed orchards and to seed inventories held by the private sector and BC Timber Sales are important considerations when developing new seed transfer standards. Significant funding leverage to the LBIS Tree Improvement Program is also being realized with projects such as the UBC-led AdapTree Project funded by Genome Canada. Ultimately these combined efforts will result in better forest health and productivity and a more secure forest-based economy.

A primary strength of this provincial program is the people who work in it. Their dedication and commitment is remarkable and accounts for ongoing program success despite economic challenges within the forest sector. Collaboration for efficient overall delivery is key. The FGC leads this collaboration and provides a structure for people from participating companies and agencies to collaborate through technical committees that focus on specific areas such as seed transfer or genetic conservation. I sincerely thank members of Council and members of all technical committees for their ongoing work.

This publication, in conjunction with the FGC Business Plan and FGC Annual Report, meets the reporting obligations of Council and the LBIS Tree Improvement Program. I would like to thank all project leaders for their contributions.

Jack Woods
Program Manager, Forest Genetics Council of BC
CEO, SelectSeed Ltd.

The Forest Genetics Council Co-chairs invite you to review the programs and projects described in this report and return any questions or comments to:

Tree Improvement Coordinator
Ministry of Forests, Lands and Natural Resource Operations (MFLNRO)
Tree Improvement Branch
PO Box 9518 Stn Prov Govt
Victoria, BC V8W 9C2

Further Tree Improvement information can be found at our web sites:

Forest Genetics Council	http://www.fgcouncil.bc.ca
MFLNRO, Tree Improvement Branch	http://www.for.gov.bc.ca/hti
	http://www.for.gov.bc.ca/hre/forgen/

BRITISH COLUMBIA
Ministry of Forests, Lands and Natural Resource Operations

FGC Forest Genetics Council of British Columbia

Table of Contents

Tree Improvement in British Columbia

The Forest Genetics Council of British Columbia (FGC) is a multi-stakeholder group reporting to the provincial Chief Forester and representing the forest industry, Ministry of Forests, Lands and Natural Resource Operations (MFLNRO), the Canadian Forest Service, and universities. Council's mandate is to champion forest genetic resource management (GRM) in British Columbia, to oversee strategic and business planning for the provincial Land Based Investment Strategy (LBIS) Tree Improvement Program, and to advise the province's Chief Forester on forest genetic resource management policies. FGC Technical Advisory Committees (TACs) provide technical and policy information to Council and contribute to the development of FGC plans and associated budgets.

Council's vision is that BC's forest genetic resources are diverse, resilient, and managed to provide multiple values for the benefit of present and future generations. This vision is supported by six objectives that are set out in Council's Strategic Plan for the period 2009 to 2014* and reported upon annually.

Annual business planning processes are designed to support achievement of the objectives, and the FGC Business Plan defines the annual set of activities and budgets needed to achieve objectives and realize the overall vision.

Forest genetic resource management is a co-operative effort in BC. In broad terms, the MFLNRO leads tree breeding activities and private companies contribute with test sites. Orchard seed production is a collaborative effort between MFLNRO and the private sector. The MFLNRO, universities and consultants carry out research supporting operational GRM programs.

Various technical advisory committees reporting to the FGC facilitate collaboration on a variety of support issues, including genetic conservation, climate-based seed transfer, orchard pest management, extension, and records management and decision support.

The Interior and Coast Technical Advisory Committees (ITAC and CTAC) are the primary committees reporting to and informing the FGC. Members are drawn from people involved with GRM activities in BC, as well as operational forestry staff from forest companies or government agencies. The Chairs of the ITAC and CTAC sit as members or Council to facilitate communication and input between the policy and management perspective of Council and the more applied perspective of the TACs. Other technical advisory committees also advise the FGC, but are not directly linked through Council membership. These TACs include Genetic Conservation (GCTAC), Seed Transfer (STTAC), Extension (ETAC), cone and seed Pest Management (PMTAC), and Decision Support (DSTAC).

* http://www.fgcouncil.bc.ca/StratPlan0914-Layout-Web-22Dec09.pdf

LBIS – FGC Tree Improvement Subprograms

The Land Based Investment Strategy, Tree Improvement Program (LBIS-TIP) is structured to deliver the provincial strategy for forest genetic resource management developed by the Forest Genetics Council. There are eight subprograms:

- Genetic Conservation
- Tree Breeding
- Operational Tree Improvement Program (OTIP)
- Orchard Seed Supply (SelectSeed Co. Ltd.)
- Extension and Communication
- Genecology and Seed Transfer
- Genetic Resource Decision Support
- Seed Orchard Pest Management

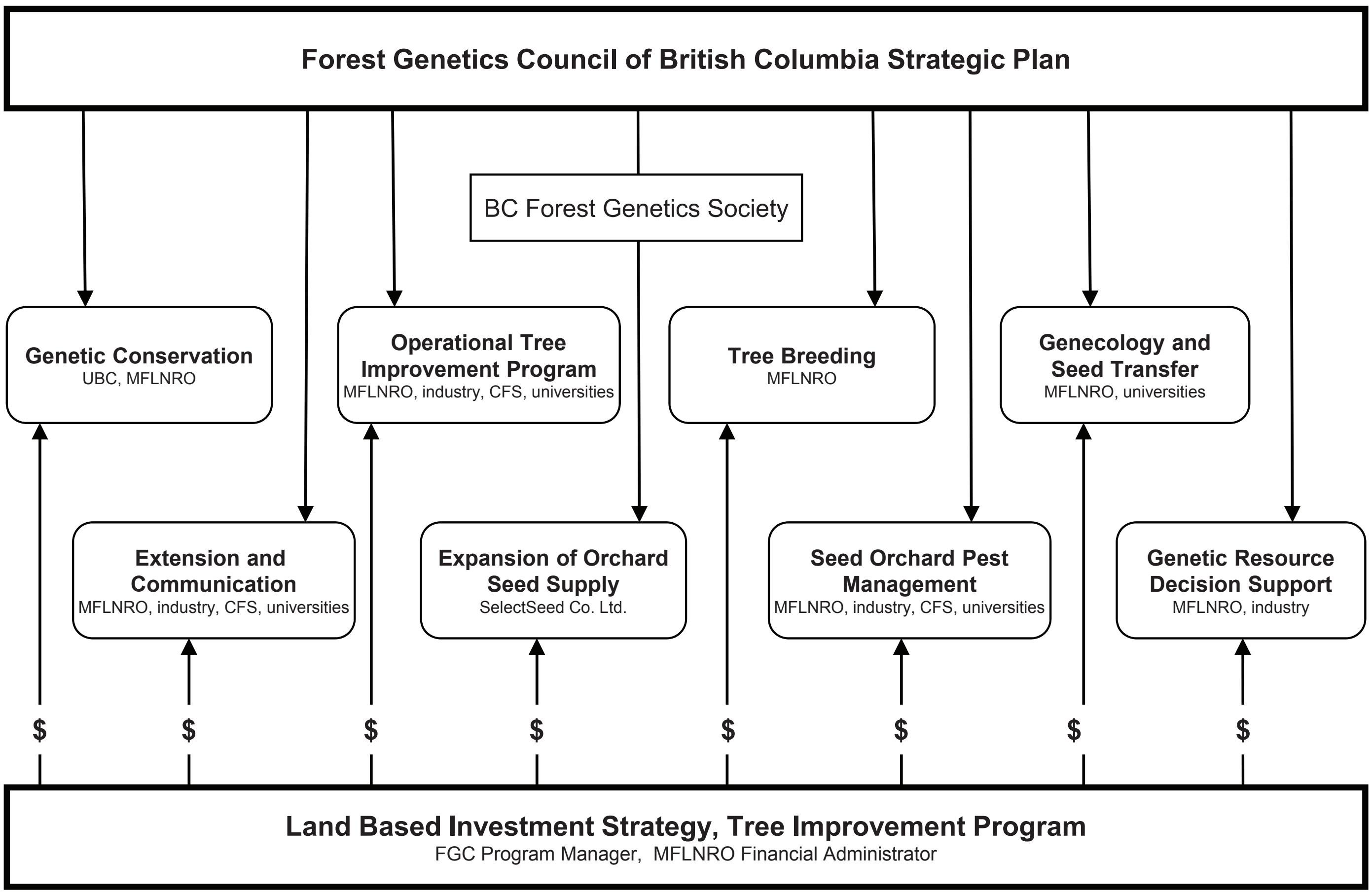


Figure 1. Relationship between FGC Strategic Plan, LBIS-TIP, and participants in various forest genetic resource management areas.

1.0 Expansion of Orchard Seed Supply Subprogram (SelectSeed Co. Ltd.)

Jack Woods

Overview

SelectSeed Company Ltd. (SCL) has a mandate from the Forest Genetics Council of BC (FGC) to produce genetically selected tree seed for use on provincial Crown land in support of FGC objectives. SCL remains wholly owned by the FGC and is managed by the CEO, reporting to a five-member board of directors. The company generates revenue through seed sales and continues to receive funding from Land Base Investment Strategy (LBIS) allocations that are managed through the FGC. As seed production and seed sales increase, LBIS contributions are diminishing. It is expected that all revenues will be derived from seed sales by about the 2014 fiscal year.

SelectSeed operations follow a business planning process that annually develops activities and budgets needed to meet objectives. This plan is prepared by management, reviewed and approved by the SelectSeed Board of Directors, and presented to the FGC for final approval. All SCL orchard investments are through long-term contracts with the private sector.

SelectSeed also provides program management services to the FGC. These include business plan and annual report preparation, support for policy recommendations, meeting organization, oversight of structural and planning issues, and legal and accounting matters.

Seed Orchard Operations

Cone crops in 2011 were smaller than in 2010 and poorer seed set for lodgepole pine resulted in both less seed and higher variable costs per kg of seed produced. For orchards serving southern seed planning units (SPU), seed set remained at an acceptable level of 267 g/hl of cones, but this was down substantially from 2010 when southern orchards produced 355 g/hl. Northern orchards, excluding a very low crop yield from one site, yielded 126 g/hl versus 160 in 2010. Overall, the nine lodgepole pine orchards operated under contract with SCL produced 176.2 hectoliters of cones and 39.4 kg of seed, down from the 2010 crop of 219.4 hectoliters 55.7 kg of seed (SCL share of crops only).

Douglas-fir crops were very small in all north Okanagan orchards in 2011, including orchards operated under contract with SelectSeed. Cones were harvested in two of the three SelectSeed Fdi orchards, with a total yield of 6.2 hl and 0.8 kg of seed (SCL shares only). This is a substantial reduction from the 2010 yield of 16.4 kilograms. During 2011 no spruce crops were produced in the two orchards operated under contract to SCL or in any other north Okanagan spruce orchards.

The total value of seed added to inventory was $314,828, down from $682,000 in 2010. This difference is primarily due to a good spruce crop in 2010 and no spruce crop in 2011. Seed sales to the fiscal year end totaled $426,684, down from $580,066 the previous year. The sale of nearly $130,000 worth of seed held in inventory, primarily spruce, brought sales close to the SCL Business Plan forecast level of $451,000. Seed inventory of about $76,000 remains at fiscal year-end (90% interior spruce and the remainder small lots of Pli and Fdi). This inventory

Plate 1. Lodgepole pine orchard produces seed for lower elevations in the Prince George area. Kettle River Seed Orchard Company operates the orchard under contract with SelectSeed Company Ltd. (Photo J. Woods).

will be marketed in 2012 and 2013. During the sales year the SelectSeed customer base remained at over 70 clients, including BC Timber Sales, the MFLNRO, major licensees, first nations, woodlot owners, and community forests.

During the fiscal year, an agreement was reached through the FGC for SelectSeed to participate in the development of a 1900-ramet Douglas-fir orchard that will provide seed for the 1100-1600m elevation band in the Thompson Okanagan seed zone. About 2000 rootstock grown in 2010 were outplanted to holding beds for grafting in 2012 and 2013. Sufficient scion was collected in February, 2012 for 500 grafts to be made in May of 2012. As the rootstock is not all large enough to graft in 2012, this number was deemed to be sufficient and the remaining 1500 will be grafted in 2013.

Pli grafting for replacement stock was undertaken on contract, with 667 grafts completed. This stock is in holding and will be planted in the late summer of 2012 or the spring of 2013. Scion collection for the propagation of 400 Pli was completed in February, 2012.

FGC program management

FGC program management activities included the coordination of Business Plan development and reporting on progress indicators, as well as governance and organizational matters related to Council meetings and activities. The FGC was represented in numerous issues on seed, genetics, and policy matters.

Reports and plans completed during the year on behalf of the FGC include:

- FGC 2010/11 Annual Report
- FGC 2011/12 Business Plan

Support was provided to Council's Technical Advisory Committees and species committees, and species plans were maintained, updated, and made available for 51 provincial seed planning units. A website was also maintained on behalf of the FGC. A number of communication activities were completed, including formal and informal talks to various forest industry staff, conferences, and committees.

SelectSeed management and administration

All SelectSeed financial and governance needs were completed. These include financial and legal matters on long-term seed orchard agreements, maintenance and audit of books of account, Company Act reporting requirements, Board of Director support, financial reporting on the SelectSeed Multi-Year Agreement, and reporting to the FGC.

2.0 Genetic Conservation Technical Advisory Committee (GCTAC)

The Genetic Conservation Technical Advisory Committee (GCTAC) has responsibility for recommending adequate conservation of the genetic structure and diversity of BC tree species. This past year the committee initiated a review of its strategic plan to guide its mandate, scope and required activities. The GCTAC budget and text below are divided by the two main funding recipients: UBC Centre for Forest Conservation Genetics (CFCG) and the MFLNRO Tree Improvement Branch.

2.1 Centre for Forest Conservation Genetics (CFCG) University of BC

Sally Aitken

Research in the Centre for Forest Conservation Genetics proceeded largely according to plan and to budgets for the 2011-12 fiscal year. Funding received from the FGC Genetic Conservation Subprogram through the GCTAC was augmented by funds from the Genecology Call for Proposals, an NSERC Discovery Grant to S. Aitken, and funding from Genome Canada, Genome BC and other organizations for the AdapTree genomics project.

Tongli Wang continues to lead forestry-related climate modeling and analysis efforts through continued development and maintenance of Climate BC and Climate WNA software used widely in forestry and other research, and through development and analysis of climate-based seed transfer approaches. Wang and others completed the "Flying BEC Zones 2.0" analysis and manuscript for publication in Forest Ecology and Management, updating the landmark work of Hamann and Wang (2006) with new analytical methods and more climate change scenarios and models.

The AdapTree project ("Assessing the adaptive portfolio of reforestation stocks for future climates") examining the genomic basis of adaptation to climate in lodgepole pine and interior spruce to inform climate-based seed transfer and adaptive diversity requirements for future climates was initiated in July 2011. This large-scale genomics project is primarily funded by Genome Canada (50%) and Genome BC (25%), but co-funding is provided from a variety of sources, including the Genetic Conservation and Genecology subprograms of the FGC, Alberta Innovates Bio Solutions, and contributions from several universities (UBC, Virginia Tech and UC Davis). Four common garden experiments containing 250-280 natural stand seedlots were established in growth chambers, and an additional common garden comparing natural populations and seed orchard lots was established in a greenhouse in 2011-12 for each species.

Amanda de la Torre completed her PhD research on the genetic structure of the interior spruce hybrid zone using both molecular genetic markers (single nucleotide polymorphisms and microsatellite loci) and phenotypic data from the interior spruce breeding program (provided by B. Jaquish). She found that hybridization occurs over a wider area and farther north than previously thought, and found that selective breeding favours hybrids with more white spruce ancestry over Engelmann spruce ancestry for all but the highest elevations. This work was largely funded by NSERC and Genome BC, but a small fraction of the funding came through the Genetic Conservation subprogram. A parallel study on the genetic structure of the Sitka-white spruce hybrid zone by PhD candidate neared completion in 2011-12, but this project did not receive any funding through the FGC.

The CFCG continued research on whitebark pine and other non-timber species in 2011-2012. Sierra McLane's PhD research on early results from her assisted migration experiment with whitebark pine was completed and accepted for publication in 2012 in the journal Ecological Applications. Whitebark pine seedlings were able to germinate, establish and survive at sites well north of the current species range in areas predicted by climatic models to be favourable. The small elevational transect experiment with whitebark pine established under the Peak2Peak gondola at Blackcomb in 2010 was assessed for survival and growth in September 2011. Results of population and ecological genetics studies of Pacific dogwood were published in the American Journal of Botany in 2011. We continue to maintain the Garry oak provenance trial at UBC and plan to re-measure and re-analyze this experiment in 2012.

Sally Aitken co-authored the conservation genetics textbook "Conservation and the Genetics of Populations", second edition, with Fred Allendorf and Gordon Luikart. This book will be published in late 2012.

2.2 Tree Improvement Branch Conservation Activities

Conservation Catalogue

Charlie Cartwright

Recent conservation cataloguing for tree species in BC consists of 3 documents.

- Technical Report 053 of Ministry of Forests and Range, Forest Science Program. (Forest Tree Genetic Conservation Status Report 1: *In Situ* Conservation Status of All Indigenouse British Columbia Species by Chourmozis et al, 2009) is a general census.
- Technical Report 054 (Forest Tree Genetic Conservation Status Report 2: Genetic Conservation of Operational Tree Species by Krakowski et al, 2009) covers details for timber species that have breeding programs.
- A catalogue is now in development, (Genetic Conservation and Genecological Traits of Minor Indigenous Timber Species), that concerns tree species that have genecology trials and seed transfer guidelines developed. By the end of 2011-12, 4 of 10 such species had been assessed.

Gene Conservation *Ex Situ* Seed Collection

Priorities for collection are derived from the assessment in Technical Report 053 and targeted species are specified for seed collection. 2011-12 was a mediocre crop year, yet 6 whitebark pine, 4 limber pine, 3 western yew, 2 juniper, 3 arbutus and 7 cascara populations were obtained. This is an ongoing project.

Whitebark Pine

Catastrophic decline in many populations, due to impacts of white pine blister rust, mountain pine beetle, fire exclusion, and logging, led the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) to recommend whitebark pine be listed in 2010 as endangered based on the status report. Approval to add the species to Schedule 1 of the Species at Risk Act (SARA) in June 2011 was given by assent in parliament by the federal government. It was listed in Alberta as Endangered in 2009. It was listed in BC in 2009 as vulnerable (which is the definition of being added to the blue list).

A meeting of interested persons from agencies including the Federal Government, Alberta Sustainable Resource Development, as well as BC MFLNRO, MOE, universities and NGOs was hosted December 2, 2011 to consider action. A proposal to screen whitebark parent trees for resistance to blister rust in field trials was developed out of the meeting comments. A revision of the proposal was presented to GCTAC for funding and some seed collection and stratification of seed was approved for the year to follow.

Plate 2. Whitebark pine regeneration.

Seed Bank Maintenance

Dave Kolotelo, Tree Seed Centre

TSC efforts have focused on sample consolidation and confirming the moisture status of new *ex-situ* collections was below 10% for freezer storage at -18 ^{0}C. Some samples of water birch, Limber pine and whitebark pine were subsequently dried to below the 10% moisture threshold. No germination testing or x-ray analysis was performed on samples in this year.

Genotyping of aspen and grand fir for gene conservation decisions

Michael Stoehr, Chang-Yi Xie, Jodie Krakowski, Charlie Cartwright

Vegetative buds of 20 trees per population for aspen and grand fir were collected for DNA analysis. A total of 13 aspen populations (12 coastal and 1 interior) and 12 grand fir populations (5 coastal and 7 interior) were sampled. DNA analysis using eight polymorphic microsatellite markers is now completed for aspen and 50% completed for grand fir. Genetic parameters, such as allele frequencies, heterozygosities, F-statistics, Nei's genetic distance and Hardy-Weinberg equilibrium conformity/deviations will be estimated/tested and used to make science-based decisions on the conservation needs of these two species. The DNA data analysis is underway for aspen and will start for grand fir as soon as the grand fir data are delivered.

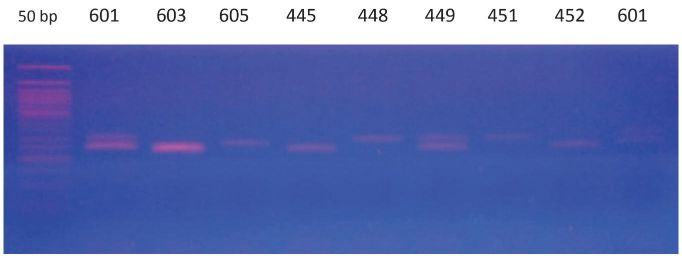


Plate 3. The image shows polymorphism between different *Abies grandis* genomic DNA samples using a tetra-nucleotide microsatellite marker (GFtet7) developed for this project. The genomic DNAs were amplified by PCR and analysed by agarose gel electrophoresis alongside a 50 bp ladder size marker. Polymorphic differences in the sizes of the amplified products are evident between different lanes of the gel.

3.0 Tree Breeding

3.1 Coastal Douglas-fir Program

Michael Stoehr, Keith Bird, Lisa Hayton

Fall measurements in 2011 and the subsequent data analysis of Series 3 progeny test (EP708.23) at age 7 resulted in the pre-selection of the best forward selections from the five sublines planted. Forecast to rotation age 60, the average breeding value (bv) of these selections is 15, but it is anticipated that these bv will increase after final measurements (2014) and age-age correlation increases. Roughly 10 scions from the candidate trees were taken in January 2012 from the Big Tree (Campbell River) and Roaches (Cowichan) sites for early grafting. Series 4 (full-sib test, EP708.24) continues to performs well, after the sites were brushed and weeded (good growth rates and high survival).

A replicated, raised-bed trial was established at RBL (Glyn Road lab) to study the relationship between secondary metabolites (phenolics and terpenes) of full-sib seedlings and potential disease and insect resistance. Growth and phenology data have also been collected from these 40 full-sib families representing trees from the advanced generation Douglas-fir program. Chemical analysis, conducted by the Analytical Lab at Glyn Road, is in progress.

The expected impacts of inbreeding on nursery and growth traits in coastal Douglas-fir are well documented. However, our knowledge of inbreeding effects on non-fitness traits, such as wood traits, is lacking. For this reason, we used an established inbreeding trial (EP982, having four different levels of inbreeding) to evaluate wood density and its relationship with levels of inbreeding. Wood cores and growth measurements have been collected and cores are currently being analyzed to determine wood density.

Final selections were made in EP1200, coastal-interior transition zone (sub-maritime, SM) based on age 12 measurements. Data analysis is also underway for this set of measurements to evaluate climate change impacts on the estimation of breeding values of A-class seed. Two superior forward selections from the Talchako test site were added to the list of candidates for the SM orchard of SPU19.

Our co-operation with the Coast Region soil scientist is continuing. The goal of this project is to check if local coastal Douglas-fir provenances have different mycorrhizal community associations than introduced provenances. Furthermore, is the composition of the communities related to type and amount of available nitrogen in the soil? EP599.3 provenance tests are used for this study. Results may have implications for assisted migration.

Regular clone bank and breeding arboretum maintenance continued with the grafting of root-stock compatible parents for the eventual increase in production of graft-compatible rootstock seed needed for orchard expansions and clone bank management.

Publications

Krakowski, J. and M.U. Stoehr. 2011. Douglas-fir Provenance Survival and Growth in the British Columbia South Submaritime Seed Planning Zone. Know. Manage. Br. Nat. Resource Sec., Victoria, B.C. Exten. Note 105.

Stoehr, M.U. and Y.A. El-Kassaby. 2011. Challenges facing the forest industry in relation to seed dormancy and seed quality. Methods Mol. Biol. 773:3-15.

Woods, J. and M. Stoehr. 2011. Seedlot Genetic Worth Values Verified for Coastal Douglas-fir at Age 12. Forest Genetics Council of British Columbia, Factsheet 2.

3.2 Western Hemlock Forest Genetics Program

Charlie Cartwright

The Hemlock Forest Genetics Program of Tree Improvement Branch continues to wind down operations as a consequence of limited planting of the species in BC. Plans developed in a recent program review call for securing investment in the field trials by "putting them to bed". This involves removal of ingress, upgrading tree tagging and access notes, as well as making a final data collection. The data will be used to develop new or revised breeding values for the current seed orchards, as well as document genetic gains as demonstrated in realized-gain trials.

This year for SPU 3 (Low Elevation Maritime) maintenance was carried out on 9 trials and 5 were measured as planned. New preliminary breeding values were calculated for 93 parent trees, but figures from more mature trees were not analyzed in this fiscal year because the data did not arrive until late March.

The breeding arboreta were dismantled, but clone-banking of over 50 important selections was done as per plan. Due to poor survival in the established clonebanks, (even of well established ramets), a new secure area is being developed for most valued selections. (Many of these are from American sources and may not be available in the future as jurisdictions and ownerships shift). Attention was also given to realized-gain installations this year as the effort is made to verify the tree improvement already in the existing orchards.

For the High Elevation Maritime, (SPU 24), 4 trials were maintained of the 6 planned due to the early arrival of snow. For this reason as well, data collections and analysis were postponed. Consequences of delaying measurements for the installations at higher elevations are less substantial due to the slower growth rates. We anticipate that activities for this single generation improvement program will be wrapped up in the next few years.

3.3 True Fir Forest Genetics Program

Charlie Cartwright

Work with the true firs involves the 4 species planted in the province, for which there are genecology tests. With Pacific silver fir as well as subalpine fir, programs have only been undertaken in the last 10 years, so there are numerous treatments required on these younger installations.

Maintenance was planned for 4 amabilis test sites, but due to quick recovery of brush, 7 needed to be treated. As well, measurement of 5 sites had been arranged, but extra work was initiated to take advantage of other activities adjacent to our sites leading to data collection for 3 additional trials. Permanent labels were also installed on one of the sites. The growing database for this species should allow for adjustment of seed transfer rules soon, while work towards climate-based seed transfer guidelines continues.

Similarly for subalpine fir maintenance was necessary on 11 trials, 3 more than planned, due largely to brush recovering from previous treatments more quickly than anticipated. As well as the maintenance, one older trial was measured and another one tagged.

For the more mature projects, work focused upon measurements or preparing for them. Four grand fir test sites were measured for age 30 years height and DBH as planned. Analysis of the data will be completed and a report written. Site selection for this series of tests was particularly good and growth has generally been impressive. The tallest tree was 40 m and the thickest exceeded 0.7 m DBH. Little further work is anticipated with these trials in the near future, but based on the results seed transfer guidelines can now be adjusted and areas for B+ seed collection identified.

For noble fir access notes were updated and some maintenance was done on 4 different test sites in preparation for upcoming age 30 year measurement.

3.4 Western Redcedar Breeding Program

John Russell and Craig Ferguson

Our objective for the western redcedar breeding program is to develop a durable advanced generation population with potential cross resistance, or at least positive genetic correlations among resistance traits. Developing breeding populations that are resilient to multiple pests may not only give protection against the current target pests but potentially against future unknown ones. Growth and cedar leaf blight (CLB) intensity are significantly correlated, and selections for increased volume production and CLB resistance are easily achieved. Genetic correlations between secondary extractives in the foliage and growth rate, and secondary extractives in heartwood and the foliage, although not strong, are positively low to moderate, allowing us some good potential for independent culling in future selections. Although this is certainly a simplistic measure and assessment of complex chemical pathways, it does give us a potential indication that there is minimal competition in chemical resources between foliage and heartwood extractives.

The first generation improvement program focussed mainly on selection for growth with some emphasis on heartwood durability through enhanced secondary extractives. The deer resistance program, which was developed after the other traits were already under selection, has been directed at elevating foliage monoterpene concentrations. This was achieved through rapid generation turnover, high selection intensity and early greenhouse testing. There was minimal information from the other populations to incorporate multiple trait selection. We currently have no information on CLB resistance mechanisms but as in many leaf disease studies, foliar monoterpenes have been implicated.

Because of the partial confounding of population with selection objectives in the first generation of screening, we are currently establishing clonal trials with a combined multi-trait objective in each of the growth/CLB and the deer resistance populations. For the growth/CLB traits, advanced generation matings from backward selections have been completed for the first four series of polycross testing (there are a total of seven). Seedlings from approximately 150 families were sampled for foliage monoterpenes in the greenhouse, winter 2011, and high monoterpene selections have been cloned through rooting. These clones will be bulked-up to produce enough cutting material for clonal testing for growth/CLB resistance across a number of environments. A second set of families were sown in 2012.

For the deer resistance population, one-year-old seedlings from second generation full-sib breeding have already been tested for foliar monoterpenes and forward selections cloned for production hedges. Approximately 60 of these deer resistant clones were established in four environments conducive to good growth (two in Powell River) and cedar leaf blight (two on north Vancouver Island). Another set will be established in 2014.

Selections for advanced generation breeding will be separated into partial diallels grouped by traits, and matings performed within and between groups (Plate 4) with assortative mating within groups.

	Growth				CLB				Foliage Terpenes				Htwd Extractives			
Growth		X	X	X		X	X			X	X			X	X	
			X	X			X				X				X	
				X												
CLB						X	X	X		X	X			X	X	
							X	X			X				X	
								X								
Foliage Terpenes										X	X	X		X	X	
											X	X			X	
												X				
Htwd Extractives														X	X	X
															X	X
																X

Plate 4. Western redcedar advanced generation breeding strategy for multiple pests and growth.

In order to achieve an effective population size of around 100, the final population will be composed of: 1) 50 3rd generation forward selections from the deer resistant population further clonally selected for growth and CLB resistance; 2) 50 first generation parental selections based on clonal values for total heartwood extractive content with selections removed with poor parental volume breeding values and foliar monoterpene parental clonal values (independent selection), and; 3) 50 2nd generation forward selections for volume, further selected for deer resistance. It will most likely not be necessary to include parents selected primarily for CLB resistance since all volume selections will be resistant to CLB and the deer population will be further tested for resistance. Currently, mechanisms for CLB resistance are unknown but being researched. It may be appropriate to make additional selections based on future potential resistance mechanisms.

Plate 5. High terpene western redcedar clones for cutting production.

Deer resistant seedlots and veglots are currently being made available to industry on a limited basis for operational deployment trials. The seedlots come from polycrossing high terpene parents and the cuttings come from high terpene clones greenhouse grown in containers (Plate 5). The first set were grown at Sylvan Vale nursery and planted out on central Vancouver Island in cooperation with TimberWest. The second set, also grown at Sylvan Vale will be planted out by Western Forest Products spring 2013. These plantings will be monitored over the next few years to determine if browsing is reduced with mixtures of resistant seedlings and rooted cuttings. In addition, two short-term deployment trials were established at Cobble Hill (Plate 6) and CLRS in 2011 and six more are planned for winter 2012.

Six new interior western redcedar provenance trials were established in the in spring 2011; two in the East Kootenays, one east of Golden, two in the Rocky Mountain Trench, and one north of Prince George. Seed has been sown and sites selected for two more trials in the northern ICH near Hazelton.

Plate 6. Deer feeding choice study at Cobble Hill 2011.

3.5 Yellow Cypress Breeding Program

John Russell and Craig Ferguson

This program is currently focussing on maintenance and measurements of the clonal full-sib field trials. A select clonal population with a genetic gain of 20% volume has been established with serial propagated donors in greenhouses at CLRS. This elite veglot has the potential to be 35% greater in early height as compared to wildstand seedlots across a wide range of ecosystems within the yellow cypress maritime SPU. In addition, approximately 100 forward clonal selections based on growth and form will be established at CLRS for archiving and future advanced generation breeding.

Twenty year measurements from the range-wide yellow cypress provenance trial were collected in 2012 (Plate 7).

Plate 7. Twenty-year-old yellow cypress in a provenance trial at Champion Lake near Castlegar.

3.6 Coastal Broadleaf Species Genetics Program

Chang-Yi Xie, Lisa Hayton and Keith Bird

Red Alder

Seed orchard establishment

Seed orchard establishment is well underway at MFLNRO Saanich Seed Orchard.

Reproductive biology study

A red alder reproductive biology study has been completed. It was found that male catkins should be collected for pollen forcing only if the catkin does not break when completely bent in order to produce adequate amount of good quality pollen.

Collected male catkins should be placed into paper bags and forced to shed pollen for 24 to 40 hours at 15-18^{0}C. Paper bags with catkins should be placed on mesh type shelving or on a counter with elevated mesh under the bag to allow air flow under the bag. Pollen should be dried for a maximum of 4 hours at 16-18^{0}C until it flows freely and does not lump. For short-term storage up to 2 days, dried pollen should be placed in vials and into a refrigerator at 2-4^{0}C. For longer storage during the current breeding season, pollen in vials should be stored in a freezer. For storage over a year, pollen should be vacuum sealed and stored at about -18^{0}C. There is no definite indication of full female receptivity and its duration as is in conifer species.

Plate 8. Grafted red alder plants in greenhouse ready for seed orchard establishment.

Plate 9. Red alder male catkin readys for pollen shedding.

Breeding

In the spring of 2012, pollen was collected from the top 14 clones in the clone bank to formulate 15 poly-mixes: 14 specific poly-mixes with 13 pollen clones excluding selfing pollen, and 1 general poly-mix with all 14 pollen clones to pollinate the rest of the unrelated clones. The same poly-mixes were used for both control and supplemental mass pollination (SMP). Breeding was conducted on 39 clones.

Plate 10. Red alder breeding experiment.

Black cottonwood

Provenance-clonal testing

The 6-year and 4-year assessments have been completed at Terrace and Harrison sites, respectively. The southern sources were 70% superior in growth at both sites. In addition, there are some native cottonwood clones that demonstrated equal or superior performance as compared to operationally planted hybrid poplars.

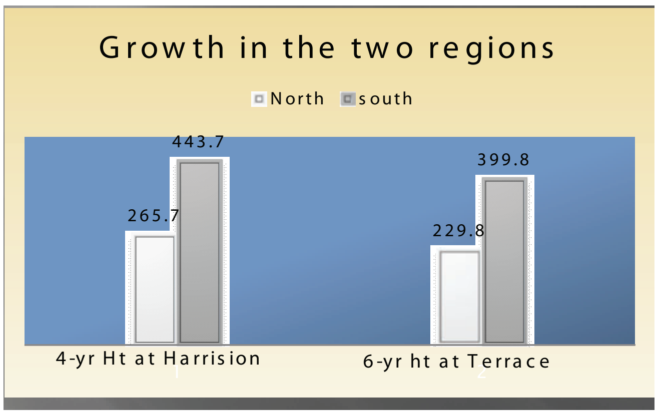


Plate 11. Southern sources are superior (70%) in both regions.

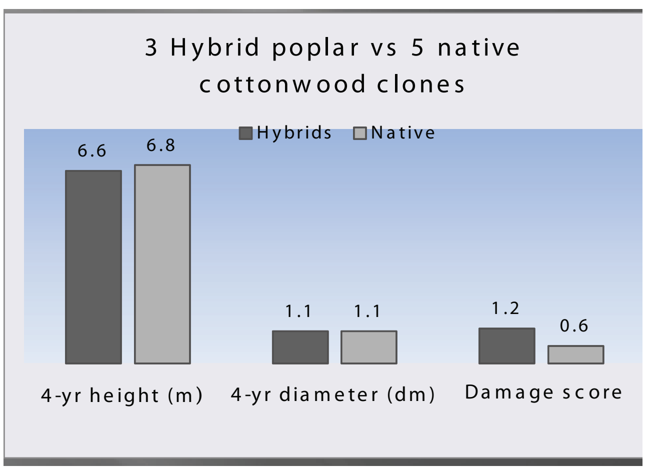


Plate 12. Superior native cottonwood clones are available.

Clone bank establishment

A total of 135 clones were selected based on their superiority in growth, form and health conditions at the Harrison site. Cuttings will be collected, and planted at Saanich Seed Orchard next spring.

Bigleaf Maple

Due to the closure of the Kruger Forest Products Nursery at Harrison and high mortality we abandoned the trial at Kilby-Carey Island. The other 3 trials are well maintained and trees started to take off.

Plate 13. Keith Bird at 3-year bigleaf maple site near Powell River.

3.7 Interior Douglas-fir Tree Breeding Program

Barry Jaquish, Val Ashley, Gisele Phillips and Bonnie Hooge

The BC Interior Douglas-fir tree breeding program began in 1982 with the objective of producing improved and genetically diverse seed for planting on productive forest lands in south-central BC. Within this wide-ranging and ecologically diverse land base, six seed planning units (SPUs) were delineated for tree improvement. The first cycle of breeding in each SPU was based on: 1) phenotypic selection in wild stands, 2) establishment of grafted breeding orchards and clone banks, 3) progeny testing using open-pollinated (OP) seed collected from wild stand trees, 4) delayed clonal seed orchards backward selection early progeny test results, and 5) controlled mating to produce pedigree material for second-generation selection. The breeding goal is to improve traits related to tree size (height, diameter and volume) while maintaining wood relative density near old growth values. Moreover, the recent discovery of resistance to *Armillaria* root disease in Interior Douglas-fir suggests that resistance to *Armillaria* could become an important trait of interest. The first-generation progeny testing program includes 1,466 OP families and 31 test sites across the six SPUs.

Seed orchards were established for each SPU in the north Okanagan in the early 1990's and are starting to come into production (Plate 14). In 2011, approximately 3 million of the 9.4 million Interior Douglas-fir seedlings planted in BC came from seed orchards. In 2010, selected parent trees from southern SPUs were identified to establish new 1.5 generation seed orchards for the Thompson Okanagan high and low elevation SPUs. The Thompson Okanagan region was excluded in the program's early stages because of low site productivity; however, recent increases in planting numbers combined with severe seed shortages for the area necessitates the establishment of orchards for these lands.

The second-generation crossing program focuses on the Nelson SPU and includes selected parents from the old West Kootenay, Shuswap Adams and Mica regions. Moreover, since inter-varietal (coastal x interior Douglas-fir) hybrids have shown to be hardy and fast growing in the Nelson low elevation zone, the Nelson second-generation breeding population has been augmented with 16 high breeding value parents from the BC coastal breeding program and 16 forward selections from superior Submaritime provenances in the Trinity Valley range-wide Interior Douglas-fir provenance test.

Unfortunately, the 2010 flower crop was poor and only 7 controlled crosses were completed and 58 pollen lots were collected, processed and stored for future breeding. Controlled crossing for the Nelson SPU remains at about 80 percent complete. In fall 2011, maintenance and measurements were completed on 11 sites (four 25-year-old West Kootenay Low sites; three 25-year-old Cariboo Transition sites; and four 20-year-old East Kootenay sites). Data analyses are in progress.

In addition to the progeny test measurements, several supportive research sites were maintained and measured. In the 20-year-old Douglas-fir coast/interior transition adaptation trial at the Skimikin seed orchard, inter-varietal hybrids between coastal and interior parents were approximately 30 percent larger in volume than local Shuswap Adams seedlots. Twenty-five-year measurements were made on the Douglas-fir seedling/steckling (rooted cutting) comparative trial (Plate 15). In this trial, seedling and steckling planting stock were produced from 23 open-pollinated families and planted in a replicated split-plot trial at the Barnes Creek clone bank. After 25 years, overall differences between the two stock types were non-significant for tree height, diameter and volume. Family mean correlations for the seedling and steckling stocktypes were significant for tree height (r=.61), diameter (r=.53) and volume (r=.62) suggesting that family growth performance was similar between the two stock types. Three sites in the 15-year-old submaritime Douglas-fir genecology study were maintained and measured, and two sites in the two-year-old Peace River Douglas-fir study were brushed.

The cooperative BC MFLNRO/Forestry Canada, Pacific Forestry Centre (PFC) program to screen Interior Douglas-fir parents for resistance to *Armillaria* root disease continued in 2011/12. New greenhouse facilities for the project were constructed at the Kalamalka Forestry Centre and paper birch (*Betula papyrifera* Marsh.) stems were collected in a natural stand at the Barnes Creek clone bank. The stems were transported to PFC, Victoria where they were cut into approximately 8,300 high quality and consistent density blocks approximately 5.5 – 8.0 cm in diameter, 10 cm long and weighing about 225 grams. Approximately 6,700 of these blocks were prepared, inoculated and stored in plastic bins at PFC until blocks are fully colonized (Plates 16 and 17). Screening is expected to begin in spring 2014.

Plate 14. Dave Barnard, Sorrento Nurseries Ltd, and his class A Interior Douglas-fir seedling crop for the Nelson low elevation SPU.

Plate 15. Twenty-year Interior Douglas-fir seedling/steckling study at the Barnes Creek clone bank.

Publications

Xiao-Xin Wei, Jean Beaulieu, Damase P. Khasa, Jesús Vargas-Hernández, Javier López-Upton, Barry Jaquish, Jean Bousquet. 2011. Range-wide chloroplast and mitochondrial DNA imprints reveal multiple lineages and complex biogeographic history for Douglas-fir. Tree Genetics and Genomes. DOI 10.1007/s11295-011-0392-4.

Kong, L, P. von Aderkas, S. Owen, B. Jaquish, J. Woods and S. Abrams. 2011. Effects of stem girdling on cone yield and endogenous phytohormones and metabolites in developing long shoots of Douglas-fir (*Pseudotsuga menziesii*). New Forests. DOI 10.1007/s11056-011-9294-4.

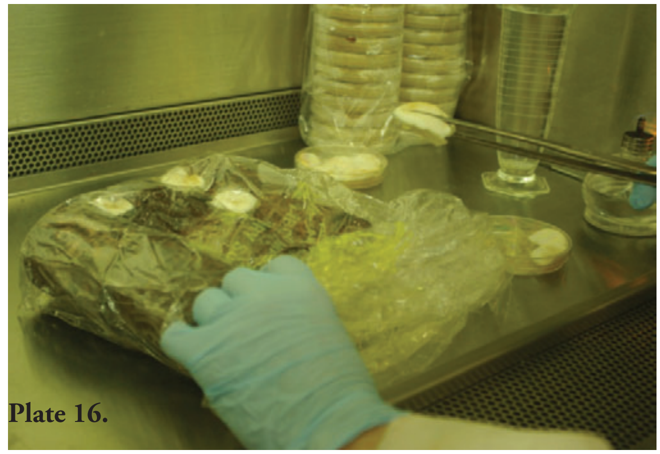


Plate 16.

Plate 17.

Plates 16 and 17. Screening of Interior Douglas-fir families uses inoculation units prepared from paper birch blocks that have been artificially inoculated with *Armillaria ostoyae* (Plate 16) and stored for approximately two years in sterilized plastic bins (Plate 17). (Photos Mike Cruikshank - Forestry Canada, PFC, Victoria).

3.8 Interior Spruce Tree Breeding Program

Barry Jaquish, Val Ashley, Gisele Phillips and Bonnie Hooge

Interior spruce is the oldest tree improvement program in the BC Interior. Genetic testing and parent tree selection began in the late-1960s and expanded rapidly through the 1970s and 80s. Phase one of the program focussed on three ecologically and geographically unique regions: Prince George, Bulkley Valley and East Kootenay. Phase two began in the mid-1970s and centred on the remaining geographic regions where Interior spruce was commercially and ecologically important. The program has progressed to the point where much of the current planting stock (50 - 90 million seedlings per year) comes from improved first-generation seed orchards. Full-sib 2nd-generation progeny tests are in place for the Prince George, East Kootenay and Smithers SPUs. In the Prince George Series 1 program, 65 2nd-generation forward selections have been grafted and established in clone banks and breeding orchards. In the East Kootenay SPU, 75 2nd-generation forward selections were made in 2009 based on 10-year measurements.

Grafting was completed in early spring 2010 and a new breeding orchard will be planted at Kalamalka in spring 2012. Breeding for 2nd-generation selection is now focussing on the Nelson low and mid-elevation SPUs. Unfortunately, the 2011 spruce flower crop was poor and no crosses were made.

Forty-year measurements were completed on the Aleza Lake progeny test, the oldest spruce progeny test in BC. Differences among families for mean height, diameter at breast height and volume were large (Plate 18). Family mean tree volume ranged from .08368 m^3 (family PG110) to .41844 m^3 (family PG29). Multiple correlation coefficients between breeding values estimated by BLP for height at age 15 and 40-year BLUPs for height, diameter and volume were significant (R^2 = .97, .91 and .40, respectively).

Six-year measurements were conducted on the four Prince George Series II full-sib progeny tests. Data analysis for this series is ongoing.

Additional test plantation maintenance and measurement included: (1) four sites in the six-year-old Prince George realized gain tests; (2) five sites in the 15-year-old interior spruce somatic embling field trials; and (3) the 35-year-old comparative study of spruce families from three early BC seed planning zones and an Ottawa Valley population. Finally, seedlings from all of the parents in seed orchard 211 (Vernon Seed Orchard Company) were raised for planting in raised beds at Kalamalka for further screening for weevil resistance.

Plate 18. Family PG29 growing in the interior spruce open-pollinated progeny test at Aleza Lake, near Prince George, after 37 years.

Publications

Nicholas Ukrainetz, G. A. O'Neill and B. Jaquish. 2011. Comparison of fixed and focal point seed transfer systems for reforestation and assisted migration: a case study for interior spruce in British Columbia. Can. J. For. Res. 41:(7) 1452-1464.

Verne S., B. Jaquish, R. White, C. Ritland and K. Ritland. 2011 Global trancriptome analysis of constitutive resistance to the white pine weevil in spruce. Genome Biology and Evolution. doi:10.1093/gbe/evr069.

3.9 Western Larch Tree Breeding Program

Barry Jaquish, Val Ashley, Gisele Phillips and Bonnie Hooge

In 2011, approximately six million western larch seedlings were planted in BC, 88 percent of which originated from seed orchards. In the second-generation crossing program, 49 crosses were completed and 71 pollen lots were collected and stored for future crossing. Second-generation crossing in the East Kootenay and Nelson SPUs is now about 80 percent complete and should be completed within three years. No activities were planned for progeny test.

Data analyses were completed for the 6-year measurement of the western larch realized gain genetic tests for the Nelson SPU. This project tests four western larch seedlots of different genetic origin (composite control, two seed orchard seedlots, and elite) planted three levels of spacing (1.5 x 1.5m, 2.5 x 2.5m, 3.5 x 3.5m) on three contrasting sites (Bear Ck, Taurus Ck and Burton Ck) (Plate 19). The experiment was established in a complete-block design with two replicate blocks on each site. Sampling units consisted of 144 trees planted in 12 x 12 tree square plots. After six growing seasons, site had the largest effect on tree growth (Figure 2). Mean tree height at Burton, the site with the greatest summer and annual precipitation, was 348cm, while Taurus Ck, a cold and dry high elevation site, was 171cm. Overall mean 6-year height of the elite and seed orchard seedlots were 25 and 13 percent greater than the control seedlot, respectively. Survival was about 83 percent across all sites and treatments. Tree spacing had little effect of tree height at this age.

Publications

Leites L., G.E. Rehfeldt, A.P. Robinson, N. Crookston and B. Jaquish. 2011. Possibilities and limitations of using provenance tests to infer forest species growth responses to climate change. Ottawa. Natural Resource Modeling. DOI: 10.1111/j.1939-7445.2012.00129.x.

Plate 19. Six-year-old tree from the elite seedlot growing at the Burton site in the Nelson western larch realized gain genetic tests.

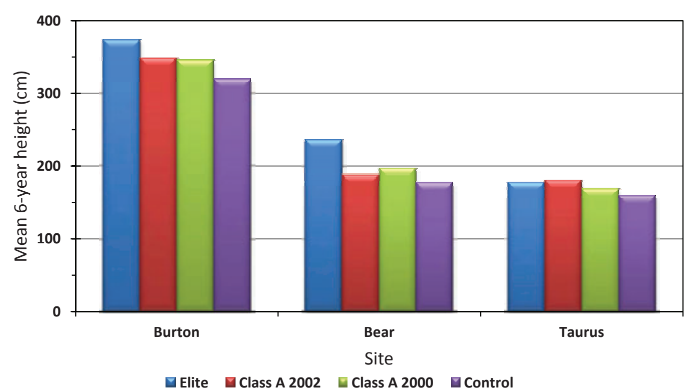


Figure 2. Mean 6-year height of elite, seed orchard and operational control seedlots on three test sites in the Nelson western larch realized gain genetic tests.

3.10 Lodgepole Pine, Western White Pine and Interior Paper Birch

Vicky Berger, Nicholas Ukrainetz

Lodgepole Pine

The lodgepole pine breeding program has advanced to the second generation of progeny testing in five seed planning zones (BV, CP, PG, TO and NE). Within each seed planning zone (SPZ), 50 parents were selected for good growth, and 50 parents were selected for high wood density. Breeding was conducted among the parents within each group to create 65 controlled cross families. The families, along with several operational control and seed orchard (A-class) seed-lots, were deployed on 3 test sites within each SPZ. These tests will become a supply of high gain material which will be available to current and future seed orchards. The first generation, open pollinated progeny tests continue to provide information for updating seed orchard parent tree breeding values and opportunities to assess pest and disease resistance, while the provenance tests remain a wealth of information for modelling impacts of climate change and seed transfer regulations.

In November of 2011, we hosted a program review for the lodgepole pine breeding program with representatives from industry, government and academia with expertise in a range of fields including molecular and quantitative genetics, silviculture, nursery services, seed production and orchard management, climate change modelling and forest pathology and entomology. The review was a two day event. The first day was a closed door session among members of the Forest Genetics Group of the Tree Improvement Branch. The focus of the first day was to review the current state of the lodgepole pine breeding program and opportunities for advanced generation breeding given the latest advances in experimental design, data analysis and molecular genetics. The goal of the second day was to gather input from forest practitioners that actively work with lodgepole pine on a number of topics including forest pathology, seed production, conservation and seed transfer. The main outcome of the two day meeting was a list of action items which will be achieved over an approximate 5-year period. The action items were designed to advance knowledge on a variety of topics including disease resistance, realized gain, provenance testing, climate change impacts and genetic conservation.

The second generation progeny tests in the Prince George low elevation seed planning unit were maintained and measured at age 10. The data was promptly analyzed which revealed a significant genotype by environment interaction between the two northern SBS sites and the one southern ICH site. Several individuals were selected as candidates for advanced generation breeding from the two northern sites and the one southern site. The process of selecting parents for advanced generation breeding must balance gain with relatedness and inbreeding. The best way to achieve this is by using optimization programs which maximize gain among the selected parents while controlling relatedness and the potential for inbreeding. Trees were selected for good height growth and were checked in the field for form and infection by pathogens (Plate 20). These trees will be monitored over the next 5 years.

Plate 20. An example of a 10-year old forward selection candidate at the Abbott Creek second generation progeny test located in the ICH.

To further our knowledge of the genetic resistance and tolerance of lodgepole pine to mountain pine beetle, the Tutu Lake open pollinated progeny test site was assessed for attack. The Tutu site is located just north of Mackenzie and has been previously used as a source of material for the Prince George gall rust resistance seed orchard. Approximately 38% of the live trees on site had been attacked by mountain pine beetle. The site had a very uniform level of attack throughout and the attack rates by family ranged from 0 to 82%. There is no significant relationship with height growth at age 9 and there seems to be no relationship between gall rust severity of infection and mountain pine beetle attack rate. Mountain pine beetle, gall rust and height data were used to develop an index to rank trees in the gall rust resistance seed orchard (orchard 352). We also selected several trees from families with low attack rates from the Thompson Okanagan open pollinated progeny tests and spent time validating their quality in the field (Plate 21). More analysis is required before we are comfortable making forward selections for mountain pine beetle resistance and tolerance in the Thompson Okanagan.

Plate 21. Investigating the bark beetle outbreak at the Dardanelles open pollinated progeny test site in the Thompson Okanagan seed planning zone. We were able to date the outbreak by sectioning a live tree through an old beetle gallery and counting the number of rings since the damage.

As the first generation open pollinated progeny tests mature, they become extremely valuable for studies of wood quality and tree form. This year we initiated a small study to investigate the genetic parameters of wood quality and form traits in two seed planning zones which are expected to become more important as the climate changes: the Nelson and Thompson-Okanagan. We selected 600 trees from each zone from families which were used for second generation breeding. This year, the trees were marked and 12mm increment core samples were collected which will be used in future studies of wood properties.

The East Kootenay open pollinated progeny tests were maintained and measured at the age of 10. The 10 year data will be used to update the breeding values for orchard 340. These progeny tests can also serve as a source of material for the orchard as they mature.

Interior Western White Pine

The supply of blister rust resistant western white pine seed in the interior of BC is produced at the Bailey Seed Orchard (orchard 335) in Vernon. The seed orchard is composed of a combination of parent trees imported from Moscow, Idaho, and local seedlings from BC. The parent trees from Idaho were selected from a 17 year old, full-sib family screening trial growing at the Priest River Experimental Station. The full-sib families were created by inter-crossing tested and selected first generation parents. Seed from BC parent trees was screened for rust resistance at the Cowichan Lake Research Station. Surviving trees were selected for having good resistance reactions to white pine blister rust. Scion was collected from selected trees, grafted and planted in the seed orchard. The genetic material now located in the Bailey Seed Orchard will form the breeding population for future breeding activities.

Over the past 8 years, thousands of seedlings have been screened for blister rust resistance at the Skimikin seed orchard using an outdoor *Ribes* garden infected with blister rust. After inoculation, the trees were monitored in the nursery and the survivors were planted in a “bone yard” at the Skimikin Seed Orchard site for continued observation. Over the past few years, an unknown agent has been killing the blister rust resistant white pine trees in the bone yard. This year, we selected approximately 100 trees from the most resistant families for archiving. Scion was collected and grafted at the Kalamalka Forestry Centre in Vernon (Plate 22).

Plate 22. Selected trees from the "bone yard" at the Skimikin Seed Orchard site.

Plate 23. The Age Related Resistance Trial (ARRT) at the Skimikin Seed Orchard site with protection from blister rust spores.

In 2005, two realized gain trials were established in the north Okanagan to evaluate the resistance estimate given to seed orchards. Currently, seed orchards in the interior are given a rating of 65 which indicates that 65% of trees are expected to survive to rotation when exposed to moderate levels of blister rust inoculum. The tests have very little to no blister rust infection after 7 years in the field. They were measured for height growth and assessed for signs of blister rust.

We are continuing work with the ARRT (Age Related Resistance Trial) which investigates the prospect of ontogenic resistance in white pine. Ontogenic resistance is the development of resistance with age. The trial was established at the Skimikin Seed Orchard site and includes 7 families and 4 age classes. The trees have been protected from blister rust spores since establishment in 2009 (Plate 23). This year, several *Ribes* plants were vegetatively propagated at the Kalamalka Forestry Centre and will be used to inoculate the ARRT in 2012.

Coastal Western White Pine Pine

The coastal western white pine breeding program has successfully incorporated local tested material with tested material from Oregon and Washington. After many years of collaboration with industry and the Canadian Forest Service, a formal F1 breeding program was initiated to take advantage of information gathered about local sources and families. Great effort was made to find the original parent tree selections in natural stands for breeding and pollen collection. The natural stand parent trees were ranked based on screening data and crossed to create a population of F1 progeny. Using collaborations with researchers in the United States, several control crossed families were acquired for testing in BC. The progeny of BC and US origins were deployed in 3 series of field trials on Vancouver Island, Texada Island and the Sunshine Coast; the seed for a fourth series of F1 progeny tests is also available. These progeny tests will be a source of resistant and tolerant material for current and future seed orchards on the coast.

The coastal western white pine breeding program was greatly affected by retirements and the latest round of job cuts. After the white pine program review of 2010, it was decided that both the interior and coastal programs would be managed by a single breeder. However, given the abrupt change in project leadership, the complexity of the white pine program and the strain on the resources of the Genetics group, it was decided that a contract for the management of the coastal white pine program would be issued. This contract has allowed us to maintain the continuity and integrity of the coastal white pine program while ensuring a period of knowledge transfer between experts in the field and the new project team.

This year, the first series of F1 field trials was measured for height growth and assessed for blister rust infection. The sites were checked for maintenance requirements and were dealt with accordingly. The data was promptly analyzed and a series of forward selections were made from families with high rust resistance and tolerance. Scion was collected in the winter and grafted this spring. This material will be incorporated into coastal white pine seed orchards.

Interior Paper Birch

The interior paper birch genetics program consists of three test series which assess several provenances and families across a wide range of test sites. EP 1069.11 tests 18 provenances collected across the range of interior paper birch on 6 test sites from Kispiox to Creston. EP 1069.12 was located at the Skimikin Nursery and contains open pollinated families collected from 19 stands in the Kootenay Region. EP 1069.13 is an elaborate genecology study planted on three test sites (Prince George, Skimikin and northern Idaho) and contains several latitudinal, longitudinal and elevational transects.

There were no significant funds spent on the interior paper birch genetics program this year.

Ponderosa Pine

The ponderosa pine genetics program consists of one well designed provenance test established in 1992 on two sites in the north Okanagan. The test includes provenances from throughout the range of ponderosa pine in BC and the northern United States. After several years of measurements and data analysis, the provenance test site at the Skimikin Seed Orchard was converted to a seed orchard for operational seed production. Little seed has been produced and a component of the orchard was moved to the Bailey Seed Orchard site in Vernon. The data collected from these provenance tests will help us to assign pseudo-breeding values for parent trees in the orchards and develop seed zones. They can also serve as a source of material for future progeny tests.

There were no significant funds spent on the ponderosa pine genetics program this year.

Hybrid Poplar

The hybrid poplar genetics program was designed by Mike Carlson to investigate the possibility of selecting fast growing poplar trees with tolerance to northern climates. Carlson collaborated with Toby Bradshaw at the University of Washington and in the 1990s sent *Populus trichocarpa* material from sources in the interior (Kamloops to Prince George). Crossing was conducted between BC clones and those in the Washington program and some were delivered back to BC. These clones were derived from crosses involving one or two northern parents. Approximately 70 clones were retained in a stool bed in Vernon for many years, however, several were lost to vegetative competition and other factors. Fifty-five were salvaged and used for testing at a common garden experiment at the PRT nursery site at Red Rock near Prince George. Several clones were selected for superior growth and minimal cold damage. Cuttings were collected in 2011 and are now available from a stool bed located at the Skimikin Seed Orchard site.

4.0 Seed Transfer Technical Advisory Committee

Lee Charleson

The Seed Transfer Technical Advisory Committee (STTAC) continues its work developing priorities in genecology research, vetting project proposals and providing budget recommendations to FGC for genecology and seed transfer research.

Funding of ministry genecology projects is done in accordance to the Genetics Section STTAC Strategy, 2011-2016, dated January 31, 2012. As each project progresses, a short lay summary is expected and will be included in this Tree Improvement Program Project report.

The TAC continues with an open call-for-proposals which is intended for innovative ideas to be tried and tested beyond the ministry genecology work.

Genecology projects are reported in several sections of this report. For specific project information refer to the following sections: Centre for Forest Conservation Genetics, Tree Breeding and in the remainder of this section.

J Marty Kranabetter

In 2010-2011, Marty Kranabetter led a project funded by STTAC titled "Coevolution of ectomycorrhizal fungal communities with local provenances of coastal Douglas -fir and the implications for assisted migration". In the following year, a report was prepared and submitted for publication, the abstract for the paper is provided below and the reference is:

Kranabetter, J.M., M.U. Stoehr,, and G.A. O'Neill. 2012. Divergence in ectomycorrhizal communities with foreign Douglas-fir populations and implications for assisted migration. Ecological Applications 22: 550-560.

Assisted migration of forest trees has been widely proposed as a climate change adaptation strategy, but moving tree populations to match anticipated future climates may disrupt the geographically-based, coevolved association suggested to exist between host trees and ectomycorrhizal fungal (EMF) communities. We explored this issue by examining the consistency of EMF communities among populations of 40 year-old Douglas-fir (*Pseudotsuga menziesii* var. *menziesii*) trees in a common garden field trial using four provenances from contrasting coastal climates in southwestern British Columbia. Considerable variation in EMF community composition within test sites was found, ranging from 0.38 to 0.65 in the mean similarity index, and the divergence in EMF communities from local populations increased with site productivity. Clinal patterns in colonization success were detected for generalist and specialist EMF fungal species on only the two productive test sites. Host population effects were limited to EMF species abundance rather than species loss, as richness per site averaged 15.0 among provenances and did not differ by transfer extent (up to 450 km), while Dr. Shannon Berch's diversity index declined slightly. Large differences in colonization rates of specialist fungi, such as *Tomentella stuposa* and *Clavulina cristata*, raise the possibility that EMF communities maladapted to soil conditions contributed to the inferior growth of some host populations on productive sites. The results of the study suggest locally-based specificity in host-fungal communities is likely a contributing factor in the outcome of provenance trials, and should be a consideration in analyzing seed transfer effects and developing strategies for assisted migration.

D. Scott Green and Hardy P. Griesbauer

This project was funded to undertake work in interior Douglas-fir dendrochronology in 2011-2012. The title of their work is "Assessing the utility of dendroecology in projecting critical seed-transfer distances of interior Douglas-fir in British Columbia".

Development of effective systems of climate-based seed transfer and assisted migration requires a good understanding of how trees from various regions (i.e., populations) will grow in future climates (Wang et al. 2010). Ecological genetics studies using provenance tests have quantified the effects of provenance and site climate on population response traits by developing response and transfer functions. Traditionally, response and transfer functions have modelled environmental and genetic effects of climate on response traits such as cumulative height and volume. These traits provide a single measurement representing accumulated response at a given age. The historical records of inter-annual radial growth patterns studied by dendroecologists provide an additional response trait that can be used to develop similar functions, with some advantages (e.g., cost effectiveness, capacity to exploit natural environmental gradients, the compatability with development of recent spatiotemporal climate models).

We undertook a reanalysis of previously collected Douglas-fir climate-growth responses (Griesbauer and Green 2010) in mature stands over wide climatic conditions in BC to explore the potential to develop a coherent universal transfer function (UTF – Wang et al. 2010). The strong relationships between Douglas-fir climate-growth responses over climatic gradients allowed us to successfully develop such a UTF. The main application of this UTF is in predicting future growth responses in wild populations, and identifying populations of potential concern.

Dendroecological approaches show promise in addressing questions related to climate-induced productivity changes and climate-based seed transfer, and we recommend further study, with certain considerations: 1) Differences in productivity should be quantified using measured stand-level attributes. 2) With respect to climate-based seed transfer, it is also important to consider that transfer limits may be linked to factors associated with tree developmental stages, which is not possible to identify in studies such as this which use mature individuals. 3) The success of this project appears to be related to the extremely wide climate range sampled by the initial project. Project results, implications and recommendations for future research will be detailed in an upcoming publication.

References

Griesbauer, H.P. and D.S. Green. 2010. Regional and ecological patterns in interior Douglas-fir climate-growth relationships in British Columbia, Canada. Can. J. For. Res. 40: 308-321.

Wang, T., G.A. O'Neill, and S.N. Aitken, 2010. Integrating environmental and genetic effects to predict responses of tree populations to climate. Ecol. Appl. 20, 153-163.

4.1 Assisted Migration Adaptation Trial (AMAT)

Greg O'Neill, Vicky Berger, Nick Ukrainetz, Michael Carlson

The AMAT is a long-term field trial of orchard seedlots that will help refine seed source selection to ensure that plantations are adapted, productive and healthy well into the future. Twelve sites are being established for each of four years with seed from orchard seedlots in BC and neighbouring states. Assessment of growth and health will begin in 2013 when the first series of trials is 5 years old.

During fiscal 2011/12, the third series of 12 sites was established, with sites ranging from Whitehorse to Sacramento, California. Seedlings for the fourth and final series were sown, grown and lifted; and sites for the fourth series were identified. Formal agreements with American collaborators were completed. Seedling phytosanitary and import permits were arranged by Michael Carlson, who also coordinated seedling transport.

Considerable effort was devoted toward extension activities in fiscal 2011/12. The project was presented or discussed at the following meetings, tours or publications:

AMAT bulletin (August 2011)
Discover Magazine (June 2011)
Revelstoke News (August 2011)
Revelstoke Forest History Association (August 2011)
William's Lake Tribune (September 2011)
Northern Arizona University (December 2011)
Western Forest Genetics Association – Troutdale, OR (July 2011)
Pacific Climate Impacts Consortium – Victoria (November 2011)
Forest Nursery Association of BC – Salmon Arm (September 2011)
Canadian Institute of Forestry – Campbell River and Port McNeill (March 2012)
Western Forest Insect Working Committee – Penticton (March 2012)

Two articles were published in fiscal 2011/12 on assisted migration in which the AMAT was discussed:

Leech, S., P. Lara Almuedo and G.A. O'Neill. 2011. Assisted Migration: adapting forest management to a changing climate. Journal of Ecosystems and Management 12:18-34. *http://jem.forrex.org/index.php/jem/article/view/91/98*

Pedlar, John H., Daniel W. McKenney, Jean Beaulieu, Stephen J. Colombo, Jason S. McLachlan and Gregory A. O'Neill. 2011. The implementation of assisted migration in Canadian forests. Forestry Chronicle 87 (6) 766-777.

The AMAT team is collaborating with researchers on mycorrhizae projects at UNBC and UBC and on a seedling physiology study at Oregon State University. The AMAT team thanks its many collaborators who have kindly provided advice, seed and test sites, and looks forward to developing further collaborations. For more information on the AMAT see http://www.for.gov.bc.ca/hre/forgen/interior/AMAT.htm.

Plate 24. Lodgepole pine seedling from Montana in newly established AMAT site near Salmon Arm. (photo Vicky Berger)

4.2 Interior Spruce Climate Change/ Genecology

Greg O'Neill and Barry Jaquish

Background

Despite the high value of interior spruce and its wide use in reforestation in BC, good provenance data has been lacking for this species. The interior spruce climate change/ genecology trial (E.P. 670.71.12) was established to address this gap.

The project is unique throughout the world in its size (74,000 trees), number and range seed sources (128 wild and selected populations ranging from -6.2 to 7.3^{0}C MAT and from 289 to 3614 mm MAP), and number and range of test sites (18 test sites from -3.7^{0}C to 9.1^{0}C MAT, and from 340 mm to 2448 mm MAP). The combination of many sources and test sites and wide climate ranges of sources and test sites offers unprecedented ability to predict seed lot performance across a wide range of current and future climates. The trial was awarded start-up funding ($50,000) from Forestry Sector Adaptation Strategies funding program of the Climate Change Impacts and Adaptation Directorate of Natural Resources Canada.

Objectives

To develop a better understanding of the climate responses of Class A and B seed sources of interior spruce and use this information to refine seed transfer and assist the migration of spruce.

Methods

Seedlings from 99 Class B and 29 Class A seed sources from BC, NWT, AB and neighbouring states were outplanted in 2005 at 18 locations in BC, YK and AB. Growth data was collected at ages 3 and 6, and will be collected at ages 10 and 15. Weather stations were established in 2010.

Growth and survival data of all Class A and B seed lots at each site will be submitted to TASS and rotation-age area-based volume will be estimated for each seed lot at each site. Response functions predicting productivity as a function of several site climate variables will be calculated and used to estimate critical seed transfer distances for each seed source. This information will be used to revise climate-based seed transfer system to identify the class A and B seed lots that maximize productivity in every climate.

Deliverables

Height, survival and condition codes on each tree in electronic format.

A report summarizing the data, response and transfer function development, and proposed refinements to climate-based seed transfer system will be developed after 10-year measurements are obtained.

2011/12 Activities

Weather data was downloaded and site maintenance performed. Collaborators with Yukon Department of Natural Resources and Alberta Forest Service were trained to download and maintain weather stations so that they can take over this function.

Age-6 growth data collected in fall 2010 was analyzed and reported on at several meetings or tours (see below). Next data collection will be in fall 2014 at age-10.

The Sx CC/genecology test sites at Skimikin and Kalamalka are being used regularly for demonstration purposes for visiting scientists, student and community groups, Forest Service executive and politicians.

Considerable effort was devoted toward extension activities in fiscal 2011/12.

The project was presented or mentioned at the following meetings or tours:

Northern Silviculture Committee – Mackenzie (June 2011)
Western Forest Genetics Association – Troutdale, OR (July 2011)
Revelstoke Forest History Association – (August 2011)
World Forestry Institute fellow (Saunders) – Kalamalka (August 2011)
Minister of FLNRO (Steve Thomson) – Kalamalka (August 2011)
Chief Forester (Dave Peterson) – Kalamalka (September 2011)
Forest Nursery Association of BC – Skimikin (September 2011)
Vancouver Island University and European Union students – Kalamalka (October 2011)
Director Inland Empire Tree Improvement Coop – Kalamalka (November 2011)
Northern Arizona University – (December 2011)
Canadian Institute of Forestry – Campbell River and Port McNeill (March 2012)
Interior Technical Advisory Committee – Vernon (January 2012)
Okanagan College student tour – Kalamalka (March 2012)

5.0 Decision Support Technical Advisory Commitee

Susan Zedel

The Decision Support Technical Advisory Committee (DSTAC) commenced its first year of projects in 2011-2012, following approval of the committee's terms of reference in March 2011. The DSTAC is responsible for identifying the needs for clients, exploring decision support options, developing proposed work and recommending projects and a budget to the FGC for approval and support. The committee works closely with Tree Improvement Branch on project management and development of decision support tools.

The first project of 2011-2012 was to complete the Mountain Pine Beetle Impact Mapping project reported on in the 2010-2011 project report. Details on this project are available on the Tree Improvement Branch website at http://www.for.gov.bc.ca/hti/seedplanning/MPB_Impact_Opportunity.htm. A cone collection opportunity map was produced for the Mackenzie Timber Supply Area (TSA) in 2011-2012. Maps were created the previous year for the Williams Lake TSA and Quesnel TSA. These maps were developed to assist forest managers to collect lodgepole pine cones from natural stands in areas for which no orchard production exists.

The second project funded by the FGC through the DSTAC in 2011-2012 included the investigation and design of a system to calculate and store seedlot 'area of use' spatial geometry. Once the project is completed in the 2012-2013 fiscal year, clients will be able to view the spatial seedlot 'area of use' polygons using SeedMap, Mapview, ArcGIS and new decision support tools yet to be developed. Queries and reports on deployment of seedlots in specific openings and across the landscape using spatial data will be developed using this new data.

The DSTAC recommended the creation of a Sharepoint site where all genetic resource practitioners and clients can share information. The Sharepoint site 'SeedTalk BC' was created as a discussion forum for subjects related to forest tree seed and seedlings in British Columbia. The link is https://spc-flnr.gov.bc.ca/SEED_TALK/. The Sharepoint site is available to all IDIR users and to SPAR clients with BCeIDs currently. Non-ministry clients need a BCeID so that they can be granted access. Subjects may include: seed policy, seed planning, seedlot information, seed orchard production, seedlot testing, seedlot germination in nurseries, seedlot and seedling performance after planting, pest management in orchards and similar topics.

6.0 Operational Tree Improvement Program

Jack Woods

The objective of the Operational Tree Improvement Program (OTIP) is to increase the quality and quantity of select seed produced from existing industry and Ministry of Forests, Lands and Natural Resource Operations seed orchards.

To meet this objective, a Call for Proposal process is administered each year in support of FGC objectives and based on priorities developed by the Interior and Coastal Technical Advisory Committees. FGC committees review and rank these proposals based on technical merit, impact, value and costs.

As a result of this work, the Land Based Investment Strategy Tree Improvement Program is supported through key investments in:

- Boosting genetic gain in seed orchards through grafting, ramet removal and replacement, and pollen management
- Boosting seed production through induction, pest management and supplemental pollination, and
- Supporting technical projects that address issues preventing orchards from meeting production objectives

OTIP uses a performance measurement system to monitor progress and set reasonable targets for project success. This year, as in past years, orchardists and researchers have responded to this approach and have achieved and exceeded planned targets.

For additional information regarding the budget and key performance indicators, please refer to the FGC Annual Report 2011/2012 at http://www.fgcouncil.bc.ca/doc.html

6.1 Orchard Projects

6.1.1 Saanich Forestry Centre (WFP)

Annette van Niejenhuis

Western Forest Products (WFP) manages tree seed orchards for forest regeneration programs in the Maritime zone at the Saanich Forestry Centre on the Saanich Peninsula. Our orchards include low and high elevation Douglas-fir, low elevation western redcedar, low and high elevation western hemlock, and low elevation Sitka spruce seed orchards as well as yellow cypress hedge orchards. As a collaborator in the Forest Genetics Council programs, WFP receives OTIP funds to implement incremental orchard management techniques to deliver quality seed in quantity to the coastal forest regeneration programs.

Low Elevation Coastal Douglas-fir Crop and Orchard Enhancement:

Revised scores for a number of established orchard parents were received, resulting in revisions to orchard plans. Replacement grafts (117) were purchased. Ten ramets were replaced in orchard 405 in the third quarter. In the fourth quarter, planning and site preparation was undertaken for ramet replacement in the first month of the following year. Nutrient management continued with fertilization of replacement stock for good crown development. Significant fencing work to maintain a deer-free orchard is now complete at WFP's expense.

Phenological and reproductive bud surveys together with pollen monitoring were used to determine the male parental contribution to the seed crop. Supplemental mass pollination was implemented for early and late clones.

Contarina spp. counts exceeded the threshold; thus, a control treatment was applied in early May. The 2012 cone crop yielded 39.4 hl of cones for 11.3 kg of seed with an estimated 25% pollen contamination resulting in a Genetic Worth of 9.

High Elevation Douglas-fir Orchard Enhancement

Forty-five grafts were purchased early in the year. Revised scores for a number of parents were subsequently received, resulting in changes to the orchard plan and requirements for further grafting. Nineteen ramets were planted in the orchard. Nutrient management for the promotion of good crown development continued. Significant fencing work to maintain a deer-free orchard is now complete at WFP's expense.

Western Redcedar Crop and Orchard Enhancement

Seventy-five grafts were purchased to continue the upgrading of the redcedar orchard. Forty-two large ramets from the holding bed were planted, increasing the orchard breeding value from 17.9 to 18.6. Nutrient management of the replacement stock continued.

The 2011 cone crop showed poor seed set with high seed insect infestations. The crop was not harvested. The reproductive bud surveys for the 2012 crop indicated an average crop. Supplemental mass pollination was implemented between February 23 and March 1.

Conelette dissections showed light midge infestation thus pesticide application was not required.

High Elevation Western Hemlock Orchard Enhancement

As seed demand for high elevation western hemlock has decreased in the past years, many years' seed supply of good genetic quality is currently banked. OTIP funds were approved only to maintain the replacement orchard for future high gain crops. This included moving tags and applying fertilizer. However, at our expense WFP planted 8 replacement ramets in orchard 187. Additionally, we implemented a supplemental mass pollination program in the tiny crop. Seed for potentially 29 k plantables and a genetic worth of 11 was harvested.

Similarly, significant amounts of low elevation western hemlock seed of good genetic quality is banked. Until work is undertaken to raise the average breeding value of the parents in the WFP orchard by roguing and replacing ramets, no OTIP activities are taking place.

Sitka Spruce Orchard Enhancement

A large supply of good genetic quality seed is banked from the 2010 crops of the Maritime zone Sitka spruce orchards. Only orchard maintenance and foliar pest management activities were approved for OTIP funding. Orchard replacement stock was fertilized. Green aphid surveys indicated population levels below treatment thresholds, and no other foliar insects showed significant presence; no treatments were required.

Yellow Cypress Production Hedges Enhancement

Hedge maintenance of the high gain orchard continued with fertilization treatments and a pesticide treatment for trisetacus mites. Sixty-seven donor plants were added to the orchard to fill vacancies. Light top pruning of donors to maximize cuttings production was undertaken. Cuttings material for an estimated 210 k plantables with genetic worth of 20 was produced. Propagation for a replacement hedge was initiated as a rooting trial to confirm that the selected good rooters continue to perform.

6.1.2 Mt. Newton Seed Orchard (TimberWest Forest Company)

Tim Crowder

Douglas-fir

OTIP project 0106 covers activities in five coastal Douglas-fir Maritime zone low elevation orchards: 134, 154, 183, 197 and 404. The management objective is to increase the genetic worth of these orchards from the current 12% to approximately18% by 2015, and maintain an average annual production of 5 million trees.

These orchards contain a total of 5,213 ramets, about half of which are not yet in production. 500 more trees were grafted this year, and 279 trees were planted to orchards in the fall. 639 trees which were too small to plant out were maintained in holding beds.

SMP was required to augment the insufficient pollen cloud on 631 trees of the early and late clones. Both fresh and stored, high breeding value pollen was used and all stored pollen was tested before use. 4 litres of pollen was collected, dried and stored for future use. Internal and external pollen flights were monitored and a contamination rate for foreign pollen was calculated.

Insect pests were monitored and due to high numbers of damaging insects, a spray program of insecticide was carried out, 80 crop trees close to the property boundary were treated with injectable insecticide and the remaining 789 crop trees were treated twice using an air-blast sprayer.

$GA_{4/7}$ and double overlapping girdles were used to induce a 2012 crop on 750 ramets.

138 large ramets with GW<7 were rogued from the orchards during the winter and the stumps removed to create new planting positions, and a further 82 trees were removed due to a recent change in breeding values.

A total of 312 hectolitres Fdc cones were collected, that yielded enough seed for approximately 5.5 million trees.

Western redcedar

OTIP project 0205 covers activities in two western redcedar Maritime low elevation orchards: 140 and 152. These two orchards are similar in composition and are typically induced in alternating years to provide a steady seed supply. The management objective for these orchards is to produce enough seed for 2 million seedlings with a gain value above 18%.

264 orchard trees were maintained and managed. Monitoring the crop trees for insect pests indicated the need to apply insecticide, so 52 crop trees were sprayed.

188 trees were sprayed with GA_3 in July to induce a crop for 2012.

421 grafts from series 3 to 6 were maintained in holding beds awaiting field test results.

7 hectolitres of cones were collected that yielded enough seed t[illegible]ain of 20%.

Plate 25. Shipping Douglas-fir cones on the pallet.

Plate 26. Shipping Cw and Hw cones on the rack. Joint TimberWest and Western Forest Products shipment.

Plates 27 and 28. Planting grafts at Mount Newton Seed Orchard.

6.1.3 Saanich Seed Orchards

Lisa Meyer

Genetic Enhancement and Production of Seed Crops from Second Generation Douglas-fir Seed Orchard #199 (SPU 0114)

The deliverable was to enhance Orchard 199 to produce orchard stock with potential to maximize production of future crops as well as the continued development of the orchard with ramets capable of producing crops with genetic worth of 20 or higher.

A total of 1608 orchard ramets and 383 high gain replacement ramets in the holding beds were managed using appropriate cultural practices over the growing season. Pollen collection targeted ramets with a BV 20 and higher, with proper consideration to maintaining genetic diversity, resulted in 1.75 litres of pollen being collected. Current year pollen was mixed with stored pollen collected in 2010/11. Supplemental mass pollination was employed to ensure effective pollination to receptive flowers and to offset contamination from outside pollen sources. Stored pollen was applied to early and late clones to optimize pollination. Some fresh pollen was processed and stored for future use.

Management included graft identification maintenance, foliar nutrient sampling and analysis, nutrient prescription preparation, and fertilizer applications to meet nutrient needs. Graft union surveys were also conducted to determine health and compatibility. Top pruning and crown management work, where required, was completed on all ramets to initiate potential cone producing sites. No graft scoring was required this year. Pest surveys were conducted; no pest control measures were required this season. 200 additional grafts were added to the orchard and holding beds in October, 2011.

The Tree Seed Centre has reported that a total of 527 grams of seed with a breeding value of 14 was produced in the 2011/12 season. This suggests that the crop management strategies adopted for this orchard are leading to positive contribution to attaining the objectives identified. The management strategies adopted will be continued in future years.

Plate 29. Orchard 199 Douglas-fir flowers. (All Saanich Seed Orchard photos by Chris Halldorson).

Orchard Management Operations to Maintain Productivity and Increase Gain in Orchard #181 SM Fdc (SPU 1902)

The deliverable was to improve the Douglas-fir Seed Orchard #181 to produce a healthy orchard capable of producing high seed yield seedlots of genetic worth of 8 or higher and to continue to develop the moving front orchard to generate future crops of even higher genetic worth.

A total of 0.5 litres of pollen was collected from all the higher breeding small ramets. The pollen was processed and stored for future use in the orchard. Seven day pollen monitors were employed to determine contamination in the orchard. A total of 584 orchard ramets and 159 high gain replacement ramets in the holding beds were managed using appropriate cultural practices over the growing season. 200 grafts were added to the orchard and holding beds in October, 2011.

Management included graft identification maintenance, foliar nutrient sampling and analysis, nutrient prescription preparation, and fertilizer applications to meet nutrient needs. Graft union surveys were also conducted to determine health and compatibility. Top pruning and crown management work, where required, was completed on all ramets to initiate potential cone producing sites. No graft scoring was required this year. Pest surveys were conducted; no pest control measures were required this season.

It is anticipated that seed will be collected for the first time from this orchard in 2012. This will allow the Saanich Seed Orchard to evaluate the effectiveness of crop management strategies which have been adopted.

Plate 30. Orchard 181 Douglas-fir pollen and flowers.

Orchard Management Operations to Upgrade Orchard #175 with Rust Resistant White Pine (SPU 804)

The deliverable was to upgrade the existing rust resistant white pine ramets at the MFLNRO Saanich Seed Orchard site with the Pw Breeding Program slow canker growth (SCG), Major Gene Resistant (MGR) and Difficult to Infect (DI) white pine ramets.

A total of 652 orchard ramets were managed using appropriate cultural practices over the growing season. 120 additional grafts were added to the holding beds in October, 2011. Management included graft identification maintenance, foliar nutrient sampling and analysis, nutrient prescription preparation, and fertilizer applications to meet nutrient needs. Graft union surveys were also conducted to determine health and compatibility. Top pruning and crown management work, where required, was completed on all ramets to initiate potential cone producing sites. No graft scoring was required this year. Pest surveys were conducted; no pest control measures were required this season.

Plate 31. Orchard 175 western white pine.

Plate 32. Orchard 175 western white pine first year cones.

Orchard Management Operations to Enhance Productivity and Genetic Gain in High Elevation Western Hemlock Orchard #196 (SPU 2404)

The deliverable was to maintain the health and vigour of the High Elevation Hemlock Orchard #196 to produce a healthy orchard capable of producing high seed yield seedlots of genetic worth of greater than 8.

A total of 234 orchard ramets were managed using appropriate cultural practices over the growing season. Management included graft identification maintenance, foliar nutrient sampling and analysis, nutrient prescription preparation, and fertilizer applications to meet nutrient needs. Graft union surveys were also conducted to determine health and compatibility. Top and intra-nodal pruning and crown management work, where required, was completed on all ramets to initiate potential cone producing sites. No graft scoring was required this year. Pest surveys were conducted; no pest control measures were required this season.

The Tree Seed Centre has reported that a total of 5.65 kilograms of seed with a breeding value of 9 was produced in the 2011/12 season. This suggests that the crop management strategies adopted for this orchard are leading to positive contribution to attaining the objectives identified in the project application. The management strategies adopted will be continued in future years.

Plate 33. Orchard 196 western hemlock cones.

Plate 34. Orchard 196 western hemlock pollen.

6.1.4 Kalamalka Seed Orchards

Chris Walsh

In 2011/2012, Kalamalka Seed Orchards received OTIP approval for 11 projects under the operational production sub-program. The funding allowed for a significant enhancement of the effectiveness of our orchards in delivering improved seed. Activities included:

- Improving orchard composition through grafting higher-breeding-value ramets, maintaining recently grafted high-value ramets destined for orchards, and transplanting the older higher-value ramets to the orchards;
- Improving orchard seed quantity and quality through cone induction and pollen management, including collecting high-breeding-value pollen from clone banks and applying Supplemental Mass Pollination; and
- Improving orchard productivity through pest and other management activities.

Orchard Quality and Quantity Boosting Activities by Project

Project	Species	SPZ	Orchard	Rootstock	Grafts Made	Maintained	Transplants	Induction
SPU0401	Sx	NE	305			41	18	
SPU0502	Sx	NE	306			8	12	
SPU0701	Pli	NE	347			208	15	
SPU1501	Pw	KQ	335	200	25	159	34	
SPU1708	Pli	BV	230		200		457	
SPU2201	Fdi	NE	324					473
SPU3501	Sx	BV	620			21		175
Totals				200	225	437	536	648

Table 1. Orchard Quality and Quantity Boosting Activities by Project.

Pollen Management Activities by Project

Project	Species	SPZ	Orchard	Pollen Collected (litres, dry)	Trees Pollinated
SPU0701	Pli	NE	307	3.0	1,499
SPU1501	Pw	KQ	335	3.0	1,870
SPU1708	Pli	BV	230	5.0	869
SPU2201	Fdi	NE	324	2.0	
SPU3201	Pli	EK	340	3.0	1,623
SPU3501	Sx	BV	620	2.5	
SPU3901	Fdi	EK	336	1.0	
SPU4401	Sx	NE	341	2.0	
Totals				21.5	5,861

Table 2. Pollen Management Activities by Project.

Plate 35. Pollen monitoring.

Operational Pest management activities at Kalamalka Seed Orchard

- monitoring pest levels to make informed decisions regarding control,
- using Safer's Soap sprays to control adelgids in Sx and Fdi,
- removing weevil-infested spruce leaders to reduce weevil populations,
- removing pine pitch moths damaging orchard tree stems,
- baiting for control of rodents feeding on tree roots,
- sanitation picking of cones in orchards with non-collectible crops to reduce pest populations,
- spraying to control *Dioryctria* in Pw,
- spraying to control mites in Fdi,
- applying dormant oil to control larch adelgids, and
- spraying to control *Leptoglossus* in Pw and Pli.

Other funded management activities to boost productivity and gain included foliar analysis to determine the nutrient status of orchard trees and crown management of orchard trees.

The OTIP funding was instrumental in increasing both the quantity and quality of seed produced. At Kalamalka in 2011 we produced approximately 112 kg of western larch, lodgepole pine, and western white pine seed equivalent to over 16 million seedlings with an average GW of +15. Large areas of the interior of the province are using Kalamalka seed.

Protecting Orchard Trees from Mountain Pine Beetle (MPB) Attack at Kalamalka (4057E29)

Gary Giampa

In 2011 our objective was to protect 4679 trees in four orchards from MPB attack in order to preserve seed production capacity. We also protected 151 Pli pollen donors in the Research Branch blocks.

In consultation with the Interior Seed Orchard Pest Management Biologist, we applied Sevin XLR insecticide to tree boles in these four pine orchards before the 2011 MPB flight. We also undertook an Integrated Pest Management (IPM) monitoring program to continuously evaluate the efficacy of the pre-flight spray through the growing season. The monitoring program was comprised of twice-weekly checks of pheromone traps to detect new flights of beetles dispersing into the orchards and regular orchard tours to detect new attacks on orchard trees.

The end result was that no seed orchard pine trees were lost to MPB in 2011.

Protecting Kalamalka Seed Orchard Pine Trees from Red Turpentine Beetle (RTB) Attack

Gary Giampa

In 2010 RTB attacks were recorded at five North Okanagan seed orchards. Ramets were killed by RTB at most of these locations. In 2011 it was necessary to monitor for these pests and protect valuable seed orchard trees. Lodgepole pine, white pine and Ponderosa pine seed orchard trees are all vulnerable to RTB attack.

In 2011 our RTB control program consisted of a three stage approach.

1. We monitored 10,002 trees for evidence of RTB attack.
2. We sprayed 2317 Pli ramets in Bailey orchard 340 with Sevin XLR bole sprays. The mature trees in orchards 230, 307 and 335 are considered to be large enough to survive RTB attacks. However, ramets in Pli 340 are of a size and age that are easily girdled and killed by RTB.
3. After spraying we surveyed all 10,002 ramets to assess the efficacy of our control program and to monitor for further attack.

The end result was that no seed orchard pine trees were lost to RTB in 2011.

6.1.5 Vernon Seed Orchard Company (VSOC)

Dan Gaudet

Operational Tree Improvement Program (OTIP) has once again provided funding for seed orchard production companies to successfully produce improved seed for Industry and the Province of BC.

Increased key indicator values have helped streamline the review process and determine successful application approvals easier than in previous years.

Vernon Seed Orchard has been diligent in fulfilling contract obligations through required reporting mechanisms. This has been very successful in assuring continued growth and accountability for this vital provincial program.

SPU 1202 Enhancing the Effectiveness of Prince George Orchard 222

Lodgepole pine is a crucial species for Northern BC and seed production levels need to increase through ramet development and increased future production levels. VSOC has begun to replace and increase production trees to reach target level demands set out by the FGC and will continue to develop and pursue silviculture demands through grafting strategies and forward selection parent trees.

1500 ramets grafted - 2918 ramets held over winter for planting in 2012/13 and insect control for existing orchard trees.

SPU 1208 Pollination and Pest Management in Prince George Orchard 236

4 litres of pollen from high gain parent trees were collected for SMP. This pollen will help achieve and maximize gain in potential seedlots.

Insect control, monitoring and spraying for 4500 trees was carried out.

SPU 1403 Enhancing Production in Prince George Weevil Tolerant Orchard 211 - White Spruce

Roguing out weevil susceptible trees to increase resistance was the primary work done in this orchard in 2012. Monitoring and spraying for pest were also funded.

SPU 1706 Pollination and Pest Management for Bulkley Valley Orchard 234

3 litres of pollen were collected for SMP in this orchard in 2012. Pest management work including pitch moth removal was initiated this year.

SPU 1801 Enhancing the Effectiveness of Central Plateau Orchard 218

2500 grafts were made to re-establish ramets that have not produced to date and to continue to get to seed production amounts for this large zone.

SPU 1709

Continued grafting ramet replacements for this orchard in 2012. 1500 grafts were made this spring as well as planting and overwintering previous grafts made in 2011.

500 trees were removed that weren't producing seed.

Monitoring for pest and pest management was also funded this year.

SPU 3702, 3703, 4102, 4103, 4301 Increasing Seed Production in Interior Douglas-fir Orchards 231, 232, 233, 225, 226

Douglas-fir orchard seed production has started to flourish in the Interior. Warm seasons have been instrumental in larger than anticipated seed yields. Pollen strategies, pest monitoring and inducing crops through $GA_{4/7}$ is part of the success. Control and good orchard management strategies are a must to be successful.

Over 500 trees were induced with $GA_{4/7}$ this year to promote seed production.

Costly sprays to ensure seed harvest success are vital in Douglas-fir orchards.

SPU 4202 Prince George High Elevation Orchard 239

Pest Management in Prince George High Elevation Orchard 239 is presently the only concern in this young orchard.

Spider mites, adelgids and other pest can seriously affect crop potential. Funding allows orchards to control potential losses efficiently through sprays and monitoring. VSOC had their first harvest of this seed which is in high demand.

6.1.6 Grandview Seed Orchards (PRT Armstrong)

Mike Brown

Projects 0702, 0721, 0728, 1001, 1002, 1007, 2101, and 4057E35

PRT Armstrong has 6 seed orchards in total which cover approximately 28 ha. Five of these orchards are lodgepole pine which produce seed for the Thomson Okanagan (TO Low) and the Nelson Low (NE Low). The sixth orchard is a Douglas-fir orchard which produces seed for the Nelson Low elevation.

For the 2011/12 operating year, OTIP funding was provided to assist with the enhancement of the overall cone yields, genetic value and tree health which facilitated the production of high value seed being produced. The activities covered under the OTIP funding were mechanical pollen distribution, supplemental mass pollination, pollen collection, insect and disease monitoring and control, crown management, crop statistics and rodent control. OTIP also provided funding for ongoing Mountain Pine Beetle and Red Turpentine beetle control.

In the spring of 2011 SMP was applied to orchard 321, 338 and 337 with the objective of maximizing seed set in all flowers and producing high quality seed. Three litres of pollen were collected, dried and stored from high BV clones in Pli 311. Due to a low number of trees with pollen in the Fdi, only one litre was collected from 321. Mechanical pollination with our air blast sprayer was used in the older orchards three times this season.

Gibberellic acid (GA) was applied to one third of the Fdi trees in conjunction with drought stress in an attempt to promote flowering in the following year. The number of injections each tree received was based on the assessment of the tree size and health. All information is recorded annually to create a data base for future years.

Monitoring the crop for insect pressure was ongoing through out the season. Our goal as always was to identify and address insect and disease pressure before they adversely affect cone and seed production. *Leptoglossus* was found to be higher than in the previous three years. Sevin was applied three times during the growing season to reduce their feeding impact on the cones.

We have an ongoing issue with *Dioryctria*, most obviously in the fir orchard. In 2011, an attempt was made to find a different method of control for *Dioryctria* because of the possible loss of Dimethoate which is the only registered product available to us. In May, BTK was applied to the crop trees in the fir. The final results at cone harvest showed a considerable insect infestation in the fir cones suggesting the efficacy of the BTK may be minimal or more trials to fine tune the timing of application are needed.

Yearly monitoring for RTB continued in 2011. Pheromone traps set out around the site showed a flight in early May. Once again, through OTIP funding, a bole spray was applied to all of the Pli ramets in 338, 337, 313, 311 and 308. There has been a notable decrease in the number of trees being killed through insect attacks which clearly shows the positive effect the preventative sprays have had. For the remainder of the season, the trees were monitored on a weekly basis to ensure no fresh attacks were found. Dead trees were regularly removed to be certain any eggs which may have been laid were destroyed.

MPB appeared to be on the decline throughout the 2010 season however; in 2011 rigorous monitoring was continued. Mature Ponderosa pine trees in the windbreak surrounding the PRT site continue to show insect damage. MPB and RTB were controlled through the same bole spray funded by OTIP.

Sequoia Pitch moth larva were once again removed manually with a concerted effort to address all of the Pli ramets twice during the season.

The control of gophers feeding on tree roots was minimized through the use of poison bait.

As part of a collaborative project with several orchards in the Okanagan, and with critical OTIP funding, cone development data was collected from trees in orchard 338, 313, and 311. The data collected will aid in the attempt to solve the issue of the loss of seed in cones during the month of August in the Pli orchards. Understanding the reasons behind these loses in seed will allow seed orchard managers to produce larger seed yields in years to come.

Crown management was done in the fir with topping performed on a quarter of the ramets.

The Pli TO low orchards produced 50 kg of seed with the potential to produce 5.8 million seedlings. In the Pli NE Low 6 kg of seed were produced with the potential for 700,000 seedlings. The Fdi NE Low orchard produced 0.28 kg of seed which equates to 10 thousand plantables. OTIP funding for the 2011 season has allowed PRT to protect the health of its 11,000 ramets and continue to produce the best A class seed yields possible.

Plate 36. PRT Laura applying pollen.

6.1.7 Eagle Rock Seed Orchards (Tolko Industries)

Tia Wagner

Four orchards are managed by Tolko Industries for the Thompson Okanagan seed planning zone. Three orchards, two interior spruce and one lodgepole pine, are SelectSeed partnership orchards. The projects funded by the Operational Tree Improvement Program aid in improving the quality and quantity of seed produced for the Thompson Okanagan forest community. In 2011, Eagle Rock produced seed for 3.3 million lodgepole pine seedlings for reforestation in the Thompson Okanagan seed planning zone.

SPU 16 Thompson Okanagan Pli High, Orchards 310 (Tolko) and 339 (SelectSeed), Project 1601

- Male bud and phenology surveys were completed to determine clonal contribution, timing of pollen shed and female receptivity for each clone.
- When surveys indicated optimal receptivity, pollination was promoted with the aid of a mist blower and helicopter.
- Pocket gophers were controlled by administering bait in the spring.
- Pest monitoring was completed for *Eucosma*, *Dioryctria*, *Rhyacionia* and *Leptoglossus*. Control sprays were required twice for *Leptoglossus* after 35 adults were observed in 15 minutes on June 6 and 27th.
- *Synanthedon* and *Dioryctri*a were manually removed from the base of young ramets to prevent girdling and full or partial ramet loss.
- As required, duff was removed from the base of trees for ease of red turpentine beetle (RTB) monitoring and removal. No spray control was required for RTB.
- Pheromone traps for mountain pine beetle (MPB) were monitored weekly. Catches reveal the population continues to decrease. Only the traps closest to the log yard caught a notable quantity of insects. One tree was observed with minor feeding, therefore no control was required for MPB.
- Foliar samples were collected and sent to Pacific Soil lab for analysis. Lab results aid in determining accurate fertilization requirements for the following season.
- Orchard 310 was retired. Four hundred trees were rogued, chipped and removed from the site.
- Phenology and cone collection was completed for OTIP0722. Information and samples were sent to Kalamalka Seed Orchard for processing.

SPU 28 and 30 Thompson Okanagan Sx Low, Orchard 342 and Sx High, Orchard 343, Project 2801

- Due to the absence of a cone crop this season no pollen or SMP work was required.
- Monitoring for pests such as Adelgid species, *Pissodes strobi*, and *Oligonychus ununguis* was completed. Leaders containing *Pissodes* spp. were removed in June to decrease the population within the orchard.
- Gibberillic acid $_{4/7}$ was applied to induce cone production for 2012. In orchard 342, 316 ramets or 70% of the orchard was treated with GA and in orchard 343, 643 ramets or 61% of the orchard was given GA.
- Foliar samples were collected and sent to Pacific Soil lab for analysis. Lab results aid in determining accurate fertilization requirements for the following season.
- Pocket gophers were controlled by administering bait in the spring.

6.1.8 Prince George Tree Improvement Station (PGTIS)

Rita Wagner

SPU 1203, 1802, 1702

Activities are aimed at increasing the quantity and quality of lodgepole pine seed from Orchard 220 (Prince George low planning zone), Orchard 223 (Central Plateau low planning zone) and Orchard 228 (Bulkley Valley low planning zone).

Four Operational Tree Improvement Projects were conducted at the Prince George Tree Improvement Station in 2011-2012.

Phenology surveys were completed to keep track of receptivity periods which can vary considerably from year to year. Pollen flights were monitored. Outside pine pollen flight is basically non-existent due to the devastation caused by the mountain pine beetle.

October foliar samples were taken for nutrient analyses. Fertilizer applications were increased ensuring maximum ramet health.

Branch damage caused by hydraulic lifts, heavy & wet snow loads and strong winds required tree maintenance. Surveys for western gall rust, *Elytroderma* needle cast, *Lophodermella* pine needle cast, *Zelleria* pine needle-sheath miner, *Cecidomyia* pitch midge, and various other insects were completed. Some topping as well as extensive bottom-branch and access pruning was completed in all three orchards.

Lindgren traps were set up throughout the site to monitor secondary bark beetle flights (mainly *Ips*). Mountain pine beetle activity in the Prince George area continued to drop in 2011.

Since 2005 all three orchards had three years of very high production, two years of medium high production and two years of medium-low production. However, even the medium-low production still exceeded the FCG target forecast for each orchard. In 2011, the three provenance orchards yielded 39.571 kg of seed, the equivalent of approx. 7.9 million potential seedlings with a genetic worth of 6%.

Some squirrel trapping was required to avoid seed loss and loss of potential cone sites.

SPU 1412

Management of interior spruce clone banks at the Prince George Tree Improvement Station is designed to ensure the availability of scion to replace existing orchard ramets or develop new orchards to boost productivity and gain. The Interior Spruce Clone Banks at the Prince George Tree Improvement Station provide vital support to the orchard and tree breeding programs in B.C. The clone banks are a centralized source of scion material for the grafting of new and improved seed orchards. They contain the only copy of many of the interior spruce parent tree selections found in seed orchards and breed arboreta.

600 grafts planted within the last four years were maintained. We replaced approximately 300 temporary tags. To improve access topping of approximately 150 trees and bottom branch pruning was carried out in various clone banks.

Ongoing clone bank data base updates and creation of 1-page field maps for each clonebank were carried out.

To ensure good ramet health the following management activities were carried out in the 12,000-tree clone banks: inventories, irrigation maintenance, fertilization, mowing and weeding/brushing, label replacement and foliar sampling. Due to a very wet season extensive headland mowing was necessary to control weeds and prevent brush from moving in. Insect (root collar weevil and spruce leader weevil) and disease monitoring was carried out to keep abreast of potential pest problems. Minimum holding area rototilling/mowing was carried out for maintenance of replacement clones.

Plate 37. Mowing base of tree with Postmaster attachment in Willow Bowron #220.

Plate 38. Genie cone collection Central Plateau-Finlay #223.

Plate 39. Girette hydraulic lift cone collection Central Plateau-Finlay #223.

Plate 40. Processing lodgepole pine crop.

Plate 41. Replacing tags in Willow Bowron #220.

6.1.9 Skimikin Seed Orchards

Hilary Graham

Summary for Projects 0404, 0411, 0501, 1503, 3502, 4002, and 4057E13.

Skimikin Seed orchards are comprised of 13 orchards covering 9 SPU's and 4 conifer species – interior spruce (Sx), Western white pine (Pw), lodgepole pine (Pli), and Ponderosa pine (Py). There are also extensive research plantations covering a wide variety of species and projects. Seven Sx orchards produce seed for the Bulkley Valley, Peace River, and Nelson seed planning units. One Pw orchard produces rust resistant seed for the Kootenay Quesnel SPU and a 2nd Pw orchard is in development. The three young Pli orchards will produce seed for the Thompson Okanagan low, Nelson high, and Prince George low SPUs. These Pli orchards are still in development and too young to be eligible for OTIP funding.

In 2011/12, 5 projects covering 8 orchards received OTIP funding for activities to increase the yield and genetic gain of seed produced in the Sx and Pw orchards. These activities included holding bed maintenance, planting of grafts, roguing, insect and disease monitoring and control, and rodent control. In addition, one project provided funding for research plantation maintenance and development, and another project covered activities to monitor and control the mountain pine beetle.

Interior spruce – orchards 301 (0404), 302 (0501), 207/208/229 (3502), and 212/213 (4002).

In the Sx West Kootenay low elevation orchard 301, 71 grafts were planted, and 61 grafts were planted in the Sx West Kootenay high elevation orchard 302. The roguing of 750 trees was delayed and all funding returned as the 16 year breeding values were not available.

For the Bulkley Valley low orchards 207, 208, and 229, there were 132 replacement grafts planted into the orchards and another 129 replacement grafts were maintained in the holding area. In orchard 207, 182 lower breeding value ramets were rogued.

In the spruce orchards for the Peace River low and mid elevation zones (orchards 212 & 213) the 52 replacement grafts were held over and maintained in the holding area for Orchard 213, and will be planted into the orchard in 2012. Due to lack of pollen availability, no pollen was collected.

All Sx orchards at Skimikin were monitored throughout the season for damage caused by insects, disease, and rodents. Rust brooms (*Chrysomyxa arctostaphyli*) and leader weevil (*Pissodes strobi*) attacked tops were removed from all orchards. Rodents were controlled by poison baits. In 2011 there was no crop produced in the Sx orchards so all funding for cone and seed pest control was returned.

Western white pine – orchard 609 (1503); Kamloops-Quesnel

The white pine orchard 609 was monitored for the presence of and damage caused by the pine cone borer (*Eucosma recissoriana*) and coneworm (*Dioryctria* spp). Traps for these insect pests were set up and monitored for the season. In addition, many visual surveys were done to assess for damage. A spray was required in orchard Pw 609 for control of *Dioryctria* just before cone harvest. Bird seed was set out beside the cone sacks to divert squirrels from feeding on the cones. The crop of 25.4 hl yielded 6.4kg of seed.

Research Plantations (0411)

The on-site research plantations and trials were monitored for insects, disease and rodent damage. All plantations and trials were mowed, treated with herbicide, and hand weeded where necessary. Rodents were controlled in all areas by poison baits. The *Ribes* garden was maintained through watering, mowing, and hand weeding. In June, the white pine Age Related Resistance Trial (ARRT) was treated for cutworms. The new Pli breed arboretum was monitored for pitch moth and lower branches were pruned in the fall. The sites where plantations were removed in 2010 were cultivated and the large debris piles were burned in the fall of 2011.

Mountain Pine Beetle (4057E13)

Extensive visual monitoring was done for the mountain pine beetle (MPB) and red turpentine beetle (RTB) in orchards Py 345 and Pw 609, as a prophylactic insecticidal spray was not applied in 2011. The small Pli orchards were also monitored for any evidence of MBP or RTB attack. Pheromone traps were set up in the spring and checked once a week. The trap counts peaked the third week in July, with few counts being over 60 beetles per trap. This was considerably less than counts in 2007 when many of the traps caught 1000's of beetles, and traps needed to be checked twice a week.

No orchard trees were attacked by the mountain pine beetle in 2011.

Plate 42. Squirrel feeding on bird seed beside Pw cone sacks.

Plate 43. Steven Farrell mulches branches from Sx 207 roguing.

Plate 44. Laurie Farrell, Alle Palmer, and "*Maggie*" - Sx 207 roguing.

6.1.10 Kettle River Seed Orchard Company (KRSO)

Rick Hansinger

Pollination and Pest Management in Central Plateau (CP) Orchard 238 – Lodgepole Pine (SPU 18)

Objectives

• Collect and store 5.0 litres of pollen for SMP in young Pli Orchard 238 to increase the production of Class A seed to 500,000 plantables by summer 2012.
• Minimize filled seed losses from predation by *Leptoglossus* through pesticide applications.

Results

• 13.5 l of pollen were vacuum collected in the Pli CP low orchard which was cleaned, dried and stored for application spring 2012 (Genetic Worth G+21). Approximately 5.250 l of pollen was applied to 2800 ramets during the receptivity period from May 20 to June 10. The Central Plateau pine orchard is now producing sufficient pollen to meet SMP needs. Three SMP passes were completed in order to ensure early and late receptive clones received sufficient pollen to fertilize female conelets. Remaining late pollen was air blasted with a turbo fan sprayer. 8.250 l of pollen was stored for SMP spring 2012.
• Developing cones were inspected for the presence of *Leptoglossus,* and as the risk to the seed crop was deemed negligible, pesticides were not applied.

Output and Deliverables

• 11.2 hl of cones were collected. The final seed crop is 1.472 kg of seed with a future potential of yielding 132.4 k seedlings.

Pollination and Pest Management in Prince George (PG) Orchard 237 – Lodgepole Pine

Objectives

• Collect and store 5.0 litres of pollen for SMP in young Pli Orchard 237 to increase the production of Class A seed to 500,000 plantables by summer 2012.
• Minimize filled seed losses from predation by *Leptoglossus* through pesticide applications.

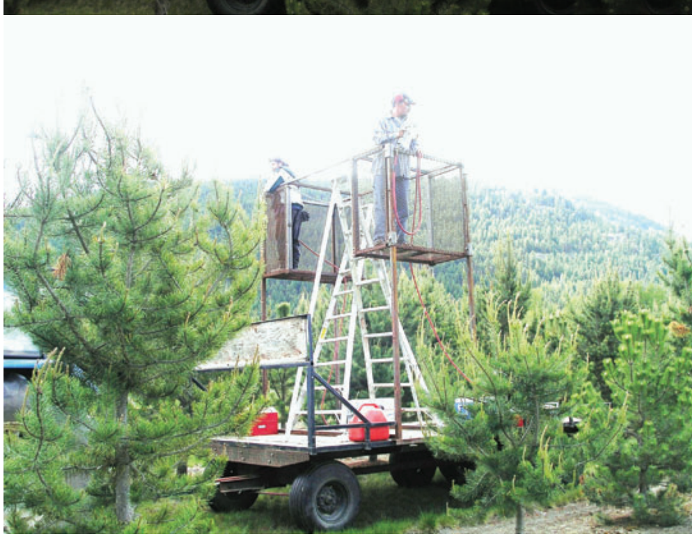
Results

• 13.45 l of pollen were vacuum collected in the Pli PG low orchard which was cleaned, dried and stored for application spring 2012 (Genetic Worth G+16.7). Approximately 4.5 l of pollen was applied to 3500 ramets during the receptivity period from May 20 to June 10. The Prince George Pli orchard is now producing sufficient pollen to meet SMP needs. Three SMP applications were completed in order to ensure early and late receptive clones received sufficient pollen to fertilize female conelets. Remaining late pollen was air blasted with the turbo fan sprayer. 8.95 l of pollen remains in storage for spring 2012 SMP.
• Developing cones were inspected for the presence of *Leptoglossus,* and as the risk to the seed crop was deemed negligible, pesticides were not applied.

Output and Deliverables

• 12.6 hl of cones were collected yielding a total of 1.737 kg of seed with a future potential of yielding 166.4 k potential trees.

Plates 45-49. All of the pictures are showing SMP from an elevated platform mounted on a trailer and attached to the orchard tractor. Compressed air is provided via a gas powered compressor and the pollen is applied from pollen guns with pollen reservoirs. Pollen is applied @ 20 – 30 psi and three morning applications are given to each orchard. Each application uses approximately 1.5 to 2.0 litres of pollen and is designed primarily to address natural pollen deficits for early and late receptive clones. Natural open pollination will now provide most of the pollen necessary to achieve seedset goals. Kettle River Orchards began producing significant amounts of pollen in 2011 and future SMP will supplement the naturally occurring pollen flow.



6.1.11 Sorrento Seed Orchards

Dave Barnard and Tia Wagner

OTIP 1707, 1803 and 4057E37, 4057E37 and Red Turpentine Beetle

Sorrento Seed Orchard manages two large lodgepole pine orchards established in 2003 in partnership with SelectSeed Company. These orchards supply seed for the Central Plateau (CP) low elevation and the Bulkley Valley (BV) low elevation seed planning units. The first cone crops were harvested in 2007. To date Sorrento has produced a total of 1.7 million seedlings for reforestation for the CP and BV forest regions.

SPU 17 Bulkley Valley Pli low, Orchard 240. OTIP 1707 & SPU 18 Central Plateau Pli Low, Orchard 241. OTIP 1803

Supplemental Mass Pollination (SMP)

Although both orchards are beginning to reach maturity, they currently do not produce a sufficient amount of pollen to adequately fertilize receptive flowers and yield an acceptable amount of seeds per cone. Therefore, when phenology surveys indicated optimal female receptivity, SMP was completed manually using pollen misters. Pollen used was either collected in 2010 from Kalmalka, Sorrento or purchased from VSOC. Three applications of SMP were applied.

Using a backpack vacuum, 5 litres of pollen for each orchard was collected at Sorrento Seed Orchards for pollinating next year's receptive flowers.

Plate 50. Using a pollen mister for SMP application.

Pest Management

Protecting cone crops and ramets from pest damage is fundamental to ensuring minimal loss to ramet health and seed yield. Weekly pest monitoring was completed for *Leptoglossus occidentalis, Dioryctria aurenticella, Rhyacionia buoliana and Synanthedon sequoia.* All pests remained below the action threshold and thus no control was required. *Synanthedon sequoia* populations are starting to increase, consequently manual control will be completed in 2012 to prevent ramet loss.

OTIP 0722

Data and cone collection was completed in orchard 240 (BV) for OTIP0722. Samples and information were sent to Kalamalka Seed Orchard for processing.

Mountain Pine Beetle (MPB) Project 4057E37 and Red Turpentine Beetle (RTB).

Attacks by MPB and RTB can result in ramet mortality. With MPB killed trees in the vicinity of the orchard, weekly monitoring for attacked trees and pheromone trap counts were completed. Trees with pitch tubes were investigated and beetles removed. For protection, trees with a diameter greater than 6 centimeters (approximately 2000 ramets) were given a bole spray of 2% Sevin at the beginning of June, before the peak MPB flight. To expose the attacks at the soil line, the duff around the base of trees was manually removed in the spring. As a result of our efforts only two trees succumbed to RTB attack in 2011, none to MPB.

Funding provided through OTIP aids in achieving the Forest Genetics Councils goal for producing a high quantity and quality of seedlings for Central Plateau and Bulkley Valley seed users.

Plate 51. Cluster of flowers from a high producing clone in CP orchard 241.

6.2 Technical Support Programs

6.2.1 Increasing Quality, Genetic Gain, and Quantity of Yellow Cypress Cuttings (SPU 1113)

Mark Griffin, John Ogg, Craig Ferguson and John Russell

Introduction

This project involves increasing the quantity and quality of high-value yellow cypress cuttings for the coastal program.

Objectives include:

1. to provide the cultural treatments required to improve hedge production,
2. to enhance hedge composition by replacing lower-genetic-value families and clones with newly tested, improved clones.

20011/2012 Highlights

Pruning of hedges occurred in June 2011.This year the pots were topdressed with Nutricote 18-6-8 type 180, augmented with applications of hi-sol.

In the autumn of 2011 there were 8966 donor plants in the operational hedge. The number of cuttings available from this hedge is currently estimated at 188,000 cuttings. Some roguing has been done, as well replacement plants have been brought in to keep the number of plants in the hedge fairly constant.

A sampling of every clone from series 1&2&3 in the greenhouse was set to test each clone's propensity to root. Clones will be evaluated and poor performing clones may be removed from production. Clones are being evaluated annually on an ongoing basis

In late 2011, some 170,000 cuttings from this operational hedge were supplied for production to reforestation nurseries.

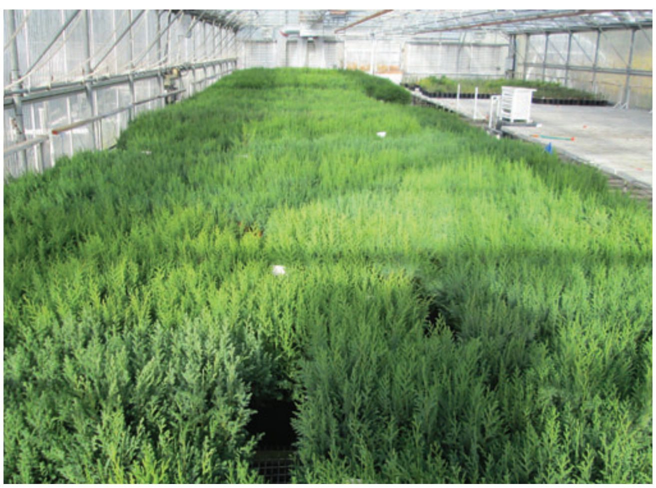


Plate 52. Part of the yellow cypress hedge at the Cowichan Lake Research Station.

Plate 53. Close up of yellow cypress hedge ready for pruning.

6.2.2 Estimating 2011 Pollen Contamination for Coastal Douglas-fir Seed Orchards

Joe Webber

SPU 1113

The 2011 contamination levels in coastal Douglas-fir orchards were 25.2% and 18.5% for Western Forest Products (WFP-166) and TimberWest (TW-183), respectively. These values can be explained by regional and orchard pollen loads during the period of orchard receptivity. Table 3 shows the regional and orchard receptivity period pollen loads for the period of 2005-2011. Pollen loads in 2011 (and 2010) were lower than in 2009 where the highest level of regional pollen loads and contamination were recorded (WFP data). Orchard pollen loads for 2011 (and 2010) were lower than in preceding years leading to higher contamination levels. For the last two years, contamination values at TW have been lower than those calculated for WFP. Since the regional pollen load values were similar at both orchards, lower contamination values at TW can be partially explained by the number of orchard parents (about 3000 at TW and 400 at WFP).

Like 2010, the 2011 receptivity period experienced cool, wet weather and orchard phenology progressed more slowly. This allowed the Orchard Adjustment Factor (OAF) to be calculated. The OAF is derived from the mean sum of ratios of early orchard pollen load to early regional (contaminant) pollen load. Only dates prior to orchard shed are used. In 2010, the OAF was 2.0 for WFP and 4.8 for TW. This raised the regional pollen load by the OAF and increased levels of contamination by the same factor. In 2011, the OAF was 0.38 and 0.79, respectively for WFP and TW. These values decreased the level of regional pollen load and therefore the contamination level by the same factor.

Since calculation of the OAF varies substantially by dates within and between seasons, I do not recommend its use for estimating the annual level of contamination in coastal Douglas-fir orchards. Current work by Dr. Y. El-Kassaby at UBC will confirm contamination estimates by pollen monitoring for the last five year crops at WFP using molecular DNA paternity analyses.

	Douglas-fir Orchard Receptivity 7-day Monitor Pollen Load (grains/mm^2/day) and %Contamination										
	WFP							TW			
	2005	2006	2007	2008	2009	2010	2011	2008	2009	2010	2011
REG PL	4.6	6.7	24.6	7.3	39.1	12.7	7.3	3.2	23.0	12.7	8.0
ORCH PL	96.3	54.6	114.6	48.9	85.4	27.5	29.0	28.6	67.8	63.7	43.2
%Cont											
PM	4.8	12.5	21.5	14.9	45.8	46.1	25.2	11.2	34.0	19.9	18.5
DNA (MS)	9.7	11.7	19.3	na	na	na	na	na	na	na	na
DNA (ELK)	10.5		DNA data for 2007-2011 in progress								

Table 3. Regional (REG) and orchard (ORCH) pollen load (PL) values (for orchard receptivity period) and estimates of contamination for two Douglas-fir orchard sites using pollen monitoring (PM) and DNA paternity analyses (2005-2011).

6.2.3 Collection of Crop Statistics for Interior Lodgepole Pine Orchards

Prepared for Michael Carlson
Joe Webber

SPU0722

Seed yields (filled seeds per cone) from north Okanagan orchards (NO) have not met expectations compared with seed yields routinely realized at Prince George (PG). For the period of 2006-2009, orchard statistics from nine NO and three PG orchards were collected. In 2010, three NO and one PG orchard were replaced with six younger expansion orchards from NO. Figures 3 to 8 show the cone (Figures 3-5) and filled seed per cone (FSPC) data (Figures 6-8) for each of the six original (older) NO orchards, six younger expansion NO orchards and two PG orchards. Figures 4 and 7 also show a summary of annual statistics for cone and FSPC from eight of the original 12 orchards (2006 to 2010). Figures 5 and 8 compare the annual statistics for the six younger orchards (2010 and 2011). Figures 9 to 11 show similar data for the mean seed per tree calculated from the number of cones and the number of FSPC.

Over the period of 2006 to 2011, the trend for higher seed yields per cone but fewer cones at PG continued. Since the number of FSPC is high and remains fairly consistent at PG, variation in the number of seed per tree principally results from variation in the number of cones per tree. This has resulted in PG orchards out producing all but KAL 230 orchards. However, in 2010 and 2011, the number of seed per tree from the two original PRT orchards equalled or exceeded that from PG. This has resulted from a steady increase in both cone numbers and cone yields.

For the younger expansion orchards both cone numbers per tree and seed yields per cone were lower than the older orchards but there were notable exceptions. Both PRT 228 and Tolko 339 produced about the same number of cones per tree as that from the two older PRT and PG orchards. PRT 228 also yielded about the same number of FSPC as the other two PRT orchards which were the highest (about 15) of all NO orchards with the exception of KAL 230.

On average, bagged cones from 2011 (Figures 12 and 14) produced about 7 seed per cone more than un-bagged cones with the two KAL and two VSOC orchards showing the greatest loss. Over the six years observation (Figure 13), the loss of seed from un-bagged cones ranged from about 2 to 11 filled seed per cone. The greatest loss of seed occurred at Kalamalka. There was no seed loss from un-bagged cones at PG.

The 2010 Bag On/Off trial was repeated in 2011 (Figure 15). Each of the three NO orchards showed substantial seed losses (FSPC) beginning in late July and continuing to mid August for both years. Table 4 shows the difference between the always bagged and never bagged cones for cone dry weight (CDW) total seed per cone (TSPC) and filled seed per cone (FSPC). Seed losses were largest at KAL, less so at VSOC and least at PRT. There was little if any effect on CDW and loss (fewer than FSPC) of TSPC at all three orchards suggests bagging effects on FSPC occurred after seed development was complete. While the two years were consistent with the time significant losses occurred so was the weather patterns for the two years, i.e., cool May and June followed by warmer July and August. The question remains, does weather affect bagging results and if so what would the effect be if a warm May and June occurred?

The loss of seed from cones always bagged and never bagged was statistically significant in both years. It may be important to note that the loss of FSPC from un-bagged cones from the sampling trial were less in both years than those observed from the Bag On/Off trial which was harvested cones 2-3 weeks later. The loss of seed from cones always bagged and never bagged was statistically significant in both years (data supplied by Dr. Ward Strong, Kalamalka Forestry Centre).

Debate continues about the cause of this seed loss. One side of the argument suggest the losses are too large to be caused by insects alone. However, data collected in this sampling trial and other trials continue to suggest insect predation is an important but probably not the sole factor affecting lower than expected seed yields from north Okanagan orchards.

	CDW			TSPC			FSPC		
	KAL	PRT	VSOC	KAL	PRT	VSOC	KAL	PRT	VSOC
ALWAYS	6.2	5.8	5.2	25.4	29.0	22.1	16.3	15.9	12.2
NEVER	5.4	5.1	4.9	19.7	22.3	14.4	5.9	9.6	3.3
Difference	0.8	0.7	0.3	5.8	6.7	7.7	10.4	6.3	8.9

Table 4. Mean cone dry weight (CDW), total seed per cone (TSPC) and filled seed per cone (FSPC) from cones always bagged and never bagged (2011).

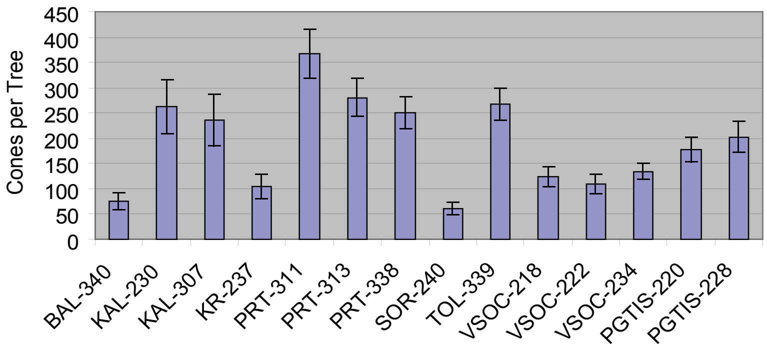


Figure 3. Mean (±standard error) total number of seed cones per ramets from each of eight original and six younger NO and two PG orchards (2011).

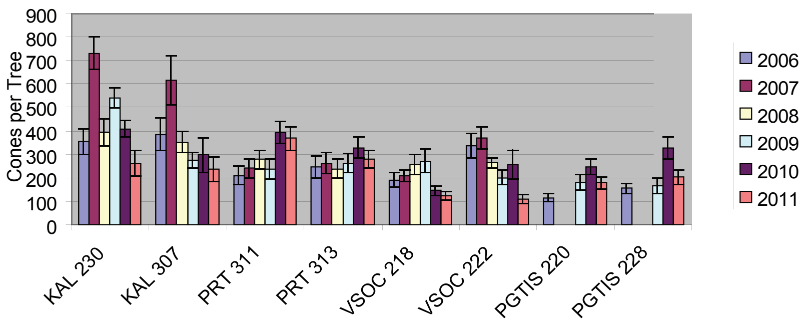


Figure 4. Mean (±standard error) number of seed cones per ramet from each of the eight original lodgepole pine seed orchards (2006–2011).

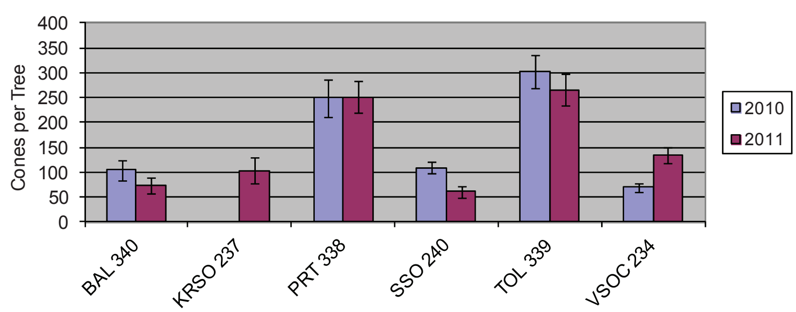


Figure 5. Mean (±standard error) number of seed cones per ramet from each of the six younger lodgepole pine seed orchards (2010–2011).

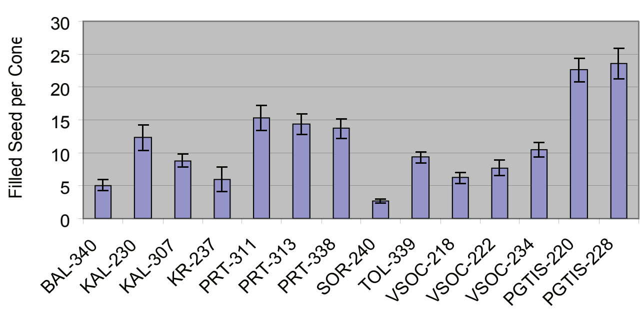


Figure 6. Mean (±standard error) number of filled seed per cone (FSPC) from each of the original eight and six younger lodgepole pine seed orchards (2011).

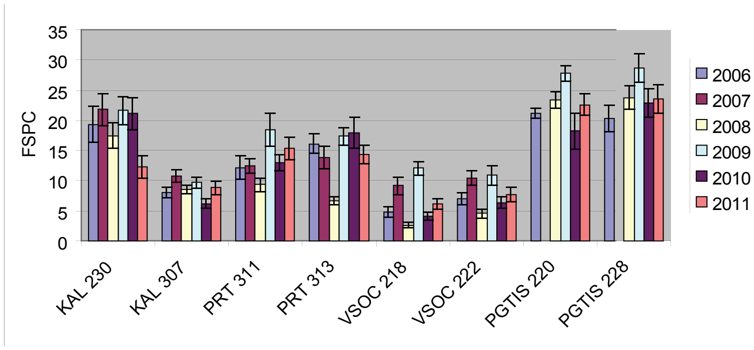


Figure 7. Mean (±standard error) number of filled seed per tree from each of the eight original lodgepole pine seed orchards (2006-2011).

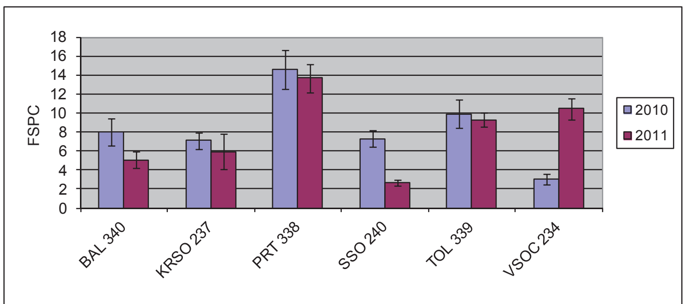


Figure 8. Mean (±standard error) number of filled seed per tree from each of the six younger lodgepole pine seed orchards (2010-2011).

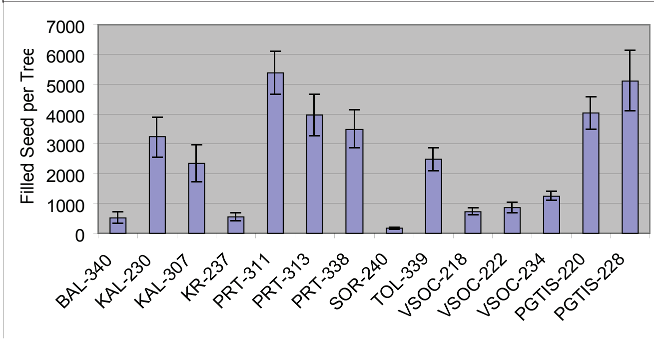


Figure 9. Mean (±standard error) number of filled seed per tree from each of the eight original and six younger orchards (2011).

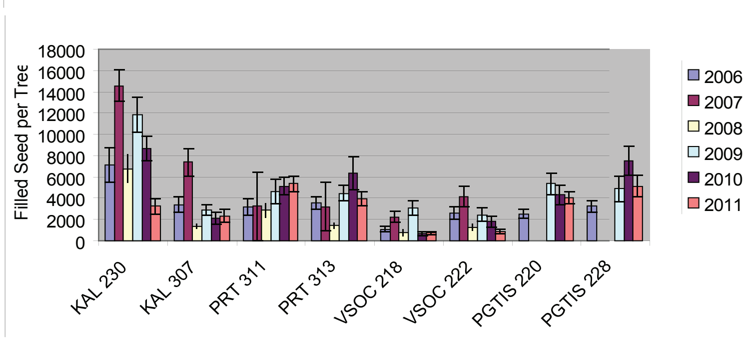


Figure 10. Mean (±standard error) number of filled seed per tree from each of the original eight lodgepole pine orchards (2006–2011).

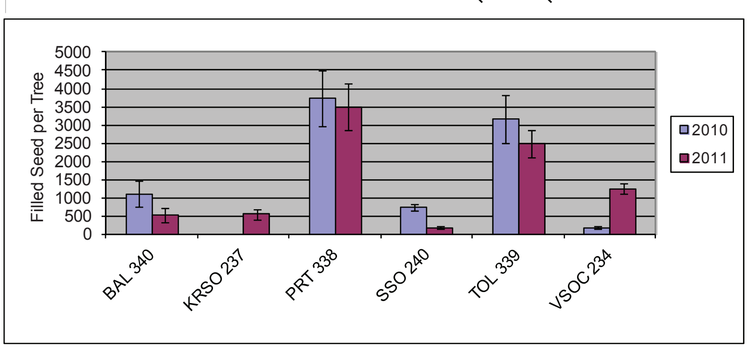


Figure 11. Mean (±standard error) number of filled seed per tree from each of the six younger lodgepole pine orchards (2010–2011).

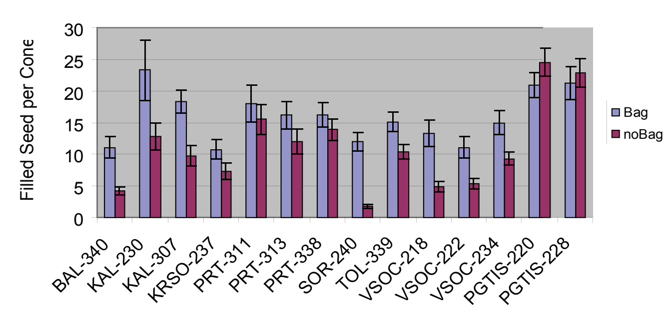


Figure 12. Mean (±standard error) filled seed per cone for bagged and un-bagged cones from the six original, six younger and two PG orchards (2011).

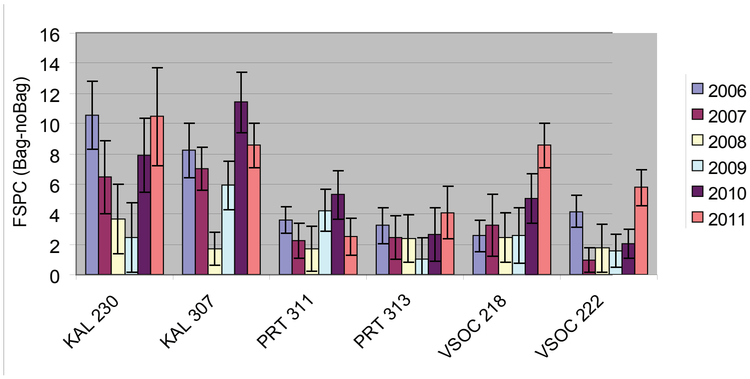


Figure 13. Mean (±standard error) filled seed per cone (FSPC) difference between bagged and un-bagged cones from the eight original NO lodgepole pine orchards (2006–2011).

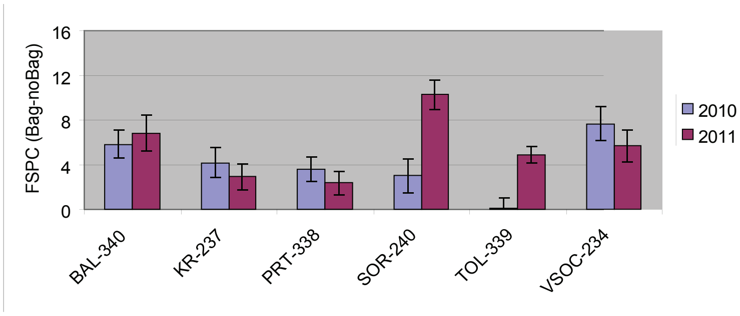


Figure 14. Mean (±standard error) filled seed per cone (FSPC) difference between bagged and un-bagged cones from the six younger NO lodgepole pine orchards (2010–2011).

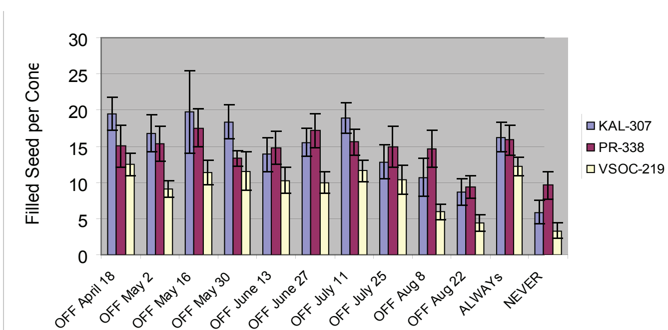


Figure 15. Mean (±standard error) filled seed per cone (FSPC) for twelve exposure periods from the 2011 Bag On/Off trial in each of three NO orchards.

7.0 Extension Technical Advisory Committee (ETAC)

Diane Douglas

Seed Orchard Pest Workshops

Kalamalka Forestry Centre, Vernon, BC, April 7, 2011

This workshop was hosted by Jim Corrigan at Kalamalka Seed Orchards with 34 in attendance. The morning was spent at Kal with presentations and in the afternoon, we toured several demonstrations set up at Kal and Bailey Road. Topics covered included: *Leptoglossus*, a fabric wrapping trial to reduce/prevent attack by pitch moths (*Synanthedon sequoiae*) on young lodgepole pine ramets and the swing-arm mower as a potential alternative to using herbicides for weed control in kill strips.

Whitebark Pine: Science and Management Forum, Lillooet, BC, July 14 & 15, 2011

The Whitebark Pine Ecosystem Foundation of Canada (www.whitebarkpine.ca)was recently formed. Their mission is the promotion and conservation of whitebark pine ecosystems by supporting restoration, education and research projects that enhance the knowledge and stewardship of these valuable ecosystems.

The foundations hosted a whitebark pine forum in Lillooet in July 2012. The Lillooet workshop was attended by about 40 individuals and was co-hosted by the Lillooet Tribal Council, Lillooet Naturalists Club and the Extension Technical Advisory committee of the Forest Genetics Council.

Topics covered were utilizing public outreach for restoration, Alberta, BC, US perspectives on Whitebark pine and research projects underway, genetic conservation, seeds, white pine blister rust, and grizzly bears and whitebark pine. The meeting was followed by a field trip to various sites in the Yalakom Valley.

Nutrient Workshop

Kalamalka Forestry Centre, Vernon, BC, October 6, 2012

Tia Wagner organized this workshop which was held at Kalamalka Forestry Centre with 36 people in attendance. A contract with Mario Lanthier from Crop Health Advising and Research to provide workshop presentations was very worthwhile. Chuck Bulmer, Soil Restoration Ecologist from Kalamalka Forestry Centre and Stephen Eng, from AAT Direct Solutions gave presentations.

Topics covered were Soil Management in Seed Orchards, typical symptoms of nutrient deficiencies in conifer plants, understanding your Tissue and Soil Reports – solutions from the wide, wide world of fertilizers. The workshops was very well received.

A big thank you to Tia Wagner!

BC Seed Orchard Association (BCSOA) meeting

The last BCSOA was held in 2007 in Prince George. The next meeting will be a joint meeting with North West Seed Orchard Manager's Association from the US, to be held in Victoria and Port Angeles, WA in June 2012. A contribution was made by ETAC for this meeting.

Publications

TIC*talk* http://www.fgcouncil.bc.ca/tictalk-2012.pdf

Plate 54. Whitebark pine: Science and Management Forum, Lillooet, participants.

8.0 Seed Orchard Pest Management

Jim Corrigan

The objective of the Seed Orchard Pest Management Subprogram is to provide research, extension support and orchard-level pest management to increase yields of high quality seed coming from the seed orchards of our province. The research and extension activities are handled through the Tree Improvement Branch of the BC Ministry of Forests, Lands and Natural Resource Operations (MFLNRO). Dr. Ward Strong has a half-time responsibility to conduct pest management research, while Jim Corrigan delivers extension services to Interior and Coastal operations. Seed orchard personnel handle hands-on pest management duties in the seed orchards.

The Pest Management Technical Advisory Committee (PMTAC) recommends annual funding allocations that come from the Forest Genetic Council to support relevant pest management research. Committee members are from the MFLNRO Tree Improvement Branch, the Canadian Forest Service, industry and BC government seed orchards and the Forest Genetics Council. The PMTAC establishes research priorities and budgets through an annual process of proposal development and evaluation. In fiscal 2011, the PMTAC supported projects on conifer seed bug, fir coneworm, Douglas-fir cone gall midge, novel pesticides, lab and technical research support, and cone and seed pest management extension operations.

PMTAC Projects for fiscal 2011 are summarized in Table 5.

Project	**Species primarily impacted**	**Progress**
Pesticide trials	Fd, Pw	Evaluations of foliar sprays of novel candidate pesticides for control of *Dioryctria abietivorella* & *Contarinia oregonensis* in Douglas-fir, and for phytotoxicity of these pesticides when applied to Douglas-fir & white pine ramets.
Contarinia/Leptoglossus Visual Foraging Cues	Fd, Pw, Pli	In collaboration with Simon Fraser University, this ongoing study investigated the interaction of visible light, infrared radiation, and host shape in host finding by *Leptoglossus occidentalis* and *Contarinia oregonensis*.
Research lab and technical support	All species	Funding was provided for on-going lab operations and technical assistance in support of research activities.
Pest management extension operations	All species	Funding provided for on-going extension support to Interior and Coastal seed orchard locations and to the Tree Seed Centre.

Table 5. Pest Management TAC projects for fiscal 2011.

Plate 55. Large populations of *Adelges cooleyi*, the Cooley spruce gall aphid, starting to wool up as they attack Douglas-fir needles, April 2011. (Photo by Jim Corrigan).

Plate 56. Nymphs of *Aphrophora parallella,* the pine spittlebug, feeding on a lodgepole pine cone, June 2011. (Photo by Jim Corrigan).

Plate 57. Late-instar larva of *Dioryctria auranticella*, the ponderosa pine coneworn, feeding on a lodgepole pine cone, June 2011. (Photo by Jim Corrigan).

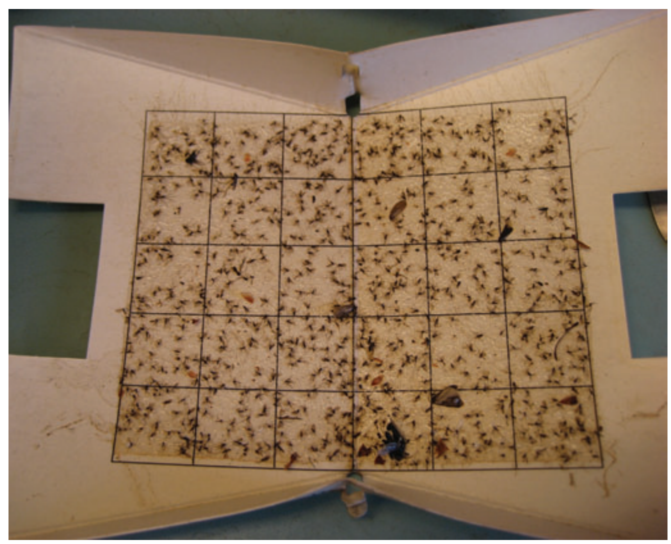


Plate 58. Males of the Douglas-fir cone gall midge, *Contarinia oregonensis*, caught in a sticky trap baited with their female sex-attractant pheromone, May 2011. Photo by Jim Corrigan).

Appendix 1 FGC Seed Planning Unit

Seed planning unit (SPU)					Program category
#	Species	Common Name	SPZ	Elev. band (m)	
1	Fdc	Douglas-fir	M	1-900	1
2	Cw	Western redcedar	M	1-700	1
3	Hw	Western hemlock	M	1-600	2
4	Sx	Interior spruce	NE	1000-1700	1
5	Sx	Interior spruce	NE	1700-2100	2
6	Ss	Sitka spruce	M	1-500	2
7	Pli	Lodgepole pine	NE	700-1600	1
8	Pw	Western white pine	M/SM	1-1000	1
9	Ba	Amabilis fir	M	1-1000	3
10	Pli	Lodgepole pine	TO	700-1400	1
11	Yc	Yellow cypress	M	1-1100	2
12	Pli	Lodgepole pine	PG	700-1400	1
13	Lw	Western larch	NE	700-1600	1
14	Sx	Interior spruce	PG	600-1400	1
15	Pw	Western white pine	KQ	500-1400	1
16	Pli	Lodgepole pine	TO	1400-1600	2
17	Pli	Lodgepole pine	BV	700-1400	1
18	Pli	Lodgepole pine	CP	700-1300	1
19	Fdc	Douglas-fir	SM	200-1000	2
20	Pli	Lodgepole pine	NE	1600-2000	2
21	Fdi	Douglas-fir	NE	400-1200	1
22	Fdi	Douglas-fir	NE	1000-1800	2
23	Sx/Ss	Spruce	SM/NST	all	2
24	Hw	Western hemlock	M	600-1100	2
25	Sx	Interior spruce	EK	750-1900	2
26	Pli	Lodgepole pine	PG	1400-2000	3
27	Cw	Western redcedar	SM	200-1000	2
28	Sx	Interior spruce	TO	1300-2100	2
29	Pli	Lodgepole pine	EK	1500-2000	2
30	Sx	Interior spruce	TO	700-1500	1
31	Fdc	Douglas-fir	M	900-1200	2
32	Pli	Lodgepole pine	EK	800-1500	2
33	Cw	Western redcedar	M	700-1500	2
34	Lw	Western larch	EK	800-1700	1
35	Sx	Interior spruce	BV	500-1400	2
36	Bg	Grand fir	M	1-700	3
37	Fdi	Douglas-fir	QL	700-1400	2
38	Hw	Western hemlock	M north	1-600 (part of SPU 3)	
39	Fdi	Douglas-fir	EK	700-1400	2
40	Sx	Interior spruce	PR	<650 & 650-1200	2
41	Fdi	Douglas-fir	PG	700-1200	2
42	Sx	Interior spruce	PG	1200-1550	2
43	Fdi	Douglas-fir	CT	600-1400	2
44	Sx	Interior spruce	NE	1-1000	1
45	Pli	Lodgepole pine	BB/CHL	All	3
46	Bl	Sub-alpine fir	all int.	all	3
47	Bn	Noble fir	M	all	3
48	Aspen/birch/poplar		Interior	-	3
49	Alder/poplar/maple		Coast	-	3
50	Lw	Western larch	NE	1200-1800	2
51	Py	Ponderosa pine	S. Interior	300-1200	2

Appendix 2 Tree Species

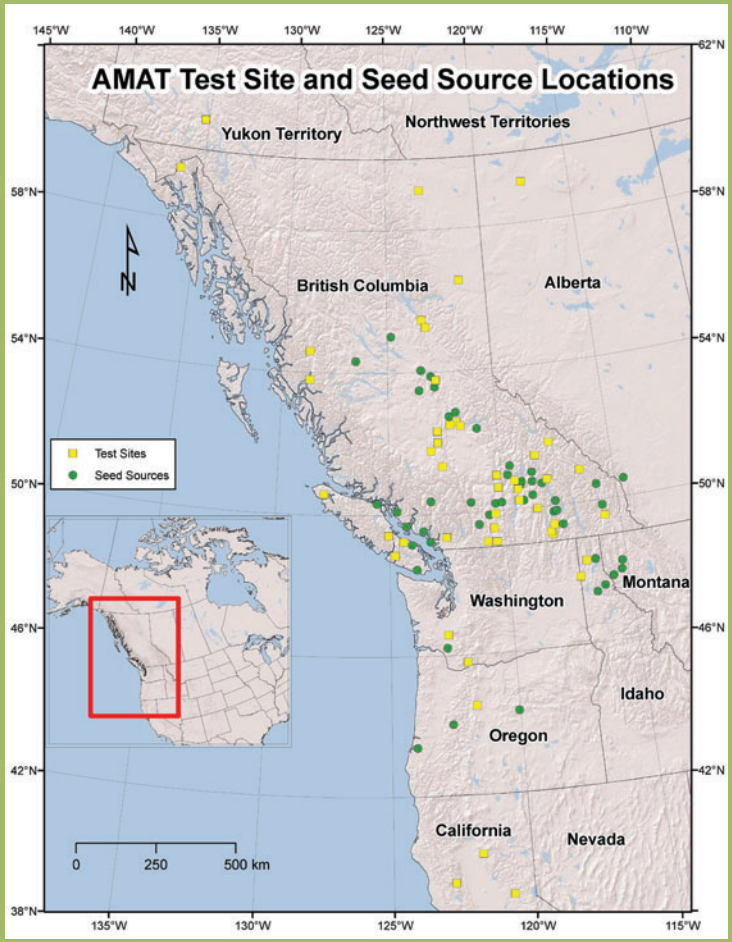
CONIFERS	LATIN NAME	TREE SPECIES CODES
western redcedar	*Thuja plicata*	Cw
yellow cypress	*Callitropsis nootkatensis*	Yc
coastal Douglas-fir	*Pseudotsuga menziesii* var. *menziesii*	Fdc
interior Douglas-fir	*Pseudotsuga menziesii* var. *glauca*	Fdi
amabilis fir	*Abies amabilis*	Ba
grand fir	*Abies grandis*	Bg
noble fir	*Abies procera*	Bp
subalpine fir	*Abies lasiocarpa*	Bl
mountain hemlock	*Tsuga mertensiana*	Hm
western hemlock	*Tsuga heterophylla*	Hw
Rocky Mountain juniper	*Juniperus scopulorum*	Jr
alpine (subalpine) larch	*Larix lyallii*	La
western larch	*Larix occidentalis*	Lw
limber pine	*Pinus flexilis*	Pf
interior lodgepole pine	*Pinus contorta* var. *latifolia*	Pli
ponderosa pine	*Pinus ponderosa*	Py
shore pine	*Pinus contorta* var. *contorta*	
western white pine	*Pinus monticola*	Pw
whitebark pine	*Pinus albicaulis*	Pa
Engelmann spruce	*Picea engelmannii*	Se
Sitka spruce	*Picea sitchensis*	Ss
white spruce	*Picea glauca*	Sw
spruce hybrid (interior spruce)	*Picea* cross (Se and Sw mixtures)	Sx
Sitka x unknown hybrid	*Picea sitchensis x*	Sxs
western (Pacific) yew	*Taxus brevifolia*	Tw

HARDWOODS		
biglesf maple	*Acer macrophyllum*	Mb
red alder	*Alnus rubra*	Dr
black cottonwood	*Populus balsamifera* ssp. *trichocarpa*	Act
hybrid poplars	*Populus* spp.	Ax
trembling aspen	*Populus tremuloides*	At
paper birch	*Betula papyrifera*	Ep
Garry oak	*Quercus garryana*	Qg

Appendix 3 Author Contact List

CONTRIBUTOR	AFFILIATION	TELEPHONE NUMBER
Aitken, Sally	UBC	604-822-6020
Ashley, Valerie	MFLNRO	250-260-4753
Barnard, Dave	Sorrento Nursery	250-675-4838
Berger, Vicky	MFLNRO	250-260-4767
Bird, Keith	MFLNRO	250-749-6811
Brown, Mike	PRT Armstrong	250-546-6713
Carlson, Michael	MFLNRO	250-260-4767
Cartwright, Charlie	MFLNRO	250-387-6477
Charleson, Lee	MFLNRO	250-387-4839
Crowder, Tim	TimberWest	250-652-4211
Douglas, Diane	MFLNRO	250-356-6721
Ferguson, Craig	MFLNRO	250-749-6811
Gaudet, Dan	VSOC	250-542-0833
Giampa, Gary	MFLNRO	250-549-5576
Graham, Hilary	MFLNRO	250-835-8626
Griffin, Mark	MFLNRO	250-749-6811
Hansinger, Rick	Kettle River SO	250-446-2771
Hayton, Lisa	MFLNRO	250-387-5443
Hooge, Bonnie	MFLNRO	250-963-8416
Jaquish, Barry	MFLNRO	250-260-4766
Kolotelo, Dave	MFLNRO	604-541-1683
Kranabetter, Marty	MFLNRO	250-952-4172
Ogg, John	MFLNRO	250-749-6811
O'Neill, Greg	MFLNRO	250-260-4776
Phillips, Gisele	MFLNRO	250 260 4756
Russell, John	MFLNRO	250-749-6811
Stoehr, Michael	MFLNRO	250-356-6209
Strong, Ward	MFLNRO	250-260-4763
Ukrainetz, Nick	MFLNRO	250-260-4761
van Niejenhuis, Annette	WFP	250-286-4109
Wagner, Rita	MFLNRO	250-963-8416
Wagner, Tia	TOLKO/Sorrento	250-546-2272
Walsh, Chris	MFLNRO	250-260-4777
Webber, Joe	ProSeed Consulting	250-537-8871
Wood, Darrell	MFLNRO	250-356-1127
Woods, Jack	SelectSeed	604-734-5778
Xie, Chang-Yi	MFLNRO	250-387-8911
Zedel, Susan	MFLNRO	250-356-1598

Assisted Migration Adaptation Trial (AMAT)
15 species being tested in AMAT (photo W. Strong)



Location of AMAT seed source origins and test sites (map S. Zedel)

BRITISH COLUMBIA

Ministry of
Forests, Lands and
Natural Resource Operations

FOREST SERVICE
BRITISH COLUMBIA

FGC

Forest Genetics Council
of British Columbia