SKIMIKIN SEED ORCHARDS

VSOC SEED ORCHARDS

KALAMALKA SEED ORCHARDS

WFP SAANICH FORESTRY CENTRE

SAANICH SEED ORCHARDS

2007/2008

Forest Genetics Council of BC

Tree Improvement Program Project Report



VSOC SEED ORCHARDS


SKIMIKIN SEED ORCHARDS

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Tree Improvement Program Project Report

Coordinated and compiled by:
Beacon Hill Communications Group Inc.

and

Keith Thomas and Diane Douglas
Tree Improvement Branch
British Columbia Ministry of Forests and Range

Acknowledgements

The Forest Genetic Conservation and Management Program is now in its eleventh year and has proven to be one of the most enduring and successful partnerships sponsored by the Provincial Government. Through the hard work and dedication of everyone involved, this program has been quick to respond to the ever-changing environment, and this year has been no exception.

Climate change continues to be at the forefront, and all our subprograms are rising to meet the challenge. Over the next few years our energies will be focused on providing a comprehensive operational program for select seed supply in the face of a changing climate. This will be challenging but I have no doubt that we will meet this challenge.

The Forest Investment Council continues to recognize the value of investing in genetic resource management. One of the key elements to our success is continuous improvement. Each year a review of at least one of our subprograms is undertaken to ensure alignment with Council's strategic direction and continued value delivery. The processes we have in place will ensure a transparent program that delivers on its targets, continues to be well respected, and is used as a standard for others.

This publication provides an excellent review of our efforts and highlights our successes. Sincere thanks to the Project Leaders for submitting their contributions, and to Lee Charleson, Diane Douglas, and Roger Painter for taking the time to review them. Acknowledgments also to seed orchard managers for providing the images for the cover collage.

Again, thanks to all those who have worked on this program in the past year and over the past eleven years, including Council members, review committees, species committees and various TACs. To all the Project Leaders, I wish you continued success for 2008/ 2009.

Keith Thomas
Tree Improvement Co-ordinator
Forest Genetics Council

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:

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

Forest Genetics Council	http://www.fgcouncil.bc.ca
Ministry of Forests and Range, Tree Improvement Branch	http://www.for.gov.bc.ca/hti
Ministry of Forests and Range, Research Branch	http://www.for.gov.bc.ca/hre/forgen/index.htm

Table of Contents

List of Figures

List of Tables

List of Plates

Tree Improvement in British Columbia

Ministry of Forests and Range Program Overview

Forest genetic resource management encompasses the conservation, controlled use, and enhancement of genetic resources of forest tree species and related communication and extension activities. The Forest Genetics Council of British Columbia (FGC) coordinates a provincial forest genetic resource management program that is implemented by stakeholders in the forest industry: the Ministry of Forests and Range (MFR), Canadian Forest Service (CFS), and universities.

The Forest Investment Account (FIA) is a major funding agency for forest genetic resource management in British Columbia. Through the Tree Improvement Program (TIP), FIA invests in forest genetic resource management activities that support its objectives and are incremental to existing government and industry activities.

The FIA BC Tree Improvement Program is guided by strategic and annual business plans prepared by the FGC.

Forest Genetics Council of BC

The Forest Genetics Council of British Columbia (FGC) is a multi-stakeholder group representing the forest industry, Ministry of Forests and Range (MFR), the Canadian Forest Service (CFS), and universities. Council's mandate is to champion forest genetic resource management in British Columbia, to oversee strategic and business planning for a co-operative provincial forest genetic resource management program, and to advise the province's Chief Forester on forest genetic resource management policies. FGC members provide strategic direction to the provincial forest genetic resource management program. 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 goal is to maximize the economic benefits from tree improvement gains in wood quality, quantity, and pest tolerance by supporting a genetic conservation program, developing long-term production capacity, doubling the average genetic gain of select seed, and increasing the amount of select seed used. The FGC Business Plan defines the annual set of activities and associated budgets to achieve this goal.

Forest gene resource management is a co-operative effort. In broad terms, the MFR leads tree breeding activities and operational production of reforestation materials is a collaborative effort between MFR and the private sector. The Canadian Forest Service, MFR Research Branch, and universities undertake research supporting tree improvement, while private institutions focus on applied research related to operational production.

"Select" refers to seed that comes from breeding programs that select from wild stands the trees with superior characteristics for growth, strength, or pest-resistance. "Seed" as used here refers to all selected reforestation materials, including vegetative propagules. The Forest Genetics Council does not support genetic engineering, and no genetically modified materials are used for Crown land reforestation in British Columbia.

A Challenge Dialogue Respecting Forest Tree Genetic Resource Conservation and Management (GRM) in British Columbia

Brian Barber

British Columbia's forest genetic resources are the foundation for maintaining healthy productive forest ecosystems and a globally competitive forest industry. BC is fortunate in having a strong, multi-sectoral community of practice involved in conserving and managing its forest genetic resources. However, a number of social, economic and environmental drivers, such as the mountain pine beetle epidemic and climate change, have challenged us to re-examine the assumptions, objectives, activities, and desired outcomes that guide Forest Tree Genetic Resource Conservation and Management (GRM) in BC.

In 2006-08, under the sponsorship of Jim Snetsinger, Chief Forester, and Craig Sutherland, Deputy Chief Forester, representatives from the Tree Improvement Branch, the Research Branch and the Forest Genetics Council of BC (FGC) undertook a Challenge Dialogue™[1] with members of the GRM community of practice, stakeholders, and interested members of the public to develop a collective vision and strategy for guiding GRM activities over the next decade.

A Challenge Dialogue is an iterative process whereby questions and draft statements are prepared for comment, and then, based on feedback, improved upon. This dialogue afforded persons the opportunity to participate, learn, share, and wrestle with ideas regarding GRM. As a result, the process of engaging persons in this Dialogue was just as, if not more, important than its final products.

In March 2008, the project champions and supporters compiled a new vision and scope, new sets of assumptions and guiding principles, and new objectives for GRM in BC based on the diverse and rich input received though various meetings, responses to two challenge papers, and a workshop. The final report can be downloaded at: http://www.for.gov.bc.ca/hti/grm/grm_dialogue.htm

This final report will serve to guide the development of business plans and the FGC's next five-year strategic plan (2009-2014). The latter will include performance measures necessary to achieve the desired objectives for the three core business areas of GRM: Conversation, Resilience, and Value and their enablers: Research, Policy, Decision Support, and Extension.

[1] Challenge Dialogue is a trademark of Innovation Expedition Inc. http://www.innovationexpedition.com/CDS.html

FIA – Tree Improvement Subprograms

The Forest Investment Account (FIA) Tree Improvement Program (TIP) is consistent with the provincial strategy for forest genetic resource management developed by the FGC. The TIP goals are to increase the growth rate, wood quality, and pest resistance of seedlings, and to preserve the genetic diversity of tree species across the province. TIP activities are organized into seven subprograms:

- Genetic Conservation
- Tree Breeding
- Operational Tree Improvement Program (OTIP)
- Expansion of Orchard Seed Supply (SelectSeed Ltd.)
- Extension and Communication
- Genetic Resource Information Management
- Seed Pest Management

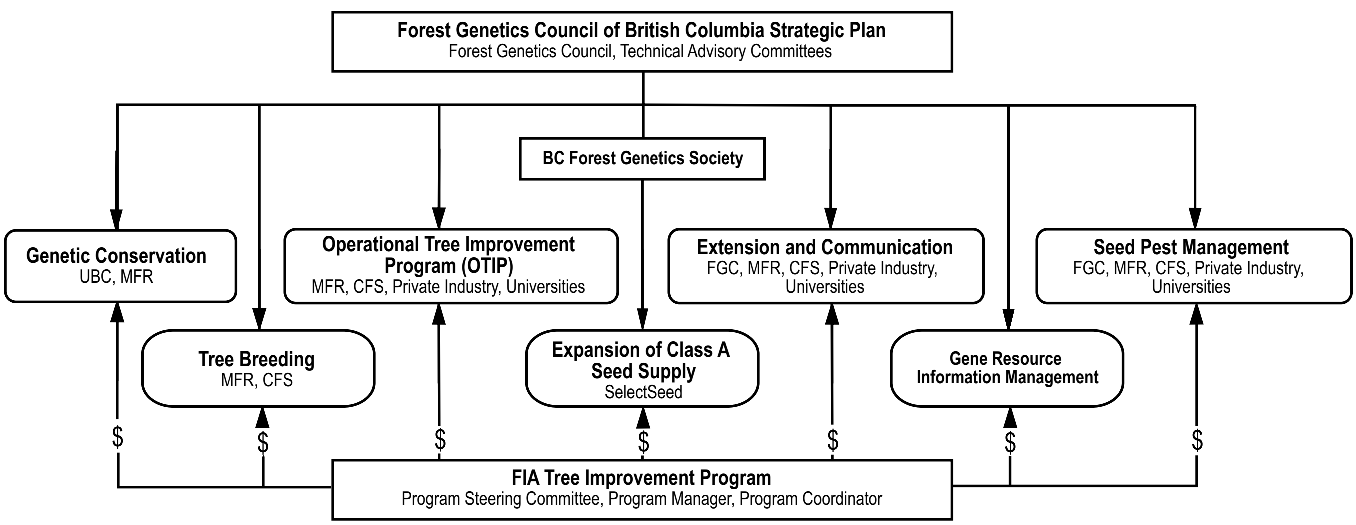


Figure 1. Relationship between FGC Strategic Plan, FIA-TIP, and participants in various forest gene resource management areas.

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

Jack Woods

Overview

SelectSeed is a provincially registered company that is wholly owned by the Forest Genetics Council of BC (FGC) through its registered Society and operated by a board of Directors. SelectSeed's mandate from the FGC is to establish and manage seed orchards needed to meet FGC objectives for seed supply. SelectSeed derives revenue primarily through Forest Investment Account (FIA) contributions and seed sales. Over time, FIA contributions have diminished and seed sales have increased. By about 2013, it is expected that SelectSeed will meet all of its cash requirements through seed sales. SelectSeed operations are guided by an annual business planning process that is reviewed and approved by the Forest Genetics Council. All SelectSeed orchard investments are through long-term contracts with private-sector companies. SelectSeed also provides program management services to the FGC, including meeting organization; participation in ongoing policy, structural and planning issues; business plan and report preparation; and legal and accounting matters.

Seed Orchard Operations

During the fiscal year ending March 31, 2008, SelectSeed orchards had their first significant year of seed production. The harvest from nine lodgepole pine orchards totaled 47.2 hectoliters (hl) of cones, yielding 7.9 kilograms (kg) of seed. The SelectSeed-owned proportion of this harvest was 32.6 hl and 5.8 kg. A substantial cone crop of 45.6 hl, yielding 42.1 kg of seed, was harvested from the Douglas-fir Nelson low-elevation orchard operated in partnership with Pacific Regeneration Technologies Ltd. The SelectSeed-owned proportion of this crop was 27.7 kg of seed. These yields were substantially above Business Plan forecasts. Supplemental pollination was carried out in all lodgepole pine orchards for the harvest of crops in 2008. Seed orchards and crops are summarized in Table 1.

FGC Program Management

Program management activities carried out during the fiscal year on behalf of the FGC included writing and publishing the FGC Annual Report for 2006/07; organizing committee work for development of the 2008/09 FGC Business Plan; policy, committee, issue management and reporting; updating species plans; and coordinating FGC activities. During the reporting period, significant effort was put towards completion of a genetic conservation plan, supporting a review of the Breeding Subprogram, and completion of the Genetic Resource Management Challenge Dialogue project.

Plate 1. Rick Hansinger at the Kettle River Seed Orchard Company/ SelectSeed Prince George lodgepole pine seed orchard.

Orchard #	Spp.	Seed zone	Planned # ramets	Total 2007 crop (kg)	Orchard company	Location
321	Fdi	NE low	2,187	42.1	PRT	Armstrong - Grandview
232	Fdi	QL	776	0	VSOC	Vernon
233	Fdi	PG	786	0	VSOC	Vernon
343	Sx	TO high	1,056	0	Tolko	Armstrong - Eaglerock
342	Sx	TO low	454	0	Tolko	Armstrong - Eaglerock
337	Pli	NE low	1,000	2.4	PRT	Armstrong - Grandview
338	Pli	TO low	4,796	1.1	PRT	Armstrong - Grandview
237	Pli	PG low	4,884	0.1	KRSO	Kettle Valley
236	Pli	PG low	4,500	0.4	VSOC	Vernon
339	Pli	TO high	3,508	2.0	Tolko	Armstrong - Eaglerock
234	Pli	BV low	3,000	0.2	VSOC	Vernon
240	Pli	BV low	3,100	0.9	Sorrento	Sorrento
241	Pli	CP low	2,000	0.7	Sorrento	Sorrento
238	Pli	CP low	3,100	0.1	KRSO	Kettle Valley
Totals				**50.0**		

PRT – Pacific Regeneration Technologies Ltd.; VSOC – Vernon Seed Orchard Co. Ltd.; KRSO – Kettle River Seed Orchard Company Ltd.; Sorrento – Sorrento Nurseries Ltd.

Table 1. Summary of SelectSeed orchards and 2007 crops.

Plate 2. Tim Lee and Onie Deardoff in the Vernon Seed Orchard Company/SelectSeed Bulkley Valley lodgepole pine orchard.

2.0 Genetic Resource Information Management Project Accomplishments

Leslie McAuley

1. Completed the Genetic Resource Conservation and Management (GRM) "Challenge Dialogue" for the purpose of engaging the GRM community of practice in

   a) the development of a common GRM Sustainable Forest Management (SFM) vision and

   b) the development of a provincial resource strategy for British Columbia's forest-tree genetic resources. The coming year will see the incorporation of proposed changes and reporting of outcomes in a revised FGC Strategic Plan.

2. Completed the Genetic Resource Conservation and Management (GRM) Decision Support System Business Architecture report. Seven key recommendations were identified across a number of topic areas, including:

   1) Climate-based seed deployment;

   2) Data access and modeling;

   3) Genetic resource monitoring;

   4) Genetic conservation;

   5) Information and knowledge transfer;

   6) Framework transition plan; and

   7) Sustainable Forest Management DSS.

3. Completed enhancements to the Seed Planning and Registry (SPAR) system, including:

   1) Technological updates to the Seedling Request and Transfer Guide routines;

   2) Development of Supplemental Mass Pollination (SMP) contribution data entry and Specific Request Sow Date screens; and

   3) New tools and reports added to the SPAR/SeedMap link feature to support clients in seed planning, registration, and seedling request ordering as per the *Chief Forester's Standards for Seed Use*.

4. Provided decision support for the modeling and analysis phase of the Coast Recovery Action Plan. Decision support included technical guidance on and/or provision of:

   Seed Planning Zone/Unit digital data;

   Seed Planning Unit (SPU); Management Unit (TSA); Timber Harvest Land Base (THLB) spatial overlays; and

   Historical (current management) seed use and genetic gain summaries.

5. Initiated a GIS-based GRM (Seed Deployment) forest resource modeling and analysis project with the University of British Columbia, Departments of Forest Sciences and Forest Management. The aim of the project is to:

   1) build capacity in GRM/Forest Genetics and GIS-based modeling and analysis;

   2) develop methodologies and protocols to support evaluation and monitoring; and

   3) provide decision support (data, knowledge and tools) for use by forest practitioners and decision-makers.

   The project will be undertaken by a student enrolled in the Masters of Science, Forestry UBC graduate program.

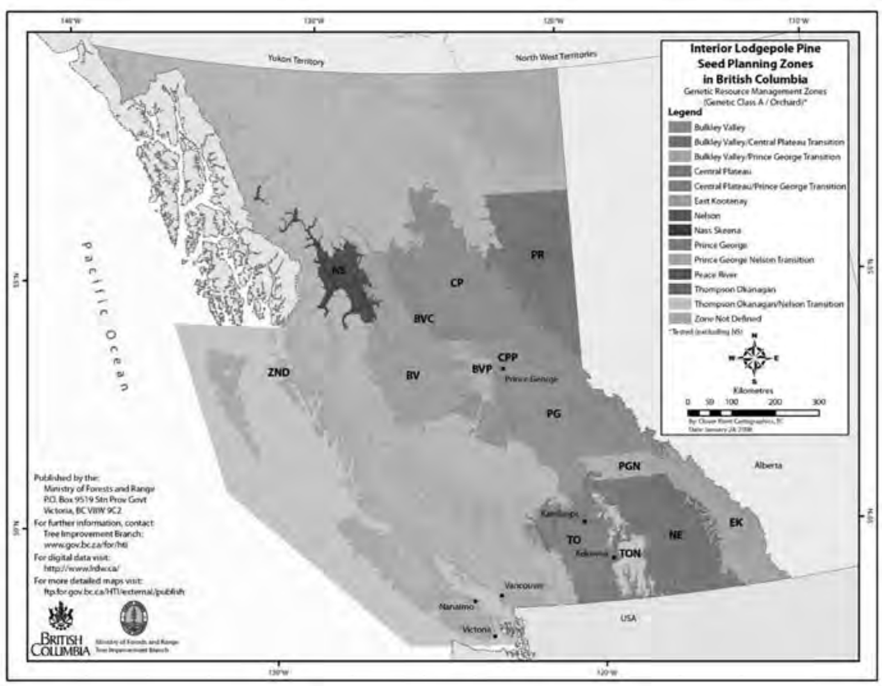


Plate 3. Interior Lodgepole Pine Seed Planning Zones in British Columbia.

3.0 Centre for Forest Conservation Genetics (CFCG)

Sally Aitken, University of British Columbia

Research activities of the CFCG in the past year fall into three main categories: (1) cataloguing the current protection of genetic diversity for all indigenous tree species in British Columbia in protected areas (*in situ* conservation in parks and ecological reserves), through seed storage (*ex situ* conservation) and in the provincial tree breeding program (*inter situ* conservation); (2) predicting the response of forest-tree populations to climate change; and (3) gaining knowledge about the genetics and conservation needs of non-commercial tree species. Information from these and previous project areas continue to inform the development and refinement of a genetic conservation strategy for BC's native tree species.

CFGC accomplishments in 2007/08 include the following:

Conservation Status

A detailed technical report documenting the *in situ* conservation status of 49 indigenous forest-tree species by BEC zone was completed for review and will be published in the 2008-09 fiscal year. We also developed a framework for a second technical report describing the *in situ, inter situ*, and *ex situ* genetic resources for commercial species, in cooperation with both the Research Branch and Tree Improvement Branch of the MFR. The gaps identified in these reports will form the basis of applied genetic conservation activities to be initiated in 2008-09.

Genetics and Climate Change

CFCG personnel published a review paper on the ability of tree species to adapt or migrate sufficiently quickly to persist in the face of climate change. This invited review was published in the inaugural issue of a new journal called *Evolutionary Applications* and is becoming well cited.

We continue to use controlled environment growth-chamber experiments to characterize the population-specific responses of tree species to environmental variables. In the past fiscal year we completed the first of two phases of a seedling growth-chamber experiment characterizing lodgepole pine and Interior spruce population response to temperature, moisture, and carbon dioxide. The second replication of this experiment will be completed in 2009-10. Results will be compared to climate change response predictions obtained from long-term field provenance trials.

Using ClimateBC and provincial vegetation plot data, we initiated a new series of climate-change-based predictions of future distributions of species and ecosystems using an improved modelling approach called Random Forest. We continue to update and maintain the ClimateBC model. This climate change forecasting tool continues to be widely used for forestry and other research in BC.

Conservation Genetics of Non-commercial Tree Species

We have established seedling common garden experiments containing range-wide collections for both Pacific dogwood (*Cornus nuttallii*) and Garry oak (*Quercus garryana*) at UBC. A second Garry oak site will be planted on Vancouver Island in 2008-09. Understanding the genecology of these species will help predict their ability to adapt to climate change and aid in the development of seed transfer recommendations for restoration of these species.

A project estimating levels of genetic diversity in Pacific dogwood populations from across the species range using both nuclear and chloroplast genetic markers is nearing completion. This species appears to be genetically depauparate in comparison with other native tree species, and shows little population differentiation.

We also established 18 seed-based common garden experiments for whitebark pine (*Pinus albicaulis*) distributed from Whistler to the BC-Yukon border with the primary goals of testing species distribution models that predict the occurrence of suitable habitat for this blue-listed species both within and outside of the current range and testing the potential for assisted migration.

Extension and Publications

Graduate students, staff, and faculty associated with the CFCG continue to participate in many extension-related workshops, conferences, and courses, within BC and beyond. We also continue to develop and maintain many online resources relating to the biology, genetics, and conservation of our native tree species. In the past year, personnel with the CFCG have published seven peer-reviewed publications in scientific journals, including the following.

References

Aitken, S.N., S. Yeaman, J.A. Holliday, T. Wang and S. Curtis-McLane. 2008. Adaptation, migration or extirpation: Climate change outcomes for tree populations. Evolutionary Applications 1: 95-111.

Bower, A.D. and S.N. Aitken. 2008. Genetic Diversity and Geographic Differentiation in Quantitative Traits, and Seed Transfer Guidelines for *Pinus albicaulis* (Pinaceae). Am. J. Bot. 95: 66-76.

Bower, A.D. and S.N. Aitken. 2007. Mating system and inbreeding depression in whitebark pine (*Pinus albicaulis* Engelm.). Tree Genetics and Genomes 3: 379-388.

Gapare, W.J., A.D. Yanchuk and S.N. Aitken. 2007. Optimal sampling strategies for capture of genetic diversity differ between core and peripheral populations of *Picea sitchensis* (Bong.) Carr. Conservation Genetics. DOI 10.1007/s10592-007-9353-8.

Holliday J.A., Ralph S., White R., Bohlmann J. and Aitken, S.N. Global monitoring of gene expression during autumn cold acclimation among rangewide populations of Sitka spruce [*Picea sitchensis* (Bong.) Carr.] New Phytologist 178: 103-122.

Mimura, M. and S.N. Aitken. 2007. Increased selfing and decreased effective pollen donor number in peripheral relative to central populations in *Picea sitchensis* (Pinaceae). American Journal of Botany. 94: 991-998.

Mimura, M. and S.N. Aitken. 2007. Adaptive gradients and isolation by distance with postglacial migration in *Picea sitchensis*. Heredity 99: 224-232.

4.0 Tree Breeding

4.1 Coastal Douglas-fir

Michael Stoehr, Keith Bird and Lisa Hayton

Testing and Selection

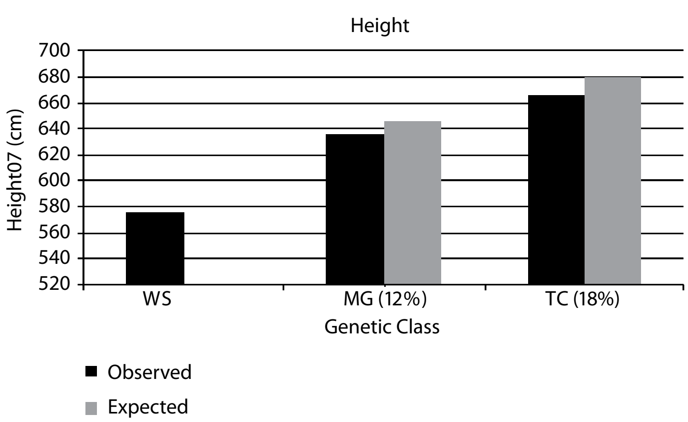
This year was highlighted by the selection of third-generation seed orchard parents from our advanced generation full-sib tests and realized gain trials. The forward selection in the full-sib blocks (two 5 x 5 full-sib family blocks of age 10 from seed) were based on the average parental breeding value derived from the general-combining-ability (GCA) progeny tests across four sites in coastal BC.

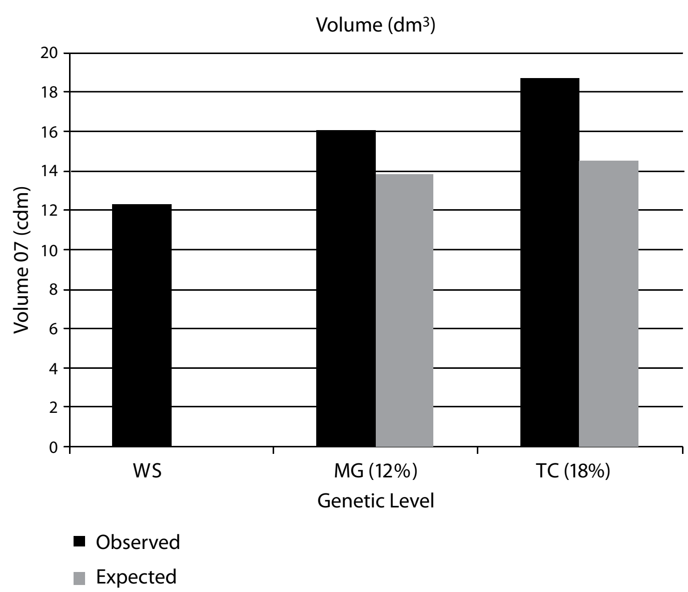
Breeding values for these forward selections ranged from 23 to 28 (volume gain at rotation age). Because demand is high for high-gain forward selections, we also selected from the "top-cross" plots of the realized-gain trials, based on breeding values of individual trees in the top-cross plots. All forward selections were grafted and are currently growing in transplant beds at Cowichan Lake Research Station (CLRS), ready to be distributed in the spring of 2009. Forward selections were also made in Series 2 of our testing program in full-sib blocks at Jordan River (age 5 from seed). Because the selection age was relatively young (five years), we decided to select and graft more candidates, to "bring them on sooner" with only 50% of these candidates (final selections) going into the seed orchards at age 11.

Realized-gain Trials

Realized-gain trials were measured in the fall of 2007 at age 12 from seed on all five active sites. These tests were initiated to verify calculated gains when seedlings of similar genetic quality are growing together. To mimic competition of seedlings at an early stage, tests were established at four spacings: 1.6 x 1.6 m, 2.3 x 2.3 m, 2.9 x 2.9 m and 4.0 by 4.0 m. Imposed on those spacing treatments were three levels of genetic gain (control (WS) with 0% gain, a group with 10% estimated gain ("mid-gain") and a group with 18% estimated gain ("top-cross"). The average heights on individual tree volumes are shown below.

Testing of progeny in the Sub-maritime (Coastal-Interior Transition) Zone continued with survival assessments on three test sites. These evaluations will be used for initial roguing of a seed orchard at Saanich Seed Orchard.





Figures 2a. and 2b. Observed means for wildstand controls (WS) and observed and expected means for mid-gain (MG) and top-cross (TC) seedlings at age 12 across five sites in coastal BC: a. height growth and b. calculated volume based on individual seedlings

Plate 4. Jordan River Forest Genetics Tour, December 2007. Michael Stoehr and Jodie Krakowski stand next to third-generation advanced selections at the Jordan River Douglas-fir progeny trial.

4.2 Sitka Spruce Breeding Program

John King and Dave Ponsford

Weevil Resistance Program

This year we are sowing the third and last series of the F1 breeding program — weevil resistance. Parents were designated by their phenotypic resistance to the weevil and their source (mainly Haney or Big Qualicum). Some susceptible parents were also used. This year we also planted the last of the OP collections from around the Big Qualicum area.

Selection and breeding work continues but our focus in this year is to select and breed for specific traits. They will still be field assessed for resistance after weevil augmentation, but a more detailed microscopic evaluation is being undertaken in order to classify parents according to putative mechanisms. This is particularly valuable for "constitutive" type of mechanisms such as sclereid cells or constitutive resin cells, and we are working to extend these techniques to look at some of the "inducible" mechanisms particularly traumatic resin cell production.

Ongoing trial assessments for weevil attack has continued. Included have been some of the hazard assessment trials. These were a series of trials established to test resistance over a variety of ecological and potential weevil hazard areas. The main objective is to aid in determining deployment guidelines. This exercise will be carried out with Don Heppner, the Coast Regional entomologist and we hope to provide Regional guidelines for spruce over the next year.

Major articles published over the last few years include:

King J.N. and Alfaro R.I. 2004. Breeding for resistance to a shoot weevil of Sitka spruce in British Columbia, Canada. In: Carson M.J., Walter C. eds. Plantation Forest Biotechnology for the 21st Century eds. 2004 Forest Research, New Zealand.

King J.N., Alfaro R.I. and Cartwright C.. 2004. Genetic resistance of Sitka spruce (*Picea sitchensis*) populations to the white pine weevil (*Pissodes strobi*): distribution of resistance. Forestry 77: 269-278.

Alfaro R.I., van Akker L., Jaquish B., and King, J.N. 2004. Weevil resistance of progeny derived from putatively resistant and susceptible interior spruce parents. For. Ecol. And Mgmt. 202: 369-377.

McKay-Byun A., Godard K-A., Toudefallah, M, Martin D. M., Alfaro R., King J. N., Bohlmann J., and Plant A. L. 2006. Wound-induced terpene synthase gene expression in Sitka spruce that exhibit resistance or susceptibility to attack by the white pine weevil. Plant Physiology 104: 1009-1021.

Other Components – QCI, NW Hybrid Program

The Queen Charlotte Island (QCI) program allows us to assess Sitka spruce growth free from weevil attack, and it also supports the seed orchard program (SO142 and its replacement). Our major difficulty has been in getting "free-to-grow" conditions — in this case not from weevil or brush, but from deer browse — and a good deal of our maintenance effort is on browse protection.

The transition program is designed mainly to test seed transferability in a very environmentally heterogeneous area with pressures from both frost and weevil. This year we did an assessment of aphid damage.

4.3 Western Hemlock Forest Genetics Program

Charlie Cartwright and Doug Ashbee

Low-elevation Maritime Hemlock (SPU 03)

Although the program for western hemlock is being curtailed and spending has been greatly reduced, efforts are being made to capitalize on the past substantial investments made by the Province. A limited number of advanced-generation selections were made this year, and poly-crossing to verify the breeding values of the best candidates based on age 5 data continues (third generation crossing however is on hold). In the field, age 10 years measurement on four of the Hemlock Tree Improvement Co-operative trials has been carried out. Some initial culling of breeding program holdings will be undertaken based on these data. Though measurement of support activities such as realized-gain or seed transfer trials have been deferred, minimal maintenance is taking place.

High-elevation Hemlock (SPU 24)

For the high-elevation program, the last series of trials envisioned for this seed planning zone (SPU) were out-planted in the spring. This last series will bring the number of tested parents to 325, which, based on results to date, will eventually result in seed orchard lots with genetic worth as high as 15%. No measurements were scheduled for this year, but over the next three years, older series of high-elevation hemlock trials will be re-measured, leading to the release of new breeding values for the SPU in 2010. As with low-elevation hemlock, only the most urgent maintenance work was carried out.

Plate 5. Jordan River Forest Genetics Tour, December 2007. Charlie Cartwright discusses the genetic worth of western hemlock selections from the Jordan River hemlock trials.

4.4 True Fir Forest Genetics

Charlie Cartwright and Doug Ashbee

Pacific Silver Fir (SPU 09)

As the effort with western hemlock is being curtailed activity with true firs, and in particular Pacific silver fir, is being ramped up. The last test utilizing left-over beef-up stock was out-planted near Gold River in the lower CWHvm2. This was necessary to clarify effects of elevational transfers and in particular the upper bounds of transfer for low-elevation source material. Despite fears that the 3-0 stock might be root bound, survival was exceptionally good, and growth was reassuring.

Maintenance of many of the now six-year-old series of tests was needed since, though the tests planted in 2003 are well established, their early height growth is not as fast as other Coastal conifers, and many plants are still mired in weeds. Two high-elevation test sites were measured this year, and in combination with data from the previous year the general pattern of variation over a broad range of sources became apparent. Though not as marked as the response of western hemlock to latitudinal and elevational transfer, clear patterns based on seed source origins were evident. Transfer guidelines for the species cannot as yet be amended based on this early data, since many plants are still protected by snow in the winter.

Sub-alpine Fir (SPU 46)

It is anticipated that planting of sub-alpine fir will increase in the years ahead as the interior cut heads higher in elevation in search of live trees. Also in light of the mountain pine beetle outbreak, there may be more planting of other species, such as true fir, where that is possible. Though this is not an orchard species, early data from our older nursery bed trials indicate that there is substantial provenance-based variability in growth traits. Early indications are that genetic gain in excess of 6% may be available through collection of B+ seedlots.

This year's field activities included maintenance of three nursery bed trials, and five field sites. One of the nursery trials that is off-site, (being in a low-elevation coastal location), is being maintained to be used eventually to assess Christmas tree traits. A more comprehensive set of field installations is being planned for sowing next year and in preparation for that, some USA provenances not having a cone crop last year were collected. In particular an elevational transect ranging from 850 m to 1,650 m was obtained in the Olympic Nation Park in Washington State. This collection is vital because the area is recognized as a refugium and material from this area has done remarkably well in other provenance test series (e.g. yellow-cypress, alder, Douglas-fir). This collection now gives a fairly complete range-wide representation for the species.

Grand and Noble Firs (SPU 36/47)

The older grand fir (EP0823) and noble fir (EP0857) experiments are in good shape, but need access notes, signage and rep markers renewed. This year only some site visits were possible, but it is a priority to update the field markers and documentation.

4.5 Western Redcedar Breeding Program

John Russell and Craig Ferguson

There are 930 parents established in first-generation polycross tests for the maritime low SPU. Seven annual series of tests were planted on 46 sites over six SPUs. Breeding values for volume at rotation are currently available for over 600 parents from series 1 and 2 based on 10-year heights, series 3 and 4 on seven-year heights, and series 5 and 6 on five-year heights. Approximately 75 parents from the first five series have been selected based on height for advanced generation and established into breeding orchards. Breeding for second generation is ongoing.

Full-sib and self families from deer-browse-resistant selections (high-needle monoterpene concentration) are currently being established into field trials and further within-family selections for browse resistance and needle monoterpene concentrations are ongoing.

4.6 Yellow-cedar Breeding Program

John Russell and Craig Ferguson

There are currently clonal values from approximately 5,000 clones represented in three series of annual testing based on nine-year data from the first and second series of cloned progeny tests and six-year data from the third series. These new clonal selections have been re-propagated for operational release. Maintenance continued this year in both field trials and breeding orchards, as well as monitoring of pollen performance and production for collection for advanced-generation breeding.

Various technical support projects were maintained and measured. These include clonal maturation, clonal competition, pollen viability, and deer resistance studies. Fifteen-year data has been collected from both the first and second series of provenance trials.

4.7 Coastal White Pine Breeding Program

John King, Rich Hunt (CFS), Dave Ponsford and David Noshad

Two phases of an F1 breeding program have been established over the last few years (approximately 90 families over three sites in each phase). A final phase was established in the fall of 2006. Parents for this effort came from the CFS screening program and were designated as either Slow Canker Growth (SCG) or Difficult to Infect (DI). SCG or "slow rusting" trees occur more frequently than DI. Also included as parents were some of the best of the Texada trees and some Idaho, interior, and Dorena trees.

Although 2004 saw Rich Hunt's "official" retirement, luckily we have managed to retain Rich, part time at least, through an appointment within the CFS. This fall we plan on having Dr David Noshad who will be working on an NSERC post-doc with the program. David is a recently graduated PhD in plant pathology and it is hoped his experience in inoculation techniques will add greatly to our program.

We started a large scale collection of whitebark pine and hope to incorporate this species in our blister rust screening in co-operation with USDA Forest Service scientists from Idaho and Oregon.

Recent publications on the white pine program include:

Hunt, R.S. 2004a. Blister-rust-resistant western white pine for British Columbia. Natural Resources Canada, Canadian Forestry Service Information Report BC-X-397.

Hunt, R.S. 2004b. Environmental and inoculum source effects on resistance of Idaho F2 western white pine in British Columbia. Can. J. Plant Pathol. 26: 351-357.

Hunt, R.S., G.D. Jensen, and A. K. Ekramoddoullah. 2004. Confirmation of dominant gene resistance (Cr2) in the U.S. white pine selections to white pine blister rust growing in British Columbia. Pp: 227-229 in Richard A. Sniezko, Safiya Samman, Scott E. Schlarbaum, and Howard B. Kriebel, eds. Breeding and genetic resources of five-needle pines: growth, adaptability, and pest resistance: 2001 July 23-27; Medford, OR, USA. IUFRO Working Party 2.02.15. Proceedings RMRS-P-32. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 259 p.

King J.N. and R. Hunt. 2004. Five-needle pines in British Columbia, Canada: Past present and future. Pp: 12-19 in Richard A. Sniezko, Safiya Samman, Scott E. Schlarbaum, and Howard B. Kriebel, eds. Breeding and genetic resources of five-needle pines: growth, adaptability, and pest resistance; 2001 July 23-27; Medford, OR, USA. IUFRO Working Party 2.02.15. Proceedings RMRS-P-32. Fort Collins, CO: U. S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 259 p.

King J. N. and A. David. 2006. Genetic approaches to the management of blister rust in white pines. J. For. Ecol. and Mgmt. (accepted).

Plate 6. Jordan River Genetics Tour, December 2007. John King takes the tour to see field performance of western white pine progeny at Jordan River.

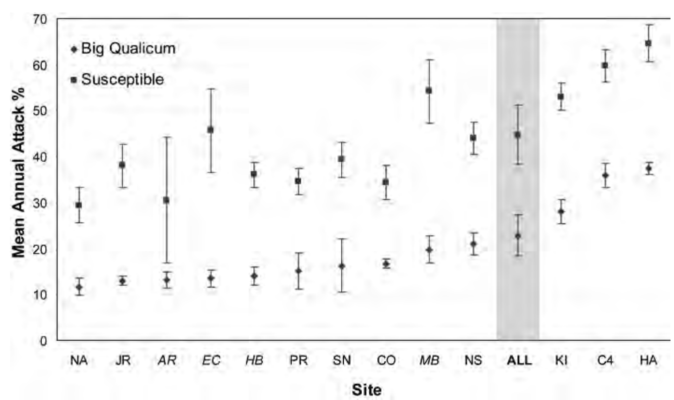


Figure 3. Mean annual attack rate of the East Vancouver Island resistant source (Big Qualicum) compared to typical susceptible sources across sites reported by increasing hazard scale. NA: North Arm; JR: Jordan River; AR: Armishaw Road; EC: Espinosa Creek; HB: Head Bay; PR: Port Renfrew; SN: Snowden; CO: Coombs; MB: Menzies Bay; NS: Nass; ALL: overall mean of all open-pollinated families adjusted across all sites; KI: Kitimat; C4: Camp 4; HA: Harrison.

4.8 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 and is structured on: 1) phenotypic selection in wild stands, 2) grafted breeding orchards and clone banks, 3) progeny testing using open-pollinated seed from the wild stand ortets, 4) clonal seed orchards based on backward selection, and 5) controlled mating to produce pedigree material for second-generation selection. Tree height, diameter and volume are the major traits considered for improvement, while wood relative density is an important secondary trait. The first-generation progeny testing program includes 1,466 open-pollinated families from six seed planning units (SPUs). Seed orchards were established in the north Okanagan in the early 1990s and are coming into production.

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

In 2007, 117 crosses were completed in six Douglas-fir SPUs, and 215 seedlots were collected, extracted and stored for future breeding. Controlled crossing for the Nelson SPU is now about 75 percent complete. Four 15-year-old West Kootenay high-elevation progeny tests and three 21-year-old Quesnel Lakes/Cariboo Transition progeny tests were measured, and data analyses are in progress. In addition, the three tests in the 20-year-old Nass Skeena Douglas-fir growth and adaptation study were maintained, pruned and measured. This study includes seedlots (o.p. families and operational wild stand) from throughout the BC distribution of Douglas-fir, and seven other coniferous species (western larch, lodgepole pine, western white pine, Ponderosa pine, Norway spruce, interior spruce and subalpine fir). Preliminary results showed that after 20 years, the western larch seedlots from the Flathead Valley were the tallest on all sites, while the subalpine fir seedlots were the shortest (Figure 4). Compared to Douglas-fir seedlots from the coast and southern interior, seedlots from the northern interior (i.e. the Central Plateau, McGregor and Mt. Robson zones) were taller, survived better and suffered less damage (Figures 4, 5 and 6). Seedlots from these northern seed zones should be considered for reforestation in the northern interior Cedar Hemlock zone.

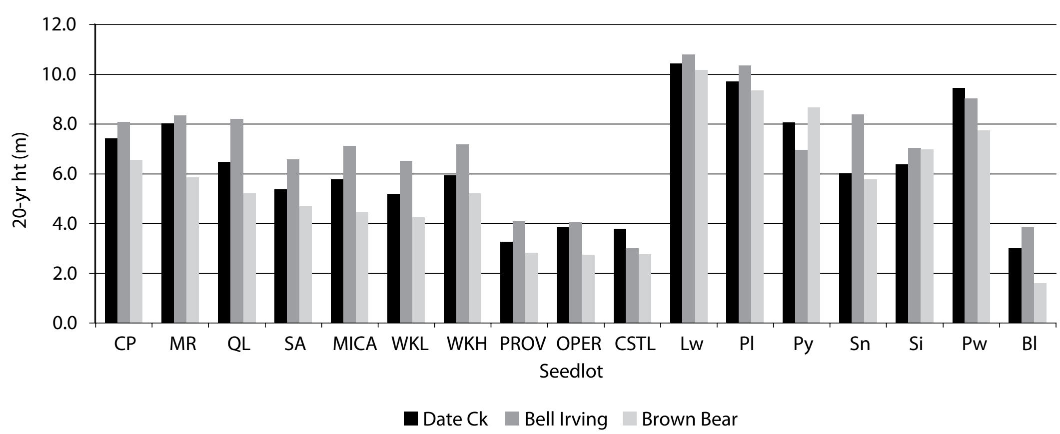


Figure 4. Twenty-year mean height of seedlots growing on three sites in the Nass Skeena Douglas-fir growth and adaptation study. Douglas-fir seedlot acronyms are as follows: CP=Central Plateau SPU, MR=Mt. Robson SPU, QL=Quesnel Lakes/Cariboo Transition SPU, SA=Shuswap Adams SPU, WKL=West Kootenay Low SPU, WKH=West Kootenay High SPU, PROV=superior Submaritime provenances, OPER=Submaritime wild stand Submaritime, and CSTL=coastal Douglas-fir. Species acronyms are Lw=western larch, Pl=lodgepole pine, Py=Ponderosa pine, Sn=Norway spruce, Si=interior spruce, Pw=western white pine, and Bl=subalpine fir.

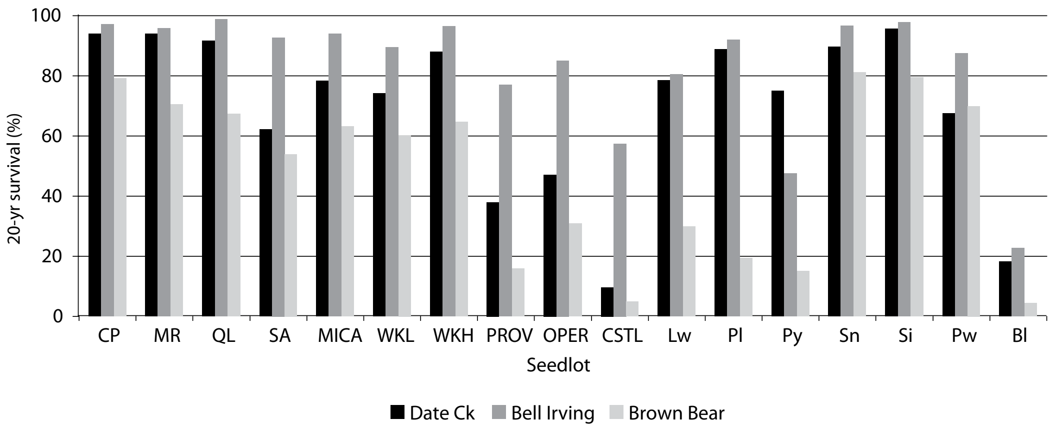


Figure 5. Twenty-year survival of seedlots growing on three sites in the Nass Skeena Douglas-fir growth and adaptation study. Douglas-fir and species acronyms are described below.

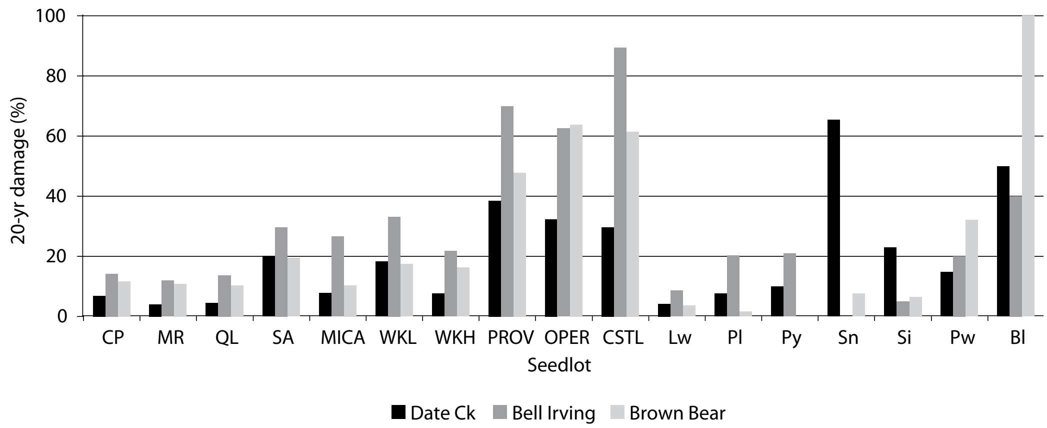


Figure 6. Percent of trees that were forked or damaged by snow or cold on three sites in the Nass Skeena Douglas-fir growth and adaptation study. Douglas-fir and species acronyms are described below.

	Date Ck				Bell Irving				Brown Bear			
Species	Number	Mn20yrht	Survival20	Damage20	Number	Mn20yrht	Survival20	Damage20	Number	Mn20yrht	Survival20	Damage20
1 CP	376	7.4	94	6.9	387	8.1	97.2	14.2	317	6.552	79.2	11.7
2 MR	376	8.0	94	4	361	8.3	95.8	11.9	265	5.843	70.5	10.9
3 QL	364	6.5	91.7	4.4	394	8.2	98.8	13.7	252	5.216	67.4	10.3
4 SA	249	5.4	62.2	20.2	370	6.6	92.7	29.7	216	4.704	54	19.4
5 MICA	313	5.8	78.4	7.8	376	7.1	94	26.6	253	4.453	63.2	10.3
6 WKL	297	5.2	74.2	18.3	358	6.5	89.5	33.2	241	4.236	60.2	17.4
7 WKH	352	5.9	88	7.7	383	7.2	96.5	21.7	258	5.216	64.7	16.3
8 PROV	123	3.3	38	38.5	259	4.1	77.1	69.9	46	2.822	16	47.8
9 OPER	66	3.9	47.1	32.3	120	4.0	85.1	62.5	47	2.73	30.9	63.8
10 CSTL	27	3.8	9.7	29.6	160	3.0	57.4	89.4	13	2.777	5	61.5
11 Lw	292	10.4	78.5	4.1	302	10.8	80.5	8.6	112	10.173	30	3.6
12 Pl	355	9.7	88.8	7.6	340	10.4	91.9	20.3	62	9.34	19.5	1.6
13 Py	30	8.1	75	10	19	7.0	47.5	21	6	8.667	15	0
14 Sn	26	6.0	89.7	65.4	29	8.4	96.7	0	26	5.765	81.2	7.7
15 Si	382	6.4	95.7	23	391	7.0	97.8	4.9	318	6.98	79.5	6.6
16 Pw	27	9.4	67.5	14.8	35	9.0	87.5	20	28	7.743	70	32.1
17 Bl	4	3.0	18.2	50	5	3.8	22.7	40	1	1.6	4.4	100

Table 2. Prince Rupert Douglas-fir prov/progeny test: 20-year results.

4.9 Interior Spruce Tree Breeding Program

Barry Jaquish, Val Ashley, Gisele Phillips and Bonnie Hooge

The interior spruce tree breeding program in British Columbia is structured in two phases. Phase one began in the mid-1960s and focussed on three ecologically and geographically unique regions: Prince George, Bulkley Valley and the East Kootenay. Phase two began in the mid-1970s and focussed on the other geographic regions where interior spruce is commercially and ecologically important. The program has progressed to the point where much of the current planting stock (more than 80 million seedlings per year) comes from rogued first-generation seed orchards, and full-sib second-generation progeny tests are in place for three seed planning units (SPUs). In the Prince George Series 1 program, 65 forward selections have been grafted and established in clone banks and breeding orchards.

Controlled crossing is now focussing on the Nelson SPU, and in 2007, 63 crosses were completed and 20 pollen lots were collected, extracted and stored for future breeding. Crossing is also ongoing at the Tolko Industries Eagle Rock seed orchard for the Thompson Okanagan SPU.

Site maintenance and measurements were conducted on various research sites including the 11-year-old East Kootenay second-generation progeny tests (Plate 7), the Prince George Series II second-generation progeny tests (Plate 8), and five somatic embling field trials. One 10-year-old embling site near McLeese Lake and the three-year-old PG Series II second-generation nursery study at Kalamalka were augmented with a population of *Pissodes* leader weevils reared at Kalamalka Forestry Centre. The augmentation at Kalamalka proved to be extremely successful (Plate 9). Leader kill among the 142 parents included in the test ranged from 0-100 percent.

All 18 three-year-old sites in the white/Engelmann spruce climate change study were maintained and measured. This study includes 128 seedlots (14 BC class-A, 14 BC elite, 34 BC class-B, 23 Alberta class-B, 8 Alberta class-A, 10 Yukon/NWT class-B, and 25 western USA class-B) tested on 18 climatically unique sites in BC, Alberta and Yukon Territory. Preliminary analyses indicated that BC class-A and elite seedlots had the highest mean height across all sites, and Yukon/NWT and southern USA sources were the shortest. Overall mean survival and damage were about 90 and 25 percent, respectively. Survival and damage on the coldest sites (Alexis Creek, BC; and Mayo, YT) were 60 and 85 percent, respectively.

Plate 7. Ten-year-old second-generation Interior spruce in the East Kootenay seed planning zone.

Plate 8. Three-year-old Prince George Series II interior spruce second-generation progeny test at the Skimikin Seed Orchard, near Salmon Arm, BC.

Plate 9. Three-year-old Prince George Series II interior spruce second-generation nursery test at Kalamalka Forestry Centre showing family variation in leader kills following augmentation with *Pissodes* leader weevils. Full-sib families are represented by three-tree row plots.

4.10 Western Larch Tree Breeding Program

Barry Jaquish, Val Ashley, Gisele Phillips and Bonnie Hooge

Commercial planting of western larch continues to increase in British Columbia, with over 6.7 million seedlings planted in 2007, 68 percent of which were class-A. In 2007, 97 second-generation crosses were completed and 70 pollen lots were collected and stored for future crossing. Second-generation crossing in the East Kootenay and Nelson SPUs is over 70% complete, and we anticipate completion of the crossing program within three years. Four 15-year-old Nelson SPU Series 1 progeny tests were maintained and measured. The three-year-old Nelson realized-gain genetic tests were maintained and measured. The composite elite cross seedlot was 18% taller than the composite operational control seedlot (Plate 10).

Plate 10. Three-year-old western larch realized-gain genetic test at Burton Creek, south of Nakusp, BC. Composite operational control and elite seedlots are viewed from left and right, respectively.

4.11 Lodgepole, White and Ponderosa Pine and Interior Broadleaved Species

Michael Carlson, Vicky Berger, Nicholas Ukrainetz and John Murphy (retired)

Lodgepole Pine

Forty additional western gall rust (WGR) resistant/tolerant trees were selected in our Finlay first-generation progeny test series. This brings the number of clones for the MFR's WGR resistance/rolerance seed orchard (SO) to 91. The orchard will be planted at the Skimikin SO site in 2009/2010.

Thirty-eight Nelson SPU high-elevation trees were selected from our NE SPU first-generation progeny test series, and will be grafted in April 2008. These will be be planted in 2009/10 and will be part of the Prince George expansion SO undertaken by the Vernon Seed Orchard Company. This is the first time the "assisted migration" concept has been applied to a SO expansion effort: i.e., combining NE SPU selects with PG SPU selects to produce seed for the PG SPU.

Scion has been collected from specific clones in the Pli breed arboretum for "replacement" grafting (breed arboretum replacement) in April 2008.

A total of 14 Pli second-generation family test sites (3) and provenance screening test sites (11) will be measured and assessed in 2008.

White Pine

A White Pine Management and Genetics workshop is planned for June 2008 in Vernon. Invited speakers will cover genetics, silviculture, ecology, wood properties and manufacturing. A field trip to visit white pine blister rust resistance/tolerance realized-genetic-gain trials is planned for the workshop.

Assisted Migration Adaptational Trial (AMAT)

The first 12 trial sites have been selected and will be laid out in summer 2008 and planted in spring 2009 (see Greg O'Neill et al AMAT update 2008). The range of biogeoclimatic variation sampled is great, with moisture/temperature extremes ranging from the PYxh (450 m el.) to the ESSFwc (2,000 m el.). Over 200 individual seedlots representing 16 tree species have been stratified and will be sown/grown in 2008.

John C. Murphy Retires

Yep, after 35.5 years with the BCMFR, John has retired. John worked as a Scientific Technical Officer for the Research Branch in the lodgepole pine breeding program for 31.5 years. John will be missed!

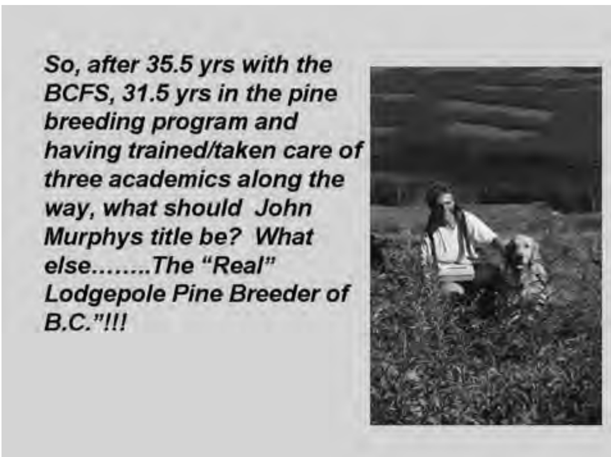


Plate 11. John C. Murphy retires after 35.5 years with BCMFR. Enjoy, Johnny. We miss you!

4.12 Assisted Migration Adaptation Trial

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

Approximately 50% of all seed used in the province originates from seed orchards. By 2013, this amount is expected to be 75%. In an effort to better understand the climatic tolerances of these important populations, so that the populations best adapted to climates anticipated throughout the rotation can be selected for each reforestation site, Research Branch has initiated the Assisted Migration Adaptation Trial (AMAT) — a long-term field trial of orchard seedlots from each seed planning unit.

Forty-nine orchard (or candidate orchard) seedlots representing 13 conifer and three broadleaf tree species will be tested across 48 test sites from Fort Nelson to southern Oregon. Growth, form and pest resistance will be recorded every five years and related to the climate of the test site to help identify the best seedlots for any climate.

Several design features make this trial unique: 1) all of BC's main commercial tree species will be tested together in a single experiment; 2) the number of test sites is greater and the climatic range of the sites is much wider than most genetic trials, allowing more accurate prediction of productivity of each population across a range of climates; 3) considering that most of BC's most productive land is expected to possess climates currently present in northwestern USA, a number of USA seedlots and climates have been included in the trial; 4) the exclusive focus on selected (orchard) populations is new in genecology trials and will allow much better understanding of the adaptation of BC's most important reforestation materials; and 5) by testing local wild-stand (Class B) control seedlots alongside the orchard populations, and by using large (five-tree x five-tree) square plots, the tests will allow calculation of realized genetic gain of BC and northwest USA's orchard populations.

Due to the large size of the experiment, 12 sites will be planted per year for four years, beginning in spring 2009. As of March 2008, a strategic approach had been developed to ensure that current and future BC climates were thoroughly sampled and the first set of 12 climates identified. One test site for each of the 12 climates had been identified. All 49 test and 24 control seedlots were completing stratification, awaiting sowing in April 2008.

The 2007/08 fiscal year has seen considerable extension activity for the AMAT. The project was presented or discussed at the following meetings, tours or classes:

- Southern interior Silviculture Committee – Naramata (April 2007)
- Pacific northwest forest genetics field tour – Harrison Hot Springs (August 2007)
- Forest Genetics Ontario – Climate Change Adaptation – Sault St. Marie (November 2007)
- Northern Silviculture Committee – Prince George (January 2008)
- Interior Technical Advisory Committee of the BC Forest Genetics Council – Vernon (January 2008)
- Inland Empire Tree Improvement Coop – Coeur d'Alene, ID (February 2008)
- Classes at UNBC (Jan 2008) and UVIC (March 2008)

The AMAT team is looking forward to sowing the seed in April 2008 and working closely with our many industrial collaborators who have generously provided seed and assisted us in finding test sites.

Technical support within the OTIP sub-program is an integral part of tree improvement in general and provides an excellent avenue for operational problem-solving. The Lodgepole Pine seed-set issue is an example of a focussed overview and analysis.

5.0 Operational Tree Improvement – the Eleventh Year in Review

Keith Thomas

With the end of our 11th year, Mountain Pine Beetle continues to attack our forests in unprecedented numbers and has moved south, even threatening our Southern interior orchards. Our ability to regenerate these forests will largely depend on our capacity to have quality seed available for our reforestation efforts.

The Tree Improvement Program has the ability to meet future seed demands due to key investments in breeding, testing, seed pest management, seed orchard quality and quantity boosts, and in orchard development through Council-owned SelectSeed Ltd. Over the years the Operational Tree Improvement Sub-program (OTIP) has provided the focus for investing in our orchards for the purposes of increasing genetic gain as well as seed yields. This sub-program continues to be an important mechanism for investment in existing orchards to help them meet their potential. This, coupled with the deployment of replacement stock from the breeding programs, the genetic worth of orchards continues to climb. In addition, our program utilises a system of performance management to monitor progress and set reasonable targets for project success. Orchardists and researchers have responded to these approaches and in many instances have achieved beyond planned targets.

Although 2007-08 was a moderate year for most orchard crops, considerable work continues with stock replacement and studies on seed supply issues. There are still numerous insect-related problems that reduce seed yields

For budget and OTIP business details, please refer to the FGC Annual Report 2007/8 http://www.fgcouncil.bc.ca/FGCAnnRpt-0708-Web.pdf

5.1 Orchard Projects

5.1.1 Saanich Forestry Centre (WFP)

Annette van Neijenhuis

The Western Forest Products (WFP) Saanich Forestry Centre manages production tree seed orchards for Seed Planning units in the Maritime Zone. These include low-elevation Douglas-fir, low-elevation western redcedar, low and high-elevation western hemlock, and low-elevation Sitka spruce seed orchards and yellow cypress hedge orchards. Development of a high-elevation Douglas-fir orchard is underway. As a co-operator in the Forest Genetics Council programs, WFP acquires OTIP funds to implement incremental management techniques to deliver quality seed in quantity to the coastal forest regeneration programs.

Coastal Douglas-fir Crop and Orchard Enhancement

Orchard upgrading included planting of 25 ramets in Fdc 166. This raises the average genetic worth of the orchard to BV 16. An additional 152 ramets were acquired in the fourth quarter; these represent many new selections for third-generation orchard development.

The 2007 cone crop — 54 hl of cones — was double the orchard projection and provided seed for an estimated 843,000 plantables at regular nursery sowing rates. This crop benefited from supplemental mass pollination, but midge control was not required. Minimal insect damage was detected. Because only the older, large trees contributed to the crop, its genetic worth is 11.

Western Redcedar Orchard and Crop Enhancement

A high-yield cone crop was realized in 2007 as a result of the induction and supplemental mass pollination applied in the previous year. This crop delivered 26.5 hl of cones, with seed for more than 6.7 million plantables at a genetic worth of 7.

Due to the heavy crop in 2007, induction was not implemented. Management of a smaller 2008 crop included pollen monitoring and supplemental mass pollination of 935 ramets in the fourth quarter. Incidence of western redcedar cone midge was below treatment threshold levels.

Low-elevation Western Hemlock Crop Enhancement

Because reproductive bud surveys in the low-elevation western hemlock orchard in 2007 showed low flowering, supplemental mass pollination was not warranted in the first quarter. The crop of 3.7 hl was harvested and is projected to produce 831,000 plantables with an average breeding value of 13. Supplemental mass pollination was initiated in the fourth quarter for the 2008 crop. Pest monitoring indicated no pest control was required.

High-elevation Western Hemlock Orchard and Future Crop Enhancement

Ramet replacement continued with planting of 66 ramets. The average genetic worth of the orchard is 11. This young orchard produced no crop in 2007.

OTIP funds supported supplemental mass pollination of the 2008 crop, initiated in the fourth quarter. As the parental contribution is not balanced, this seed will be saved to combine with future crops to meet the *Chief Forester's Standards for Seed Use* requirements for effective population size. Additionally, pollen was harvested, extracted, and stored for application to future crops.

Sitka Spruce Orchard and Crop Enhancement

An additional seven ramets were planted in the weevil-resistant Sitka spruce orchard. This orchard averages 86% cent weevil resistance; crops are managed to deliver 86 to 88% resistance for deployment using supplemental mass pollination. Pest surveys throughout the year indicated below-threshold incidence of foliar pests. No treatments were required.

The 2007 cone crop yielded 2 hl of cones, estimated to deliver 134,000 plantables. Supplemental mass pollination of the crop in the first quarter delivered seed with high germination. Minimal cone insect damage was detected.

Yellow Cypress Production Hedges Enhancement

Enhanced management of the yellow cypress hedges, including fertilizer treatments, pest control, and shoot pruning, resulted in delivery of cuttings material for 203,000 plantables to the 2008 nursery crop. The average genetic worth of this A-class material is 20. Clones that demonstrated poor rooting in the rootability trials were not included in the deployment; this removed 17% of the hedges. The best rooting stock identified in the rooting trials was purchased and maintained in the holding bed for development of a new yellow cypress hedge orchard.

Yellow Cypress Clonal Rootability Study

The first phase of the rootability studies is now complete. Sixty-three clones of genetic worth 14 or greater have been in test. Strong positive rooting was demonstrated by 23 clones; these are identified for inclusion in the next hedge orchards. Twenty-two clones demonstrating poor rootability are rogued from the production hedges. The remaining hedges have incomplete testing and will be further tested in a second phase of rootability trials. Phase 2 will include these clones, together with additional clones selected from the later field trials. The rejuvenation of the hedges, together with the selection of the best rooters is projected to improve nursery recoveries by 15%.

5.1.2 Sechelt Seed Orchard (CanFor)

Patti Brown

Douglas-fir

We SMP'd 400 ramets from Orchard 177 with GW 20 pollen to increase seed yield. The crop trees were then sprayed with 1% dimethoate in early/mid April. From this orchard, we harvested 7.4 kg (400,000 potential seedlings) with a GW of 17%.

In the high-elevation orchard, we injected the 100 crop trees with Acecaps, Admire or Tristar in early to mid-April.

Orchard 116 produced 41 kg of seed or 1.8M potential seedlings.

Western Redcedar

The maintenance of 2,400 redcedar ramets from test series 4 through 6 in the holding beds at Sechelt continues.

We sprayed the 100 crop trees in Orchard 186 with 1% dimethoate in early April to reduce damage due to redcedar midge and applied Sevin in July to control the increasing *Mayetiola* population. This orchard produced 7.6 kg or 1.5M potential seedlings with a GW of 8%.

Western White Pine

We collected MGR pollen from the MGR-identified trees in the Robert's Creek test site and reapplied it to all female cones produced in 2007 in Orchard 174.

We monitored the 600 cone-producing ramets and spot treated them for *Leptoglossus* control on a regular basis throughout the seed production season. We collected undeveloped cones attacked by *Conophthorus* and burned them prior to cone collection season for future control purposes. This orchard produced 26 kg of MGR seed.

5.1.3 Mt. Newton Seed Orchard (TimberWest)

Tim Crowder

Douglas-fir

SPU 0106 covers activities in four Fdc M Low orchards: 134, 154, 183 and 197. Orchards 134 and 154 are mature orchards that are rogued and upgraded as new ramets are available. Orchard 183 is a younger orchard that is in full production, while Orchard 197 is in establishment phase.

We applied SMP to 470 early- and late-flowering clones in all orchards, particularly as there was a small crop and the pollen load was light. We collected 4.7 litres of pollen with GW 16+, mixed 2.1 litres of this year's pollen with 1.2 litres of stored pollen, and re-applied it. We monitored for *Contarinia* midge and other pests; however, infestation levels were low this year, and no control was required.

We induced 650 ramets by stem injection of GA4/7 to produce a crop in 2008. This was less than normal as most trees in the orchard were already carrying a crop. We fertilized all four orchards by injection through the irrigation system, top-dressed newly planted trees with a granular fertilizer, and hand-watered them as necessary.

We transplanted 931 young grafted ramets into empty spots in the orchards in the fall, and maintained 314 trees in a holding bed.

We grafted 1,072 new ramets with an average GW +20% for future upgrading of the Douglas-fir orchards.

A combined total of 246.35 kg of seed was produced in five seed lots that ranged between GW 7-12%. This seed is capable of producing 10.3 million seedlings, of which 6.9 million will be above GW 10%.

Western Redcedar

SPU 0205 covers activities in two Cw M Low orchards: 140 and 152. These two orchards are similar in composition and are typically induced in alternating years to provide a steady seed supply.

Both of the cedar orchards contain large original ramets as well as small high-gain ramets from test series 1 and 2.

We induced 141 of the younger ramets by spraying with GA3, for a crop in 2008.

We maintained 225 grafted ramets from test series 1, 2, 3 in a holding bed and out-planted 1,768 grafts from test series 4, 5, 6, into the holding area in the fall. Grafts were staked, irrigated, fertilized, weeded, pruned and labeled as required.

Two seed lots produced a combined total of 39.559 kg of seed. This is enough to produce five million seedlings with GW 5% and five million with GW 8%.

We monitored for *Mayetiola* midge and other pests; however, infestation levels were low this year and no control was required.

Western Hemlock

SPU 0310 covers activities in Hw M Low Orchard 182. This orchard has been producing small crops since 2002 but has not yet reached full production capacity. Because of the small size of the ramets, we carried out SMP on 181 trees to ensure adequate seed set.

We collected 4.864 kg of seed from this orchard, which is enough for 0.972 million trees with GW 14%

All ramets were fertilized by injection through the irrigation system and were pruned to increase the surface area for cone production.

Western White Pine

SPU 0808 covers activities in Pw Orchard 403. In 2007, we collected rust-resistant MGR pollen from the Ladysmith test site and applied it to the developing cones for the 2008 seed crop.

We monitored the 2007 crop for *Leptoglossus* and spot treated it frequently for control of this tenacious pest. Over 2.147 kg of seed was harvested in 2007.

Trees were top-pruned, irrigated and fertilized to create vigorous shoots with large numbers of flowering sites.

Plate 12. Douglas-fir graft.

Plate 13. Douglas-fir cone harvest.

Plate 14. Western Hemlock cone harvest.

Plate 15. Cone conditioning before seed extraction..

Plate 16. Orchard lift training.

5.1.4 Bowser Seed Orchard

Carolyn Lohr

This project was designed to upgrade the genetic composition of Douglas-fir seed through various management activities and to increase the seed yield of the seedlots produced here. This is the fifth year of the project.

SPU 0110
Controlled Pollination

Pollination bags were placed on 672 branches of 33 high BV ramets in orchards 149 and 162. Pollen mix of average BV 17 was applied at least twice to each bag. Seedlot 60592 yielded a collection of 4.3 hectolitres (approximately 11 000 cones) and 1.265 kg of seed with a GW of 20. Seed yield per hectolitre was 0.294 kg.

Induction

Eighty-one suitable candidates (current year's crop negligible; no crop last year; not induced last year; sufficient vigour and adequate number of cone-bearing sites) from Orchard 162 and 8 from Orchard 149 were induced using irrigation delay and the double overlapping girdle technique. A very large 07/08 natural crop resulted in reduced numbers of suitable induction candidates.

Orchard Management

All orchard trees were maintained through appropriate cultural practices. Foliar nutrient samples were taken; fertilizer was applied both for growing stock and for crop maintenance; identification and irrigation systems were maintained, and irrigation was applied as required.

Insect Monitoring and Control

Surveys were conducted for *Contarinia*, *Dioryctria* and *Leptoglossus*. No control measures were undertaken for *Contarinia* or *Leptoglossus*. The *Dioryctria* trapping program was continued throughout the year. Population levels did not require control measures.

For the Record

The Bowser Seed Orchards' 2007-2008 cone crop was the largest crop to date. 313.50 kg of seed was collected from four seedlots in total: 1.265 kg from controlled crosses with GW 20; 29.24 kg from Orchard 162 with GW 16; 139.875 kg from Orchard 162 with GW 11, and 143.115 kg from Orchard149 with GW 9. The labour to pick the 700.71 hectolitres included three regular employees and 12 auxiliary employees collecting over a period of a month.

Plate 17. Cone shed at Bowser Seed Orchard.

Plate 18. Bagged tree at Bowser Seed Orchard.

5.1.5 Kalamalka Seed Orchards

Chris Walsh

In 2007/2008, Kalamalka Seed Orchards received OTIP approval for nine 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, planting rootstock for future grafting, transplanting the older higher-value ramets to the orchards, and roguing lower-value ramets from the orchards;
- improving orchard seed quantity and quality through pollen management, including collecting high-breeding-value pollen from clone banks and applying Supplemental Mass Pollination; and
- improving orchard productivity through pest management and other management activities.

Pest management activities included:

- 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 and Fdi cones,
- spraying to control mites in Fdi and Sx,
- applying dormant oil to control larch adelgids, and
- spraying to control *Leptoglossus* in Pw, Fdi and Pli.

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

The OTIP funding was instrumental in increasing both the quantity and quality of seed produced. At Kalamalka in 2007 we produced approximately 453 kg of western larch, lodgepole pine, interior spruce, interior Douglas-fir, and western white pine seed equivalent to over 68 million seedlings with an average GW of +17. Large areas of the interior of the province are using Kalamalka seed.

Project	Species	SPZ	Orchard	Roguing	Grafts Made	Maintained	Rootstock	Transplants
SPU0401	Sx	NE	305	19		191		49
SPU0502	Sx	NE	306			341		3
SPU0701	Pli	NE	347		2300			
SPU1302	Lw	NE	332	59	70	46	50	123
SPU1501	Pw	KQ	335		100	114		97
SPU1708	Pli	BV	230	152				
SPU3201	Pli	EK	340		12	63		162
SPU3501	Sx	BV	620		20	54		75
Totals				**230**	**2502**	**809**	**50**	**509**

Table 3. Orchard Composition Activities by Project.

Project	Species	SPZ	Orchard	Pollen Collected (litres, dry)	Trees Pollinated
SPU0401	Sx	NE	305		510
SPU0502	Sx	NE	306		459
SPU0701	Pli	NE	307	3.0	1,665
SPU1501	Pw	KQ	335		1,958
SPU1708	Pli	BV	230	5.0	1,000
SPU2201	Fdi	NE	324	2.0	908
SPU3201	Pli	EK	340	3.0	500
SPU3501	Sx	BV	620	2.5	432
Totals				**15.5**	**7,432**

Table 4. Pollen Management Activities by Project

5.1.6 Vernon Seed Orchard Company (VSOC)

Dan Gaudet and Tia Wagner

Seventeen projects at Vernon Seed Orchard were funded through the Operational Tree Improvement Program (OTIP) in 2007/2008 (Table 5). Funding provided is instrumental to increasing the seed yield and quality produced.

Orchard Health

Ongoing orchard integrated pest management practices are fundamental to ensuring minimal loss due to insects or diseases and producing maximum seed yield. Pest management activities included:

- Mountain pine beetle flights and populations were monitored closely this year using Lindgren pheromone traps.
- Tree boles were monitored twice weekly for mountain pine beetle feeding. Due to the application of two Sevin bole sprays only two trees in Prince George orchard 222 where removed due to beetle attack.
- Weekly monitoring for *Leptoglossus occidentalis* in all pine orchards.
- Control of *Oligonuchus ununguis* in young spruce.
- Spraying Safers Soap in spruce and fir orchards to control *Adelges cooleyi.*
- Removing *Pissodes strobi* in spruce orchards to control populations.
- Trap monitoring of *Synanthedon sequoiae* in pine and manual removal in young orchards.
- Trap monitoring of *Rhyacionia buoliana* in pine orchards to monitor populations.
- Cone dissections in spruce and fir orchards in late spring to quantify cone feeding pests and determine if control strategies are required.
- Monitoring and spraying for *Dioryctria abietivorella* in mature fir orchards.

Orchard Activities

- Douglas fir orchards continue to be induced with GA4/7 to increase cone production.
- The top half of Prince George 214 orchard (2600 ramets) was rogued in early fall to prepare for the planting of second generation spruce in 2010.

- Second generation spruce (2300 grafts) were maintained in the holdbed, requiring pruning, fertilization and pest and disease control.
- Foliar samples and analysis was completed in all orchards. Sample results aid in determining nutrient application levels in the following seasons.
- Pollen management occurred in all young orchards where pollen availability is low to promote optimal ovule fertilization and increased seed yield.

Available funding has a positive effect on the ability to achieve the Forest Genetics Council's goals of 12% gain and 75% use of Class A seed.

Plate 19. Mountain Pine Beetle Trap overlooking Orchard 219.

SPU Project	Species	SPZ	Orchard	Pest Monitoring and Control	Induction	SMP - Ramets Treated	Pollen Collected (L)	Seedlings Produced (million)
1201	all		site	Nutrient Analysis				
1208	Pli	PG	236	4329		3000	5	0.1
1706	Pli	BV	234	2927		2000	5	0.06
1801	Pli	CP	218	4143		4143		3
1701	Pli	BV	219	5455		5455		4.8
1202	Pli	PG	222	3746		3746		1.8
3703	Fdi	QL	232	781		0	2	0
4103	Fdi	PG	233	775		0	1.6	0
4102	Fdi	PG	225	510	300	244	4	0.66
3702	Fdi	QL	226	351	120	261	2	1.70
4301	Fdi	CT	231	1050	393	406	2	3.6
1403	Sx	PG	214	2500				192.5
1403	Sx	PG	211	3500				24.2
1421	Sx	PG	Hold-bed	maintenance of 2.0 generation holdbed (2600)				
4057E32	Pli	All	All Pli	Spraying Sevin on all Pli for MPB protection				
4057E33	Pli	Trial	219/218/222	Cone collection for Pli seed set trial				

Table 5. Summary of Vernon Seed Orchard 2008 orchard activities.

Plate 20. Excavator removing trees in Orchard 214..

5.1.7 Grandview Seed Orchards (PRT Armstrong)

Hilary Graham

Projects 0702, 0721, 1001, 1002, 1007, and 2101

PRT Grandview manages five lodgepole pine orchards and one Douglas-fir orchard, producing seed for the Thompson Okanagan (TO) low-elevation and the Nelson (NE) low-elevation seed planning units.

In 2007/08, projects in each of the orchards received OTIP funding for activities to increase the yield and genetic gain of seed produced. These activities included grafting, maintaining holding beds, planting grafts, rogueing, insect and disease monitoring and control, rodent control, crown management, foliar analyses, pollen monitoring, pollen collection, flower induction, and supplemental mass pollination (SMP). In addition to the individual orchard projects, two incremental projects were funded.

Pli Orchards

To improve the quality of the older Pli orchards (308, 311, and 313), 301 grafts were made and maintained in holding beds. In the spring of 2008, the 265 surviving grafts were planted out to fill vacant orchard positions. Forty-eight unproductive ramets were rogued from these three orchards, providing for long-term increase in GW as the vacant positions are filled with higher-gain material.

Pollen management activities began in early May with pollen collection, monitoring, and distribution using an orchard air-blast sprayer. The young SelectSeed Pli orchards (337 and 338), as well as the early- and late-flowering clones in orchards 311 and 313, received SMP applications. Pollen was collected from orchards 311 and 313 and at the Kalamalka Forestry Centre. Whole pollen buds were collected both manually and by backpack vacuum, by clone. Thanks to Michael Carlson and Chris Walsh for providing access to the Kalamalka clone banks. We collected five and a half litres of pollen for the TO low orchards and four litres of pollen for the NE low orchards. After processing, samples of the pollen were tested for viability at the Vernon Seed Orchard Company lab before going into freezer storage for future use.

Foliar tissue samples were taken to determine the appropriate fertilizer mix for spring and fall applications. Throughout the season, we monitored all Pli orchards for insect, rodent, and disease problems. This ensured that measures were taken to protect ramet health and

Plate 21. Sandra Eschbach weighs and measures cones for DNA study.

Plate 22. Kris King collects Fdi pollen by vacuum.

developing cones. Insecticide sprays were applied to control *Leptoglossus* seed bug. Fungicide sprays were required in the older orchards 308, 311, and 313. Poison baits were laid to control rodents feeding on tree roots, and Sequoia pitch moths were removed by hand. In the fall of 2007, pruning was done in the larger orchards to open up the crowns, restrict ramet height, and maintain tractor access down the rows.

Fdi Orchard

Pollen monitoring began at the first flight of pollen in the orchard, indicating a relatively small pollen load in the orchard. Because of the limited supply of natural pollen and a large flower crop, we applied stored pollen to receptive flowers four times (SMP). At the same time, pollen for future use was collected at the Kalamalka Forestry Centre. Thanks to Barry Jaquish and Valerie Ashley for providing access to the clone bank. Approximately two litres of pollen were collected, processed, and put into freezer storage after viability testing at the Vernon Seed Orchard Company lab.

Throughout the season, we monitored the Fdi orchard for insect damage to the developing cone crop. An insecticide spray was applied early in the season to protect the crop from *Dioryctria* (fir coneworm), which has caused substantial damage to previous cone crops. With a well-timed spray and a smaller population of *Dioryctria* in the Fdi orchard in 2007, little to no damage was evident at the time of cone harvest.

To induce the crop for 2008, we applied gibberellic acid (GA) to 600 ramets by stem injection. The large number of flowers and the increasing amount of pollen seen in the orchard in 2007 may be a result of GA induction in previous years.

Grandview Seed Orchards Incremental Projects Mountain Pine Beetle – Pli Ramet Protection

In 2006, seed orchards in the Okanagan faced mountain pine beetle (MPB) attacks for the first time. The Kalamalka Forestry Centre was particularly hard hit in early August, but responded quickly to the challenge and protected their Pli orchards from further attack by applying a prophylactic insecticide to the tree boles. This information was immediately communicated to the other Okanagan seed orchards, and all Pli orchards were protected from damage.

For 2007, with the assistance of OTIP funding, we took a proactive approach to the MPB problem and applied prophylactic insecticide sprays in advance of any beetle flights. In addition, MPB pheromone traps were set up around the PRT Armstrong site to monitor the presence and abundance of beetles in the area.

Trap monitoring indicated that the orchards were exposed to high populations of beetles during the summer of 2007. After the prophylactic spray was applied, only one orchard ramet was attacked by a single beetle. There were nine unprotected (not sprayed) Pli trees near the main office that were heavily attacked and killed during this same period. Numerous Py trees in the orchard windbreak (unprotected) were mass attacked and dying in the spring of 2008. The high level of exposure to beetle attack (as observed by high trap catches) and the absence of damage in the orchards indicates that the single prophylactic spray was very effective in protecting our orchards.

Gamete Contribution

This was our final year participating in a companion study to support/complement the Pli seed orchard DNA fingerprinting project approved by the FGC. A cone survey was conducted prior to cone harvest. Cone weight and volume data were collected during the cone harvest for each of the 65 clones. A report of the findings will establish whether or not the current protocols for estimates of gamete contributions were adequate for the calculation of seedlot quality and effective population size for this seedlot. Also, 30 cone samples were collected for 15 of the clones for DNA fingerprinting, and dormant bud samples were collected from each clone for parental genotyping and minor clonal ID labeling verification. Completion of this project will complement the FGC-funded DNA fingerprinting study and provide baseline data for comparing male and female gametic contribution protocols.

All projects were completed as planned in the 2007/08 season. In the Pli Thompson Okanagan Low, we collected 12.611 kg of seed with the potential to produce 2.35 million seedlings. In the Pli Nelson Low, we collected 10.7 kg of seed with the potential to produce 1.96 million seedlings. The Fdi Nelson Low orchard produced 42.09 kg of seed with the potential to produce 1.7 million seedlings.

The activities conducted in 2007/08 with the assistance of OTIP funding continue to move us towards our goal of increasing the amount and quality of A-class seed for the Pli NE low, Pli TO low, and Fdi NE low seed planning units.

5.1.8 Eagle Rock Seed Orchards (Tolko Industries)

Greg Pieper

Tolko Industries manages five seed orchards for the Thompson Okanagan region. There are two older orchards and three younger orchards.

We have an older Sx seed orchard soon to be phased out, as well as an older Pli orchard also entering its final time. We established low and high Thompson Okanagan spruce orchards in 2003 and a high-elevation Thompson Okanagan lodgepole pine orchard in 2003 through SelectSeed funding.

SPU16 Thompson Okanagan Pli High Orchards 310 (Tolko)and 339 (SelectSeed) Project 1601

- 8.8 hl collected from Orchard 339 for 2,016 grams with a GW of 19 (SelectSeed/Tolko).
- 22 hl collected from Orchard 310 for 4,523 grams with a GW of 10.
- 10 liters of pollen (collected in 2006) was applied to Orchard 339 in three applications using spritzers.
- 12 litres of pollen were collected from Orchard 310 for SMP application next year in Orchard 339.
- Leaders and branches were clipped to enhance future cone sites and keep branches more accessible in SelectSeed Orchard 339.
- *Leptoglossus* required four sprays for control in both Orchard 339 and Orchard 310.
- A successful application of 2% Sevin was applied in 310 for mountain pine beetle control.
- Pine pitch moths were removed by hand from the base of the trees.
- Orchards were mowed, sprayed and fertilized to maintain optimum health.
- Pocket gophers were controlled with treated bait.
- Foliar samples were collected and sent for analysis.
- Several passes with a helicopter were used to SMP the pine crops for next year.

SPU28 Thompson Okanagan Sx High and Low Orchard 303 (Tolko) and Orchards 342 and 343 (SelectSeed)
Project 2801

- In the young SelectSeed orchards (342 and 343) all trees were topped to keep ramets short and accessible and increase potential cone sites.
- Basal branches were clipped to facilitate herbicide spraying.
- Pollen surveys were completed and pollen was collected for use in future years.
- Pollen collection from Orchard 303 resulted in stored pollen for future use.
- 500 trees with low breeding values were rogued in Orchard 303, put in bins and used for Salmon River bank stabilization.
- Pest Monitoring was done on a weekly basis for *Leptoglossus*, *Dioryctria* and Adelgids. Adelgid populations were low and spraying was not required.
- Weevils were clipped from the SelectSeed orchards and disposed of.
- Pocket gophers were controlled using treated bait.
- Foliar samples were collected and sent to the lab for analysis.

Plate 23. Corry Stuart doing some pruning.

5.1.9 Prince George Tree Improvement Station

Rita Wagner

SPU 1203, 1802, 1702, 4057E34

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).

Five Operational Tree Improvement projects were conducted at the Prince George Tree Improvement Station (PGTIS) in 2007-2008.

Phenology surveys were completed to keep track of receptivity periods, which can vary considerably from year to year. As well, some extremely late flowering clones received SMP. Pollen flight was monitored both inside and outside the orchards. No outside pollen flight occurred, due to the mountain pine beetle's efficiency in large-scale pine eradication.

October foliar samples were taken for nutrient analysis. Fertilizer applications were increased to ensure maximum ramet health.

Significant damage to branches was caused by pesticide equipment, large hydraulic lifts, and heavy wet snow. Extensive tree maintenance was carried out to ensure that damaged trees will not serve as beetle attractants.

Surveys for western gall rust, lophodermella needle cast, root collar weevil, and various other insects were completed. No increase in root collar weevil activity was observed, thanks to the Sevin application. Root collar weevil activity can increase dramatically in the wake of mountain pine beetle (MPB) flights.

Detailed weekly tree-by-tree bark beetle surveys were carried out to pinpoint the correct date for pesticide application. Lindgren traps were set up throughout the site to monitor MPB flights. Mountain pine beetle presence at PGTIS has decreased drastically in 2007. However, secondary bark beetle build-up (*Ips, Pityogenes, Pityophthorus*) prior to and after the local mountain pine beetle flights necessitated the application of Sevin XLR in early July. Thanks to our custom-made, tractor-mounted application equipment, designed and built by our machine operator, we were able to reach a spray height of up to 12-14 ft. The sprayer was adjusted to include large-diameter branches. This application method resulted in considerable savings over the 2006 emergency application, which was carried out by a contractor with a 40-man backpack spray crew. As in the previous year, secondary bark beetle attacks required some tree removal in orchards 223 and 228.

Plate 24. Sevin Application in Willow-Bowron #220 Orchard.

2007 yielded the largest cone crop at PGTIS since the establishment of the first lodgepole pine seed orchard in 1974. The three provenance orchards yielded 88.98 kg of seed, the equivalent of approximately 16.85 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 to 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 BC. The clone banks are a central 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.

Clone bank fill-planting was carried out to replace dead ramets.

The remaining 2006 grafts plus 150 older grafts in the holding area were weeded, watered, fertilized, pruned, and monitored and treated for insects and disease. Frequent rototilling and hand weeding were required due to the wet weather.

Similar management activities were carried out in the 12,000-tree clone banks. Irrigation maintenance, fertilization, mowing, and weeding/brushing were required to ensure ramet survival. Extensive headland mowing was necessary to control weeds and prevent brush from moving in.

Foliar sampling was carried out. Insect (root collar weevil and spruce leader weevil) and disease monitoring was carried out to ensure ramet health. Ramet labelling was continued, replacing old, damaged tags and labelling newly planted trees with more permanent tags.

5.1.10 Skimikin Seed Orchards

Keith Cox

Summary for Projects 404, 411, 501, 1503, 3502, 4002, 4057E13, and 4201

Work was funded in eight of the seed orchards, in the research plantations, and to help deal with the mountain pine beetle infestation at Skimikin in 2007.

The West Kootenay (Nelson Mid and High) spruce orchards had 100 replacement grafts made in the spring and another 452 grafts were maintained in the holding area. The orchards were surveyed for insects and disease, rust brooms (*Chrysomyxa arctostaphyli*) were removed, and rodents were baited. The orchards were also sprayed for spruce budworm, mainly to protect the smaller trees. The bigger trees in both orchards were drought stressed until the end of June for cone induction.

The white pine orchard (609) was monitored extensively because of the mountain pine beetle, the conifer seed bug, and the pine cone moth, resulting in 71 surveys being done over the season. The orchard was sprayed for cone moth and mountain pine beetle. The 66.6 hl crop yielded 41.156 kg of seed.

In the three spruce orchards for the Bulkley Valley Low, the crop was sprayed for spruce cone maggot. In Orchard 207, a total of 416 trees were injected with the flowering hormone GA in May and drought stressed until the end of June. Repairs were done where the ground had settled from previous roguing. Another 136 replacement grafts were made, and 448 grafts were maintained in the holding area. The crop was 98 hl and yielded 127.357 kg of seed.

In the spruce orchard for the Peace River mid-elevation zone (212), the 2,725 trees were monitored for insects, disease, and rodents. In May, 1,322 trees were injected with GA and drought stressed, and another 861 smaller trees were drought stressed only. A total of 21 weevil-damaged tops were removed. The young orchard was baited extensively for rodents, and it was sprayed for spruce budworm.

In Orchard 206, for the Prince George High Sx SPU, the final levelling was done where 630 trees had been rogued in 2005. The trees were monitored for insects and disease, rust brooms were removed, and rodents were baited. All 346 trees were injected with GA and drought stressed until the end of June.

The on-site research plantations were also monitored for insects and disease and baited for rodents, and the two newly established spruce plantations were sprayed for weeds and spruce budworm. Approximately 2,500 white pine seedlings were also planted as part of a rust-resistance screening trial, and a site was prepared for more to be planted in 2008. The *Ribes* garden was maintained, and white pine seedlings were inoculated in September. Eight plantations were removed in the fall by pulling them out with an excavator. The trees were shipped to the Salmon River for bank stabilization.

Extensive monitoring was done for mountain pine beetle; Orchards 345 (Py) and 609 (Pw) were sprayed with Sevin; and to reduce the fire hazard, two areas were cleaned up by hand-piling and burning or mulching.

5.1.11 Kettle River Seed Orchard Company

Rick Hansinger

Pollination And Pest Management in Central Plateau Orchard 238 – Lodgepole Pine (SPU 1804)

Objectives

- Collect and store 2 litres of pollen for SMP in Pli Orchard 238 to increase the production of Class A seed to 500,000 plantables by summer 2008.
- Minimize filled seed losses from predation by *Leptoglossus* through pesticide applications.

Results

- Two litres of pollen was purchased from Vernon Seed Orchard Company. Approximately one litre of pollen was applied to approximately 2,000 ramets producing female conelets from May 22 to June 2, 2007, the receptivity period. One litre of the remaining pollen was retained in cold storage for SMP use in spring 2008.
- Developing cones were inspected for the presence of *Leptoglossus*, none were observed and therefore the option to apply pesticides was not required.

Output and Deliverables

- A conelet survey has been conducted to determine the BV contribution to the GW of the seedlot. The numbers of cones available for harvest have been tabulated but information regarding total hl, seedset and seed quantity will only be available following the 2008 harvest and seed processing activity.

Pollination and Pest Management in Prince George Orchard 237 – Lodgepole Pine (SPU 1210)

Objectives

- Collect and store 2.5 litres of pollen for SMP in Pli Orchard 237 to increase the production of Class A seed to 300,000 plantables by summer 2008.
- Minimize filled seed losses from predation by *Leptoglossus* through pesticide applications.

Results

- 2.5 litres of pollen was purchased from Vernon Seed Orchard Company. Approximately 1.5 litres of pollen was applied to approximately 1,450 ramets producing female conelets from May 22 to June 1, 2007, the receptivity period. One litre of the remaining pollen was retained in cold storage for SMP use in spring 2008.
- Developing cones were inspected for the presence of *Leptoglossus*, none were observed and therefore the option to apply pesticides was not required.

Output and Deliverables

- A conelet survey has been conducted to determine the BV contribution to the GW of the seedlot. The numbers of cones available for harvest have been tabulated but information regarding total hl., seedset and seed quantity will only be available following the 2008 harvest and seed processing activity.

5.1.12 Saanich Seed Orchard

Carolyn Lohr

The following Operational Tree Improvement Projects (OTIP) were approved for the 2007/2008 year at Saanich Seed Orchard.

Establishment and Monitoring of Regional Pollen Monitors on the Saanich Peninsula (SPU 0109)

Five, seven-day recorders were set up at locations throughout the Saanich Peninsula. The objective of this project was to provide consistent estimates of local pollen contamination to Joe Webber (ProSeed Consulting) for further analysis, and ultimately to coastal Douglas-fir seed producers on the Saanich Peninsula, in order for them to determine the effect on the genetic worth of Fdc seedlots produced. The pollen flight monitoring period is from March 20th to April 30th (six weeks). Charts were changed weekly. Two fields per day per chart were counted and averaged, and counts were forwarded to Joe Webber at ProSeed Consulting.

Funds were used to obtain new clock works, suitable chart material, and printing of seven-day recording charts.

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

Orchard 181 is a 95-clone, 1,000-ramet, first-generation SM, mid-elevation, Fdc orchard. Fdc breeders planted progeny test plots in spring of 2005. Initial rogue of the orchard will be in fall 2008/spring 2009 (three-year data). The final composition of Orchard 181 will be 25-30 clones from both forward and backward selections.

Management operations included surveys for the health and vigour of the ramets as well as graft maintenance, rootstock pruning, mortality replacement, fertilizer and irrigation application, foliar nutrient sampling, and pest surveys for foliar and cones. *Contarinia* levels were low in 2007 — no treatments were applied.

Crop management included phenological and bud surveys, pollen collection, and SMP. Production for 2007 was 16.4 hl of cones and 6.812 kg of seed.

Pest Management in High-elevation Western Hemlock Orchard 196 (SPU 2403)

Orchard 196 consists of 26 clones and 243 ramets. The mean BV of this orchard is 10.

SPU 2403 covers pest management activities for cone and foliar insects in Hw orchards to retain the health and vigour of ramets. Insect surveys were conducted weekly by orchard staff, and after consultation with MFR pest management, chemical applications were deemed unnecessary. Active populations of *Syrphid* fly larvae and other natural predators kept Hemlock adelgid populations under control for the 2007 growing season.

Plate 25. Hemlock adelgid *Syrphid* larvae.

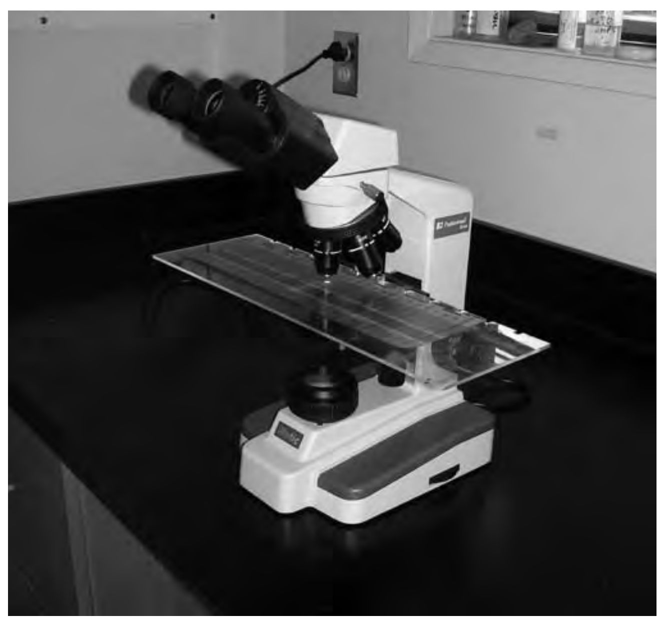


Plate 26. Viewing pollen slides at Saanich Seed Orchard.

Plate 27. Bruce MacPherson and seven-day pollen recorder.

5.1.13 Sorrento Seed Orchards

Hilary Graham

Sorrento Seed Orchard manages two large lodgepole pine orchards (BV 240 and CP 241) established in 2003 in partnership with SelectSeed Company. These orchards will supply seed for the Central Plateau (CP) low-elevation and the Bulkley Valley (BV) low-elevation seed planning units.

In 2007/08 OTIP funding was approved to maximize potential seed yield through pollen application (SMP) and protecting the crops from insect damage. These young orchards produce very little pollen, and SMP is required for adequate fertilization. We purchased pollen from the Vernon Seed Orchard Company where mature CP and BV orchards are established and applied it four times to all receptive flowers during the pollination period.

We monitored for cone and seed pests weekly from mid-May to September to determine the need and timing for control measures. Because we did not observe *Leptoglossus* seed bug until the time of cone harvest, spraying was not necessary.

Cones harvested in the BV orchard yielded 0.923 kg of seed, or 184,000 plantables in 2007. In the CP orchard, the 2007 harvest yielded 0.662 kg of seed or 132,000 plantables.

Plate 28. Sorrento Seed Orchards and Nurseries overlooking Shuswap Lake.

Early seed production in these young orchards directly supports the FGC's goals by making more genetically improved seed available for use in BC's forests.

5.2 Technical Support Programs

5.2.1 Cone and Seed Pest Management – Interior Operations

Robb Bennett

This project covers operational expenses for the Interior Seed Pest Management Biologist's activities, including all expenses associated with lab, field, and office work. Included in this project are wages for auxiliary technical support (as needed) to assist with operational pest management trials, data analysis, and development of new operational techniques. The 2007/08 fiscal year was the first full year of Jim Corrigan's tenure as the Interior Pest Management Biologist.

Between 1 April 2007 and 31 March 2008, the Interior Seed Pest Management Biologist provided the following services:

1. Performed 42 site visits, pest surveys and identifications, and damage predictions and assessments.
2. Delivered 46 written pest status reports, position papers and/or backgrounders for colleagues and superiors inside the Ministry of Forests and Range and for partners outside MFR.
3. Prepared ~20 other extension recommendations, pest identifications, responses to requests for information, and other transfers of technology.
4. Dealt with ~20 requests for information from members of the public.

Work continued on in-house and collaborative development of protocols for seed bugs, seed wasps, cone worms, mountain pine beetle, and other insects of importance to interior cone and seed production. In summary, the Interior Pest Management Biologist accomplished the following:

1. Initiated, or collaborated with university, government, and other research personnel on various pest management projects in the field, including pesticide injection trials, preparation of field guides, monitoring of saw fly pests in Douglas-fir pollen, winter moth monitoring, adelgid biocontrol, Chylisa pitch fly monitoring in lodgepole pine, and timing of spring emergence of cone midges and seed wasps.
2. Organized the 2007 mountain pine beetle risk assessment and management for interior seed orchards.
3. Organized installation of "HOBO" temperature and day-degree recording hardware and software at all interior orchard sites.

As well as providing training for orchard technicians, the Interior Pest Management Biologist provided the following training and educational experiences:

1. Delivered six professional presentations for colleagues.
2. Actively participated in 17 meetings with professional colleagues in the MFR, FGC (and its subcommittees), Entomological Society of British Columbia, and other groups.
3. Made numerous "tail-gate" type extension presentations to operational personnel.

The following publication resulted from this project:

Corrigan, J., Cox, K., Graham, H., Murphy, J., Nicholson, G., Pieper, G., Turner, K., Wagner, T. 2007. Confronting the Mountain Pine Beetle in the Interior Seed Orchards in 2007. TIC*talk* 8(1): 19-23. http://www.fgcouncil.bc.ca/

5.2.2 Western Redcedar Pollen Monitoring, Saanich Peninsula Regional and Orchards

Joe Webber

SPU 0212 (2007)

The *Chief Forester's Standards for Seed Use* (CFS) in British Columbia has established the legal requirements for the use of tree seed on Crown land. For orchard seed lots, this includes effective population size (Ne) and genetic worth (GW). As well, where the risk of contamination exists, orchard managers must also include estimates of contamination.

On the coast, species at risk from contamination include Douglas-fir, western redcedar, and western hemlock. Previous monitoring of regional Sitka spruce pollen flight suggests that our current orchards are not at risk. Estimates of contamination for Douglas-fir are covered in a separate project. This report covers the third year of monitoring western redcedar pollen flight on the Saanich peninsula and includes monitoring in two Saanich peninsula orchards (Western Forest Products and TimberWest).

The ministry's seven-day pollen monitors were used at each of five locations on the Saanich peninsula. Ministry of Forest and Range, Tree Improvement Branch (Saanich Seed Orchard), erected the monitors and changed the charts weekly. We also monitored western redcedar pollen in Western Forest Products (WFP) Orchard 189 and TimberWest (TW) Orchard 140 at Mount Newton.

Two replicates were counted on each chart. The total number of pollen grains for the two replicates were averaged and then divided by 44 mm^2 (the area of the chart counted). This represented the daily pollen catch expressed as the number of pollen grains per mm^2 for a 24-hour period. Daily pollen catches were then summed over the monitoring period (six weeks) to determine pollen load for 2007. The monitoring period for the Saanich peninsula was February 13 to March 19, 2007. However, western redcedar pollen flight effectively stopped March 8, and from there on only red alder pollen was counted (data not shown).

Figure 7 shows the mean western redcedar pollen catch for five stations on the Saanich peninsula. Compared to the two previous years, the 2007 pollen load was about 107 (pollen grains/mm^2/day summed over the monitoring period) compared to 33 in 2006 and 118 in 2005 (Table 6). Daily pollen catch varied between orchard sites (Table 6) with the Agriculture Canada site producing the highest values and the Mount Newton site the lowest values for each of the three years.

The monitoring period at WFP was February 13 to March 13 and February 11 to March 13 at TW. The receptivity period for WFP Orchard 189 was February 20 to March 8, and at TW it was February 16 to March 5. Table 7 shows the pollen load values for each of the two orchard sites, including the pollen load values for a monitoring site at the edge of WFP property (reservoir). The seven-day monitor was placed adjacent to each of two WFP slide monitors. Pollen load values for the two monitoring techniques were 38 compared to 160 at the reservoir site and 55 compared to 137 in the orchard. These are substantial differences between pollen catches and may be explained by monitoring height (slides located at 2 m and monitors at 3 m). Also the seven-day monitors are protected from the weather (capped), whereas the slides are exposed to the weather.

To estimate the level of contamination in western redcedar orchards, we compare regional and orchard pollen loads for 7-day monitors only. Table 8 shows corresponding pollen loads for the receptivity period from the two orchard sites (WFP and TW) and for the mean regional counts for the same period. Percent contamination is expressed as the ratio of regional load to orchard load (x100). The 2007 estimate of contamination in WFP and TW orchard sites was 72.6 and 65.5%, respectively.

Conclusions

The magnitude and extent of western redcedar pollen on the Saanich peninsula was as great as for any coastal species monitored. However, since western redcedar pollen is among the smallest (30µ) of all local conifers, the error in counts will also be considerably higher than those for Douglas-fir, which is among the largest pollen grain of our local conifers (95µ). A second difficulty in counting western redcedar pollen is its size and form. It is very similar to red alder pollen. Western redcedar pollen is about 20 to 30 µ in diameter, with some warty structures (orbicules) on the excine. At x100 magnification, it is possible to identify redcedar pollen, but it is very difficult to separate it from red alder pollen. Red alder is slightly smaller (20 to 25 µ in diameter) with pores. It looks very similar to redcedar at x100 magnification but with smaller orbicules. Positively

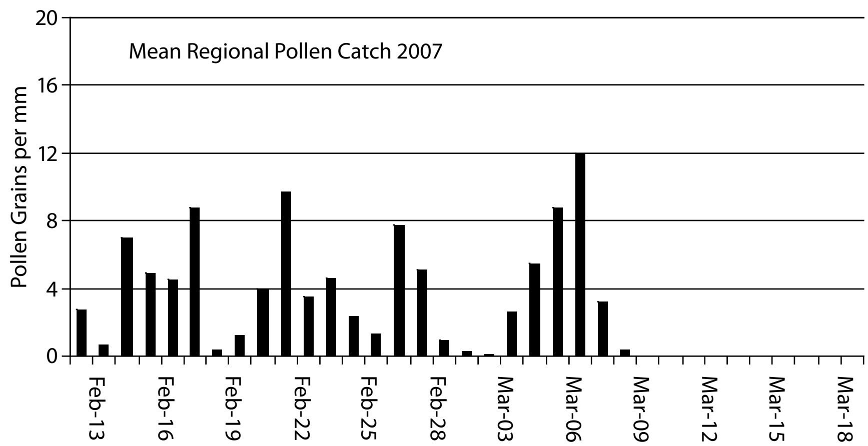


Figure 7. Mean daily western redcedar pollen catch (pollen grains/mm^2) for five regional Saanich peninsula sites.

Orchard Site	6 Week Pollen Load Slides	7 Day
WFP Reservoir (monitor 4)	38	160
WFP Orchard 189 (monitor 8)	55	137
TW Orchard 140	na	123

Table 7. Total pollen load (sum of daily pollen capture-grains/mm^2 over the six-week monitoring period in WFP and TW orchards) 2007.

Monitoring Location	Pollen Load Saanich Peninsula 2005	2006	2007
Puckle Road	148.1	54.8	118.0
Saanich Pen Hospital	113.3	18.9	107.6
Agriculture Canada	155.4	65.4	189.9
Stelly's X Road	99.2	15.4	70.9
Mount Newton	75.8	12.1	47.8
Mean All Stations	**118.5**	**33.3**	**106.8**

Table 6. Total pollen load (sum of daily pollen capture-grains/mm^2 over the monitoring period on the Saanich peninsula) for 2005, 2006 and 2007.

Orchard Site	Receptivity Pollen Load WFP	TW
PL Orchard	100.3	103.1
PL Regional	72.8	67.5
% Contamination	72.6	65.5

Table 8. % contamination based on orchard and regional pollen loads (PL) for the receptivity period at WFP and TW orchards, 2007.

distinguishing the two species at x400 is possible (glass slide and cover slip). However, distinguishing the two species at x400 on the Vaseline coated charts (no cover slip) is very difficult. In general, the two are separated on the basis of shape and phenology.

Given the magnitude of pollen counts for western redcedar at both the monitoring sites, it is likely that significant contamination exists. Based on data collected for seven-day monitors only, the corresponding contamination levels for 2007 at WFP and TW was 72.6 and 65.5%, respectively.

5.2.3 Pilot-Scale Operational Application of Yellow-cedar Seed Production across Climatically Contrasting Sites using Methods Developed under Previous OTIP Projects and Existing Clonal Trials

Oldrich Hak and John Russell

SPU 1118

Yellow-cedar seed production in natural stands can be minimal and sporadic; consequently, seed is in short supply for reforestation. Seed orchards were established at low elevations with the idea that the influence of warmer climates would promote earlier and increased quality cone production. To the contrary, seed orchards produced lower quantities of viable seed than wild stands.

Results from previous yellow-cedar studies under OTIP indicate that site location has a considerable influence on viable pollen and seed production. Sexual reproduction of yellow-cedar, which is adapted to cold climates and short growing seasons, may be negatively affected when grown at warmer, low elevations with longer growing seasons. Study results point out that the lack of filled seed at low-elevation sites, most likely because of both poor quality pollen and poor female flower and embryo development, may be a consequence of the prevailing climate. For example, significant differences in pollen viability were observed between populations characterized by distinct climatic conditions (Hak, SPU 1107). There was a significant trend in the acceleration of pollen development and in the corresponding reduction of pollen quality as the elevation of the testing site decreased. This reduction in pollen viability was also correlated to site mean monthly temperature. In addition, viable seed production at a low-elevation warm site was significantly lower than that at both a high-elevation site and a low-elevation cool microclimate site, even when the same high-quality pollen from a high-elevation site was used on these three sites (Hak, SPU 1106). This suggests that site conditions may also have a negative effect on normal female strobili development.

Orchard establishment at low-elevation cool micro sites may be a viable and economically feasible option for seed production. For example, the significant improvement in full seed production at the low-elevation site in Jordan River, when compared to the Mt. Newton low-elevation site, may result from the influence of a cooler microclimate (Hak, SPU 1106). The summer climate at the Jordan River site is influenced by a cool breeze and frequent cold fog coming from the nearby ocean. This cooling effect has a positive influence on healthy male cone development and possibly female cone development during the otherwise longer and warmer summers at low elevations on Vancouver Island.

These earlier studies provide valuable information on environmental conditions necessary for viable seed production. It is now appropriate to put this knowledge into practice at a pilot-scale operational level. The information obtained from this project will help determine if establishing yellow-cedar seed orchards at favourable low-elevation locations is a viable option for accessing genetic gain from the breeding program.

The project is being carried out at four climatically variable locations at Port McNeil and Jordan River. These areas were selected from existing Western Forest Products clonal trials, Phases 1-3, age 12 years and older. Establishing seed production trials using existing sexually mature tests enables us to induce trees 10 to 15 years earlier than if sites were established with new grafts. The sites were chosen based on operational accessibility while targeting climatic conditions conducive to viable seed production. Each of four existing replications per site was thinned (currently at 2 m x 2 m spacing) to approximately 100 trees. Larger trees were topped. These two treatments should help to mimic actual seed orchard conditions and enable viable seed production. There are a total of 400 test trees per site and 1,600 trees in total (16 ramets per clone).

In each of the two years following thinning, two replications per test site per year will be induced with GA3 according to protocols developed by an earlier OTIP project (Hak, SPU 1107). Pollen and female cone production will be surveyed in the spring following each of the two induction years, and a subset of clones will be tested for pollen viability across all four sites. Seed will be collected from the common 30 clones on each of the four test sites over the two years of treatments. Number of filled seed per cone will be assessed from a sample from each clone across all sites. In addition, seed viability will be assessed according to ISTA protocols.

5.2.4 Testing The Effects Of Interior Spruce Cone Collection Timing on Seed Yield and Quality

Gary Giampa

Objectives

- To test the effect of early collection on seed yield and seed quality.
- To produce a report that will help managers of interior Sx seed orchards determine the optimal time to collect their cone crops.

Activities

We selected ten clones in Kalamalka Sx orchard 304. Each clone was represented by three ramets in the orchard. We collected three cones per tree beginning in the first week of July and continued sampling on a weekly basis for a total of six weeks. The samples were stored in the cone sheds at Kalamalka to replicate operational cone storage conditions.

We processed the samples at Kalamalka. During cone processing, each sample was broken down into two portions — seed that was released by processing in a cone tumbler (tumble) and seed that had to be extracted by breaking the cone apart by hand (break). This was to decide if collection timing had any effect on the efficiency of extraction. We were able to determine that harvest timing had no effect on extraction efficiency.

The seed was x-rayed to determine seed yield (expressed as filled seed per cone) throughout the collection period. Figure 8 shows that collection timing had no significant effect on seed yield.

We then germination tested the extracted seed to determine the effect of harvest timing on seed quality. Figure 9 indicates that collecting cones operationally during the first two weeks of July would result in less than optimal germination results. However, germination increases to acceptable levels by the third week in July.

Results

- Collection timing does not appear to have any effect on the efficiency of seed extraction.
- Seed yield was not affected by collection timing.
- Germination rates reach acceptable levels by the third week in July.

Conclusion

Based on the results of this trial, we conclude that managers of interior seed orchards can begin operational harvest of Sx cone crops as early as the third week in July in an average year.

Credits

We would like to thank the following people for their assistance with this trial:

- Faye Klassen, Karen Meggait, Nancy Swanson, Petra Nielsen and Penny Major. Seed extraction and cone collection.
- Randy Armitage and Chris Walsh for getting the growth chambers running.
- Dave Kolotelo for technical advice and germination supplies.
- Ward Strong for his help with statistics

	Average FSPC tumble	Average FSPC break	Average FSPC total
week 1	60.8	2.6	63.4
week 2	67.8	2.9	70.7
week 3	70.7	2.8	73.5
week 4	58.7	3.2	61.9
week 5	61.7	3.6	65.3
week 6	55.6	4.8	60.4

Table 9. SPU 0413

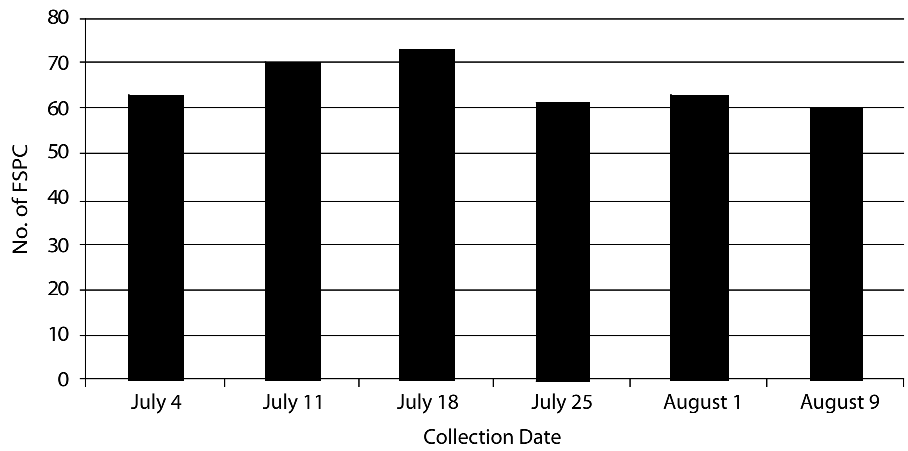


Figure 8. FSPC by collection time.

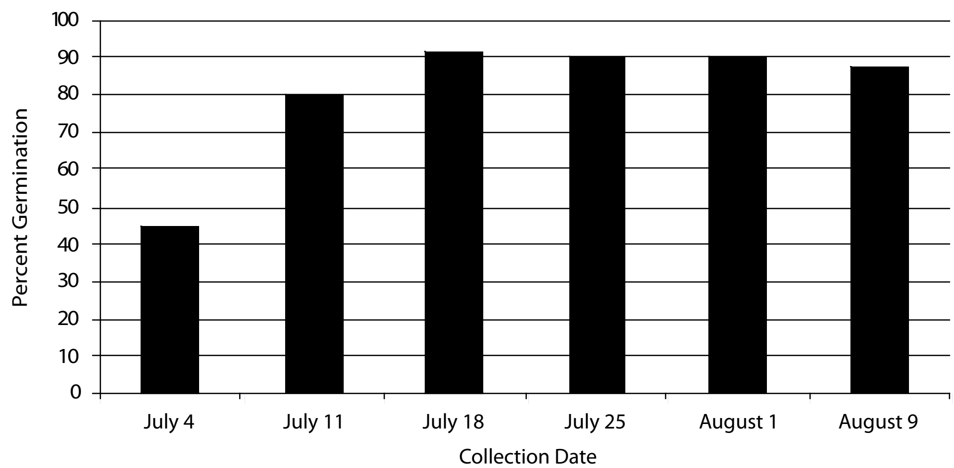


Figure 9. Germination rate by time of harvest.

5.2.5 Testing the Effects of Upgraded Irrigation Delivery Systems in an Interior Spruce Seed Orchard, an Interior Lodgepole Pine Seed Orchard and a Western Larch Seed Orchard.

Gary Giampa

Objectives

- To determine how the broadcast delivery irrigation system impacts orchard performance.
- To compare the portion of each orchard treated with the upgraded system to the portion of each orchard that continues to be watered by the old drip system.
- To make the results of this study available to other seed orchard managers.

Activities

In the summer of 2004, we installed broadcast irrigation systems in a portion of Sx Orchard 305 and Pli Orchard 307 and chose permanent sample trees in each orchard (82 trees in Orchard 305 and 80 trees in Orchard 307). We converted five rows in Lw orchard 332 to the microsprinkler irrigation system in 2006 and selected 80 permanent sample trees.

The sample trees were chosen in pairs based on establishment date — one tree in the area irrigated with the micro sprinklers and the other in the drip-irrigated area.

Three major branches on each sample tree were chosen at random and marked with metal tags. Shoot elongation was measured annually on each sample branch. Stem diameter below all branches was also measured annually on each sample tree.

In the summer of 2007, we repeated these measurements. We surveyed flower production in the orchards and collected cones from the sample trees. We have extracted seed from these cones and compared seed production. We also collected foliar samples in the orchards and analysed nutrient uptake.

Results

The new irrigation regime has been in effect for four growing seasons in Orchards 305 and 307 and one growing season in Orchard 332. We are noticing an impact on ramet performance. The table below illustrates the differences in annual shoot growth.

Seed was extracted from the cone samples and X-rayed. In 2007, Pli and Lw samples from the broadcast irrigated sections had better seed set than the samples taken from the drip-irrigated areas. In 2006, the Sx ramets in the area irrigated with micro sprinklers had better seed set than ramets in the drip-irrigated section. However, in 2007 Sx seed set was better in the drip-irrigated section.

Nutrient uptake is another area where broadcast irrigation seemed to have an effect. When the foliar samples were processed, higher levels of aluminium, boron, calcium, manganese, nitrogen and phosphorus were observed in the samples collected from the portions of the orchards watered with the broadcast delivery system.

Output and Deliverables

Although this trial is only in its fourth season, it is starting to appear that the different irrigation delivery systems do have an impact on ramet performance.

We need to continue monitoring the permanent sample trees on an annual basis to confirm our data. We hope these orchards will produce good cone crops in 2008 so that we can collect more flowering data. We will collect a set of comprehensive baseline observations over the course of several growing seasons. Comparing these results will allow us to determine the effectiveness of broadcast delivery and make recommendations to other orchard managers who are considering irrigation system upgrades.

	average shoot growth 2004	**average shoot growth 2005**	**average shoot growth 2006**	**average shoot growth 2007**
#307 micro-sprinklers	16	18.8	18.1	14.8
#307 drip	17	15.1	15.9	13.3
difference	-1	3.7	2.2	1.5
#305 micro-sprinklers	14	16	16	13.2
#305 drip	13	13.4	12.3	8.9
difference	1	2.6	3.7	4.3
#332 micro-sprinklers				15.4
#332 drip				14.1
difference				1.3

Table 10. SPU 0412 average shoot growth comparison (cm).

Irrigation Treatment	average # filled seed per cone 2005	average # filled seed per cone 2006	average # filled seed per cone 2007
307 drip	11.2	13.8	13.2
307 micro sprinklers	13.7	13.4	16
305 drip	No crop	56.8	80.4
305 micro sprinklers	No crop	65.8	71.1
332 drip	No Data	No Data	57.7
332 micro sprinklers	No Data	No Data	62.6

Table 11. SPU 0412 average #FSPC comparison.

5.2.6 Crown Pruning Technique for North Okanagan Lodgepole Pine Seed Orchards

Chris Walsh
Prepared by Joe Webber

Project SPU 0720

Most north Okanagan lodgepole pine seed orchards are now at the age when crown management activities are required. Lodgepole pine Seed Orchard 230 at Kalamalka was chosen for this pruning trial because the tree age (12-15 years) and height (4-6 m) were such that crown management was required.

This project is testing three levels of height control: control (no topping), moderate (3.5-4.0 m) and severe (2.5-3.0 m), in addition to two levels of lateral pruning: tractor (remove only laterals extending into the row) and picker (remove extending and upper crown laterals to improve crown access). Tree response to crown pruning treatments was measured initially (2004) and subsequently in 2005, 2006 and 2007.

Results

A complete analysis of all data is available in the final report for OTIP SPU 0720. This report summarizes the data from 2004 to 2007 for cone counts (whole tree and branch counts) and seed yields (high and low crown with and without insect protection).

Cone Counts

Figures 10 and 11 show the mean whole-tree seed cone counts for each of the three pruning and lateral pruning sub-blocks. Figure 10 shows cone numbers by eye estimates for 2004-2006. Cone counts dropped (Figure 10) the first year after pruning (removed existing first-year cones in 2004) and substantially increased in 2006. Note the 2006 cones were already formed in the remaining branches after pruning so we do not expect pruning regimes to dramatically affect these counts until 2007. However, it is interesting to observe that cone counts for the moderate pruning level is the same as the control block, and as expected, cone counts in the severe block are substantially lower.

In 2007, cone count numbers were calculated by weighing all harvested cones and then comparing that figure to the weight of a known number (30) of cones. Figure 16 shows this data for each of the three top-pruning treatments. Cones harvested in 2007 were initiated and differentiated in 2005 (the year following pruning treatments), and the response clearly shows that cone production in both the moderate and severe blocks equaled or surpassed cone production in the control block.

The magnitude of the standard error bars in Figure

11 suggest there may not be significant differences in cone production for all pruning treatments, but the real importance is access for cone harvest. Figure 12 shows the time (minutes) to pick 1,000 cones. Cone harvest was faster in the two topped blocks and substantially faster in the lateral pruned trees. This was not what we expected because pruning treatment in the picker-access trees opened the crown and presumably provided easier access to the crop.

Figures 10 and 11 are shown separately because sampling methods were different. There was a substantial increase in cone numbers for 2007, which may be attributed to a better method for determining cone numbers (cone weight) and to more cones initiated in 2005. Figure 13 shows first-year cone numbers for two major whorl branches in each of the three top-pruning treatments. Based on the first-year cone counts for 2006, second-year cone counts for 2007 would be about twice that of 2006.

Seed Yields

Figures 14 and 15 show the mean total seed per cone (TSPC) and filled seed per cone (FSPC) by the three top-pruning blocks. There was a decline in both TSPC and FSPC the year following pruning (2005), but these increased slightly in 2006 and 2007. Although we would not expect to see substantial differences in cone yields from pruning treatments, there is a small, positive indication that yields in the moderate and severe pruning blocks were higher in 2006 and 2007. This result may indicate that re-invigorating the top pruning crowns improved seed set.

Figure 16 shows the FSPC data for the three top-pruning by two lateral-pruning blocks. Again, FSPC values were slightly better in the top-pruning blocks and slightly better in the tractor-pruned treatments of the severe-topping block.

Finally, Figure 17 shows the differences in seed cone yields by insect protection for each of the three topping blocks for the three years following treatments. Although seed loss to insect predation is not necessarily associated with top-pruning treatments, this data clearly shows that seed losses in 2006 were in the order of 10 FSPC. In the two Kalamalka lodgepole pine seed orchards, insect damage in 2006 was among the highest recorded.

Conclusions

Three years after top and lateral pruning treatments were applied, cone numbers and seed yields were equal to or slightly greater for the treated blocks than for the control block. While seed yields did not improve substantially, time to pick the crop was substantially faster. This was a direct result of cones being more accessible (lower). It is also important to note that the lateral pruning for cone access (picker) did not improve either seed yields or picking times. Both of these results suggest that cone response in lodgepole pine is generally on the surface (closest to light) of the crown and simply topping trees and pruning back lateral branch extending into the row is all that is necessary for trees that exceed the optimum height for efficient management. Observations for 2008 and 2009 are still required to substantiate this conclusion.

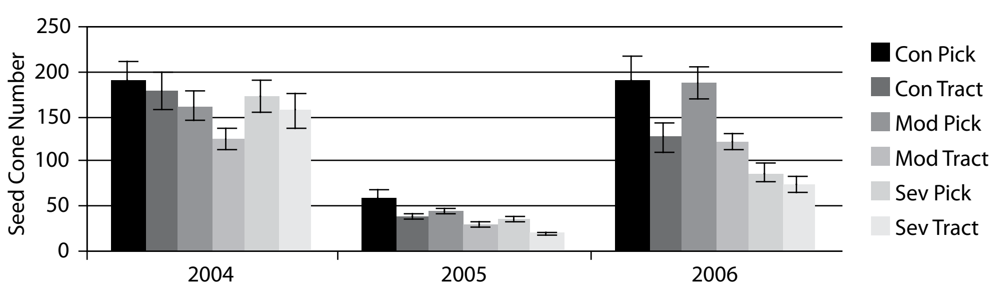


Figure 10. Whole-tree cone estimates (by eye) for each of three top pruning treatments and two lateral pruning treatments for the year prior to pruning (2004) and the two years following (2005 and 2006) – Kalamaka 230.

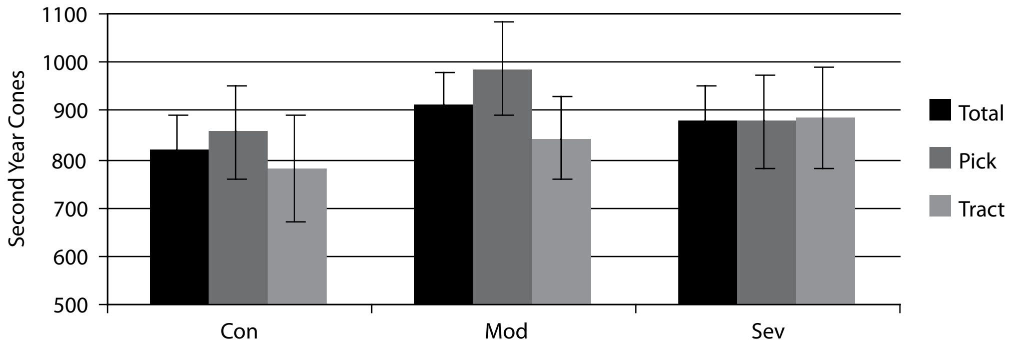


Figure 11. Whole-tree cone counts (based on cone weight) for three top pruning and two lateral pruning treatments for 2007 – Kalamalka 230.

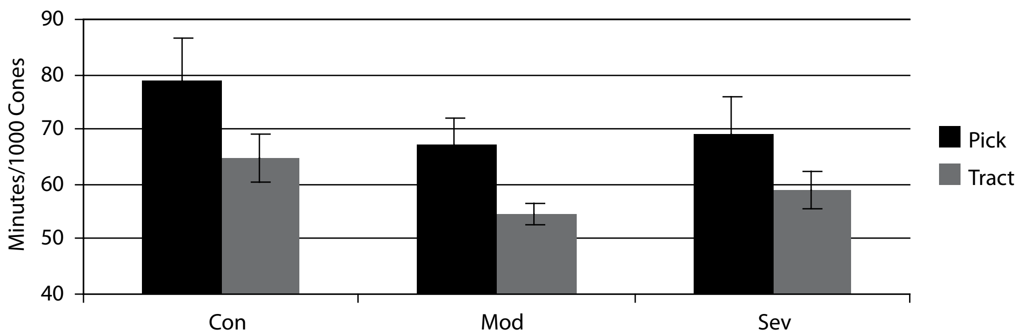


Figure 12. Cone harvest times (min/1000 cones) for each of three top pruning and two lateral pruning treatments in 2007 – Kalamalka 230.

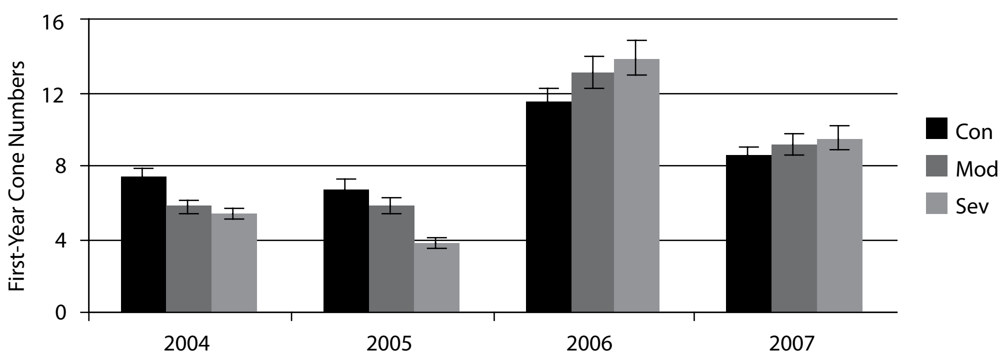


Figure 13. Mean first-year cone counts (±standard error) for two major whorl branches in each of three top pruning treatments – Kalamalka 230.

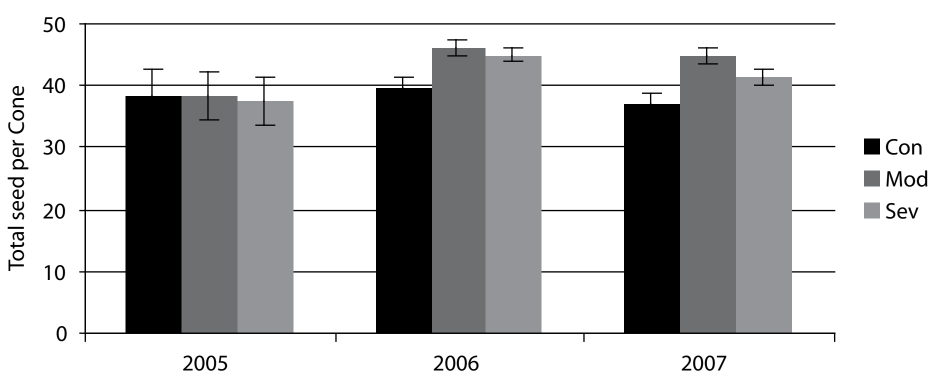


Figure 14. Mean TSPC (±standard error) for each of three top pruning treatments for each of three years following treatments – Kalamalka 230.

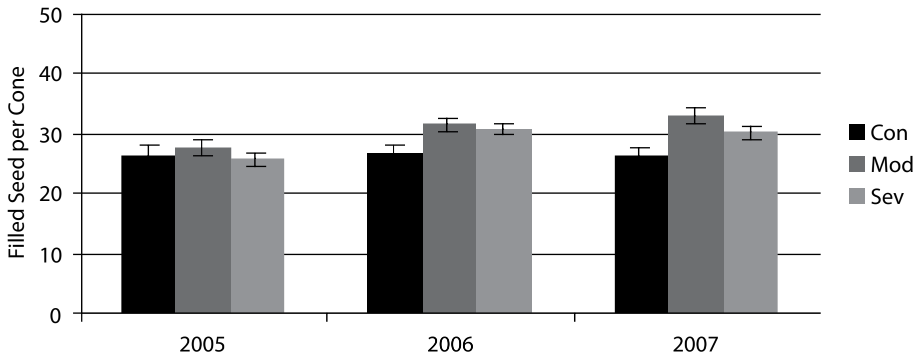


Figure 15. Mean FSPC (±standard error) for each of three top pruning treatments for each of three years following treatments – Kalamalka 230.

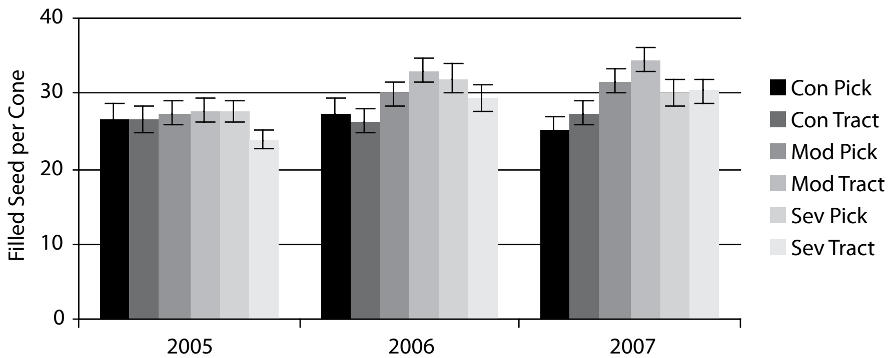


Figure 16. Mean FSPC (±standard error) for each of three top and two lateral pruning treatments for each of three years following treatments – Kalamalka 230.

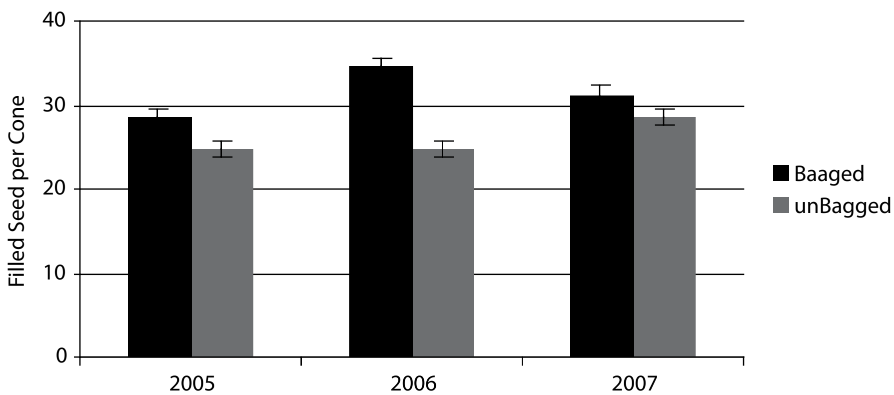


Figure 17. Mean FSPC (±standard error) for insect protected cones (bagged) compared to cones not protected (unbagged) for three top pruning treatments in each of three years following treatments – Kalamalka 230.

5.2.7 Increasing Quality, Genetic Gain, and Quantity of Yellow-cedar Cuttings

Mark Griffin, John Ogg, Craig Ferguson and John Russell

SPU 1113

Introduction

This project involves increasing the quantity and quality of high-value yellow cedar cuttings for the coastal program. Objectives include:

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

Highlights

Pruning of hedges occurred in early 2007, and fertilizing of both the soil-based and field-based container-planted hedges with 34-0-0, 19-18-18, and 12-51-0 continued throughout the growing season. The media for the greenhouse-grown container-planted donor plants contained APEX 16-5-11, augmented by weekly applications of hi-sol.

There was an existing inventory of some 8,210 donor plants. Analysis of the nine-year measurements was completed and, based on field performance, 27 clones were rogued from the main production greenhouse. This created space for the newer, genetically improved material and also increased the genetic worth of our greenhouse stock. Many of these rogued young clones were later added to the unimproved SSM hedge, and some 2,680 older hedge donors were removed completely from production.

Also based on the results on the nine-year height measurements, some clones were being bulked up to augment the hedge. The ones chosen were the top 28 clones from series 1 and 5 clones from series 3. In all, some 5,000 new cuttings were set.

In an effort to increase the rooting success of the clones in the hedge, some 2,520 cuttings were set to test their hedge rootability. A sampling of every clone from series 1 and 2 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.

5.2.8 Competitive Effects of Selfing and Outcross Pollen on MGR SMP Efficacy in White Pine

Joe Webber

SPU 0814

Long-term improvement of white pine blister rust resistance is through a combination of incorporating clones with a mechanism for slow canker growth (long-term) and by incorporating Dorena Major Gene Resistance (MGR) pollen through Supplemental Mass Pollination (SMP) (short-term). Since controlled crossing is not an operational option, SMP must be accomplished under open-pollinated conditions. Under these conditions, we do not know the efficacy of SMP in mature orchards where pollen production is large. Furthermore, white pine is known to be a good selfer. Under the conditions of a large orchard pollen load and a propensity to self, the short-term goal of improving white pine rust resistance with MGR pollen needs to be verified.

To determine the efficacy of MGR SMP in white pine, we created a series of control crosses (self only, MGR polymix only, and a 50/50 mix of self and MGR polymix) at CanFor's Sechelt white pine orchard 174. In addition to the control crosses, we completed two SMP treatments (self and MGR only) on separate ramets from each of ten clones. The complete pollination scheme is available in the final report for SPU 0814 (2007/08).

Patti Brown, CanFor seed orchards, Sechelt, completed all pollination treatments in 2007. In 2008, cones will be collected and hand extracted, and seed yields will be determined for each of the five pollination treatments. Finally, paternity analyses of the self and MGR SMP treatments, as well as the 50/50 self/MGR control crosses, will be completed.

5.2.9 Enhancing Lodgepole Pine Seed Set

Chris Walsh
Prepared by Joe Webber

SPU 0719

This report summarizes the data collected for 2007 on seed set in the upper and lower crown with and without insect protection. It also summarizes the data for protecting developing first-year cones as well. Because the pollination season of 2006 was hot and dry, crown cooling was activated and cones collected from three blocks were compared. Finally meteorological data for 2007 is summarized for each of the four important reproductive stages for lodgepole pine in Kalamalka Seed Orchard 307.

Insect Effects

Leptoglossus feeding will reduce the number of filled seed per cone (FSPC), and cones protected in their second year of development also have higher total seed per cone (TSPC). Because yields in protected cones have also dropped over the past few years, we suspect that *Leptoglossus* may begin feeding on first-year cones in late summer (after harvesting) and possibly continuing the following year (April) before insect bags are put on.

Figure 18 shows the seed yields (TSPC and FSPC) for cones protected in both years of development (year 1 and 2), cones protected in the second year of development only (year 2), and cones not protected in either year. Both TSPC and FSPC were highest in cones protected in year 2 only. Seed yields from cones protected in both years had fewer TSPC and FSPC although the differences were likely not significant. On average, insect damage in 2007 reduced seed yields by about four FSPC.

The effect of insect protection was also tested over three different cultural blocks previously used to determine the effect of watering regimes (irrigation and control) and crown cooling (mist applied during the period of pollination, May 15-31). Figure 19 shows the FSPC for each of the three blocks for cones protected (bagged) and unprotected (unbagged). The loss of seed from the control, irrigation blocks and mist blocks was about the same (4-5 FSPC). However, the actual number of seed from the mist block was about three FSPC higher (although this may not be significant).

The difference in seed yields from cones in the upper crown (high) and lower crown (low) is shown in Figure 20 for the control and mist blocks only. Cones from the lower crown had fewer FSPC lost, which suggests either that the control measures (spraying) were more effective or that insect damage is less in the lower crown (cooler?).

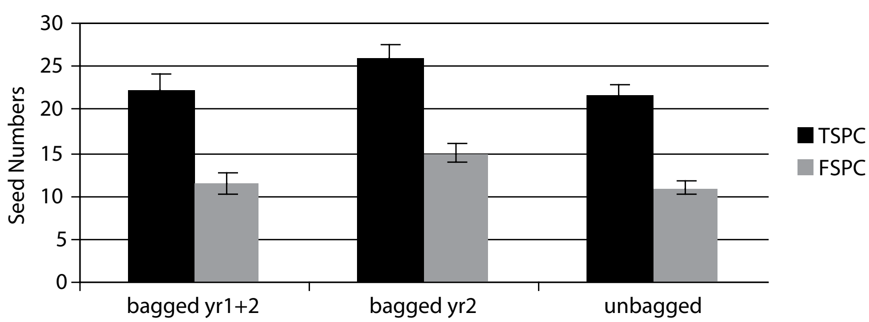


Figure 18. Mean (±standard error) TSPC and FSPC for cones protected from insect damage in year 1and 2 (bagged yr 1+2), year 2 (bagged yr2) and unprotected (unbagged) – Kalamalka Orchard 307.

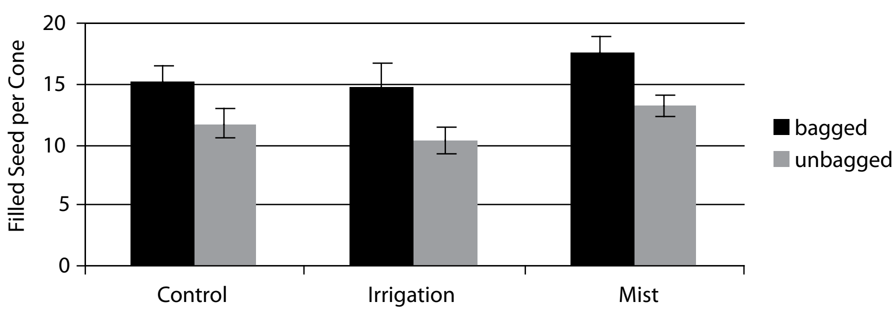


Figure 19. Mean (±standard error) FSPC for cones protected from insect damage in year 2 (bagged) and unprotected (unbagged) from three blocks – Kalamalka Orchard 307.

Meteorological Data

Temperature (Tsum) and vapour pressure deficit (VPDsum) sums are shown for the irrigation block only. Tables 12 to 15 show the meteorological data for four important periods of reproductive development in lodgepole pine. April to mid-May represents the period of rapid second-year cone development and pre-pollination development of the first-year cones. The last two weeks of May represent the period of flowering, pollination, pollen uptake and early pollen development (penetration of the nucellus). June represents the period of fertilization and early embryo development of the second-year cones, and September is the period of differentiation of first-year cones (although recent data on describing the period of seed cone differentiation suggests that it occurs much earlier).

Most notable about the pre-pollination (Table 12) and pollination period (Table 13) are the heat sums and precipitation. The pre-pollination period was second only to 2005 as the warmest since monitoring temperature began in 2000. It was also the driest — no recorded rainfall from mid-April to mid-May. This warm trend continued through the pollination period (May 15-May 31). In fact, heat sums recorded for this period were the highest recorded to date, again with the lowest precipitation.

It is also interesting to note that heat sums during June were wetter and lower than usual (June 2005 was the coolest and wettest). September 2007 was not unusually warm or dry.

Conclusions

Seed loss from *Leptoglossus* (three to four) was not as high as in previous years, most likely because June was so cool and wet. Seed yields from cones protected in both the first and second year were lower, but likely not significantly lower, than cones protected in year 2 only. Because cones were just past receptivity, it is possible that abrasion of the first-year cone could result in lower yields. Regardless, it would be useful to repeat bagging of first-year cones but wait until the end of June when the cones have hardened.

Seed yields from bagged cones in both the upper and lower crown of mist-treated trees (Figure 20) produced higher FSPC than their control counterparts. However, the magnitude of the error bars suggests that these differences may not be significant.

Further, the period of fertilization and early embryo development (June) was unusually cool and wet. We feel the effect of cooling may have its greatest effect on seed yields in June, but to date, exceptional hot dry weather has not occurred.

	2000	2001	2002	2003	2004	2005	2006	2007
Tsum	na	4740	3673	4400	5365	6480	4205	5474
Tsum>24	na	299	74	48	456	1009	186	697
T>24 (hrs)	na	12	3	2	18	39	7	27
VPDsum	na	518	503	414	547	629	559	677
VPDsum>2	na	39	45	28	67	130	49	133
VPD>2(hrs)	na	17	20	13	29	55	21	54
precipitation (mm)	na	16.9	13.9	73.4	60.4	47.8	49.0	0

Table 12. Heat sum, vapour pressure deficit and precipitation data for Kalamalka Seed Orchard 307 for the period of pre-pollination (mid April to mid May) – irrigation block only – 2000 to 2007.

	2000	2001	2002	2003	2004	2005	2006	2007
Tsum	3466	4100	3603	3771	3631	4156	3905	5068
Tsum>24	104	1515	304	48	578	1480	1148	1450
T>24 (hrs)	4	54	12	2	18	51	41	54
VPDsum	313	424	283	414	283	407	349	587
VPDsum>2	23	163	50	54	67	178	146	254
VPD>2(hrs)	10	56	22	22	29	58	49	100
precipitation (mm)	na	20.1	38.5	38.6	143.8	25.6	45.0	0.254

Table 13. Heat sum, vapour pressure deficit and precipitation data for Kalamalka Seed Orchard 307 for the period of pollination (May 15-31) – irrigation block only – 2000 to 2007.

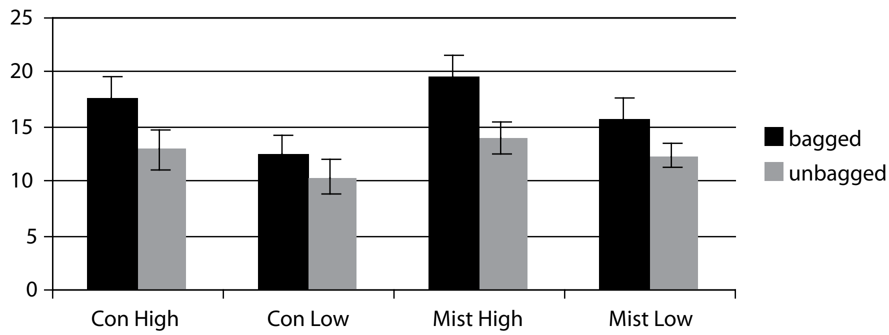


Figure 20. Mean FSPC (±standard error) for cones protected from insect damage in year 2 (bagged) and unprotected (unbagged) with values for two crown heights (upper and lower) in each of three cultural blocks – Kalamalka Orchard 307.

	2000	2001	2002	2003	2004	2005	2006	2007
Tsum	8257	7591	10061	9896	9895	7906	9612	8556
Tsum>24	2128	1495	5013	4443	4861	1116	3318	2689
T>24 (hrs)	79	56	179	161	172	42	116	98
VPDsum	701	630	1056	887	882	509	963	755
VPDsum>2	209	161	595	443	444	84	459	268
VPD>2(hrs)	78	63	202	161	154	35	143	96
precipitation (mm)	na	60.9	15.4	83.6	48.0	164.8	7.4	131.3

Table 14. Heat sum, vapour pressure deficit and precipitation data for Kalamalka Seed Orchard 307 for the period of fertilization and early embryo development (June) – irrigation block only – 2000 to 2007.

	2000	2001	2002	2003	2004	2005	2006	2007
Tsum	5240	7617	7102	7773	5811	6092	7613	7128
Tsum>24	328	1528	5014	1896	322	323	1955	1742
T>24 (hrs)	13	58	179	68	231	13	72	65
VPDsum	345	672	660	681	297	437	772	675
VPDsum>2	22	178	123	211	11	28	291	206
VPD>2(hrs)	10	72	47	75	5	13	103	79
precipitation (mm)	na	40.6	20.6	63.2	100.3	55.6	19.3	35.1

Table 15. Heat sum, vapour pressure deficit and precipitation data for Kalamalka Seed Orchard 307 for the period of seed cone differentiation (September) – irrigation block only – 2000 to 2007.

5.2.10 Long-term Storage Behaviour of Interior Spruce Families Collected Prematurely and at Natural Seed Release

Dave Kolotelo

SPU 0414
Objective

- To evaluate the germination effect of early collections of interior spruce after 20 years of storage.

This project made use of seed samples that were organized and collected by Clare Hewson in 1987 and stored at -20° C. The collections were made in 1987 from five clones at collection times ranging from July 24 to September 3 (or until natural seed release) resulting in 42 Family x Collection Date combinations. Germination tests were performed in 1988, 1991 and 1992, and the seed does not appear to have been disturbed since. These past results indicated that maximum germination was not consistently obtained at natural seed dispersal (maximum maturity), a result that conflicts with generally accepted seed biology principles. Although studies have indicated that cones can be collected prematurely, if properly after-ripened, the concern has always been with the seed-storage behaviour of this material.

The trial has practical implications as some orchardists want to collect some clones earlier due to work scheduling issues and the risk of seed loss by waiting until just before natural seed dispersal if many of the clones progress rapidly due to warm weather conditions. The results will provide information regarding the long-term (20 year) risk of collecting cones early from a sample of five clones.

The seed was retested in 2008 using the standard protocol of three weeks stratification with four replicates of 100 seeds. The results are presented graphically in Figure 21 and are in general agreement with Clare's past results that maximum germination is not achieved for all clones at natural seed release. There is significant clonal variability, with clones 100 and 107 achieving over 95% germination at all collection dates. The other three clones showed a reduction in germination over time, but the rate and pattern varied by specific clone.

The results are quite surprising and not easily explained. It isn't the first time this phenomenon was observed:

Plate 29. Clare Hewson

Edwards (1980) reported that white spruce seeds collected two to six weeks before natural seed fall produced the tallest and heaviest seedlings 20 weeks after germination. Mercier and Langlois (1992, 1993) showed reduced germination from some white spruce sources as degree days accumulated and that it seems preferable to collect them at this time because their germination rate is better and they maintain good viability after 15-month stocking. Other factors may also be contributing, as Caron et al (1990) showed that cone storage duration of mature white spruce seed could have a profound effect on germination, with two weeks of storage producing 62% germination, but with six weeks of cone storage the germination rose to 95%. Optimization of collection timing and post-collection handling can possibly increase the quality of seed orchard crops from the current 89% germination average, but a great deal of effort will need to be invested on an individual clone basis.

References

Caron, G.E., B.S.P. Wang, and H.O. Schooley. 1990. Effect of tree spacing, cone storage, and prechilling on germination of *Picea glauca* seed. Forestry Chronicle 66(4): 388-392.

Edwards, D.G.W. 1980. Maturity and quality of tree seeds – a state-of-the-art review. Seed Sci. & Technol. 8:625-657.

Mercier, S. and C-G Langlois. 1992. Indice de maturité et conservation en fonction de la période de récolte des semences d'épinette blanche du Québec. Can. J. For. Res. 22 :1516-1523.

Mercier, S. and C-G Langlois. 1993. Relationships between *Epilobium angustifolium* phenology and *Picea glauca* seed maturation. Forest Ecology and Management 59:115-125.

Date	CL21 DE	Germination Capacity (%) Clone 21	CL79 DE	Clone 79	CL 107 DE	Clone 107	CL 148DE	Clone 148	CL 100 DE	Clone 100
24-Jul	41	88	35	90	31	98	25	91	25	98
27-Jul	38	93	32	86	28	98	22	86	22	99
31-Jul	34	90	28	84	24	97	18	84	18	97
4-Aug	30	93	24	86	20	96	14	86	14	97
8-Aug	26	90	20	84	16	97	10	82	10	96
12-Aug	22	94	16	80	12	96	6	72	6	96
18-Aug	16	92	10	77	6	96	0	73	0	98
24-Aug	10	83	4	77	0	95				
28-Aug	6	85	0	76						
31-Aug	3	89								
3-Sep	0	87								

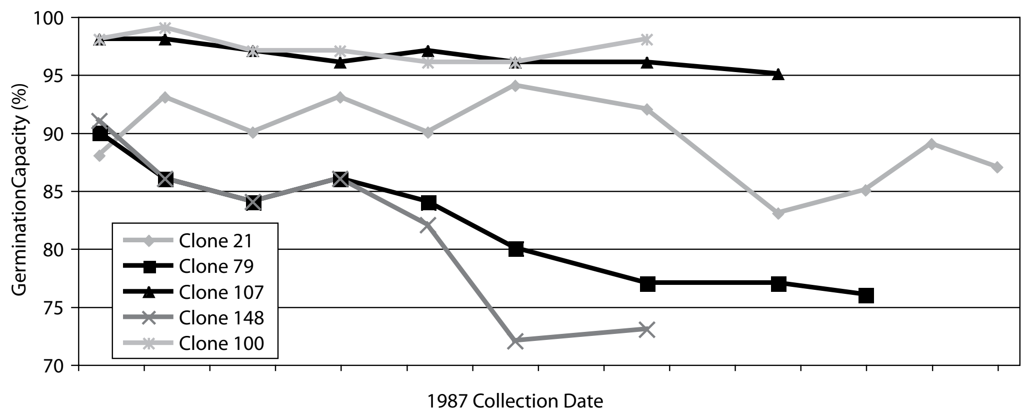


Figure 21. The relationship between collection date and germination capacity (%) for five clones of interior spruce (Sx).

5.2.11 Development of Pollen Quality Guidelines for Pollinations in Western Redcedar Seed Orchards.

Oldrich Hak

SPU 0213

Pollen collection, processing, and storage are required for control and supplemental mass pollinations in western redcedar seed orchards. Because of its small size and limited food reserves, western redcedar pollen is highly susceptible to damage from premature pollen collection, adverse temperature and humidity conditions during processing, and inadequate storage conditions. As a result, the viability of pollen varies widely between collections and after storage. The effect of various pollen viability levels on production of filled seed is unknown.

The objective of this study is to develop pollen quality guidelines that specify which pollen viability levels (i.e., percentage of pollen viability) are unacceptable for pollinations (i.e., when the percentage of filled seed is zero or very low).

The study is being conducted at the Cowichan Lake Research Station and at the Mt. Newton Seed Orchard in Saanichton (TimberWest). Approximately 50 pollen lots with various levels of viability, ranging from 0% to 90%, are being used to control pollinate female flowers during each of the three years of the study. The percentage of filled seed per cross will be calculated. Collected data will be used to create a graph showing the relationship between percentage of pollen germination and percentage of filled seed.

The study will be completed in December 2008.

5.2.12 Collection of Crop Statistics for Interior Lodgepole Pine Orchards

Michael Carlson
Prepared by Joe Webber

SPU 0722

Seed production in the north Okanagan lodgepole pine seed orchards is chronically poor. To determine the source of these losses and make recommendations for orchard management practices to improve seed production, we began collecting standardized data for all producing orchards in 2006. This included estimates for phenology and for the number of cones per tree (based on cone weight), cone mass, cone yields (filled seed per cone, total seed per cone, seed weight), pollen load, and seed losses from insect predation. For comparison, data are also being collected from Prince George orchards where seed production is much higher (although cone production is lower). Because these data are collected over several years, trends in yearly variation in cone numbers and seed yields will help determine why seed set in the north Okanagan lodgepole pine seed orchards is chronically low. The following is a summary of cone and seed yield data. For a complete report, refer to the final report for OTIP 0722 (2007/08).

In the spring of 2006, 15 trees (clones) were selected to include both early, mid- and late-flowering clones. Where possible, the same clones/ramets were sampled in 2007. The number of cones per tree was estimated by weighing a known number of cones and the total number of cones per tree. This method removed a source of error that resulted from estimating cone numbers per tree by volume. Figure 22 shows the data for the 15 selected trees (± standard errors) from each of 12 lodgepole pine orchards (2006 and 2007). Note 2007 sampling for Prince George included only one 30-cone sample from Orchard 223.

Kalamalka produced the highest number of cones (both orchards) followed by Tolko 310 and VSOC 222. Any further comparison of production between orchards would require data for crown volume and tree age. All data represent one ramet of each of 15 producing clones. The method may not capture the variation in per tree seed production among ramets of a clone, nor does it include typically unproductive clones. However, the 15-tree sample does provide useful comparisons between years for total seed produced per tree, and when data is expressed as filled seed per cone, relative production between orchards and orchard sites is available.

Data shown in Figure 23 were calculated using the number of cones per tree (Figure 22) multiplied by the number of filled seed per cone (Figure 26) determined for the 30-cone sample. Averaged over all 12 orchards, the mean seed production per tree in 2007 was up from 2006 (3,200 and 5,100, respectively). Over the 12 orchards, filled seed per tree ranged from 2,240 (VSOC 213) to 14,527 (KAL 230).

Cone mass varied slightly among the north Okanagan orchards, and these cones were considerably smaller than Prince George cones. Figure 24 shows the dry cone mass (gm) for all 12 orchards in 2006 and for nine orchards in 2007 (data for two Prince George and one Okanagan orchard were not available). Mean cone size was considerably larger for Prince George orchards in 2006 (7.57 versus 4.97 gm). In 2007 mean cone mass for the one PG orchard was 9.5 gm and for the nine Okanagan orchards it was 5.40 gm.

Cone yields varied considerably among the 12 orchards. Figure 25 shows the total seed per cone (TSPC), and Figure 26 shows the filled seed per cone (FSPC) for 2006 and 2007. Prince George consistently produced the highest TSPC (all above 30), but KAL 230 and PRT 313 also produced above the 30 value. All the rest produced 20 or fewer. TSPC values for 2007 were slightly greater but not likely significantly. Since lodgepole pine can have between 30 to 40 potential seed per cone, we must try to explain where the 10 or more TSPC are lost for most Okanagan orchards.

For example, only 10 TSPC were extracted from Tolko 310 cones. Were there fewer ovules producing fewer potential seed? Was the pollen load limiting (not according to data shown in the final report)? Was insect damage a cause? (About 10 TSPC were lost when insect-bagged cones were compared to unbagged cones: see Figure 27.) We certainly understand how insect (*Leptoglossus*) damage can lower FSPC, but it is not obvious how insect-protected cones produce about 10 more TSPC.

Filled seed per cone (Figure 26) follows a similar trend to TSPC for both 2006 and 2007. Again Prince George produced the highest FSPC (all above 20 FSPC), and Kalamalka 230 produced the highest values (about 20) for the north Okanagan orchards. Excluding Kalamalka 230, PRT 313 produced the highest (about 15 FSPC) yields of the north Okanagan orchards, with FSPC for the remaining

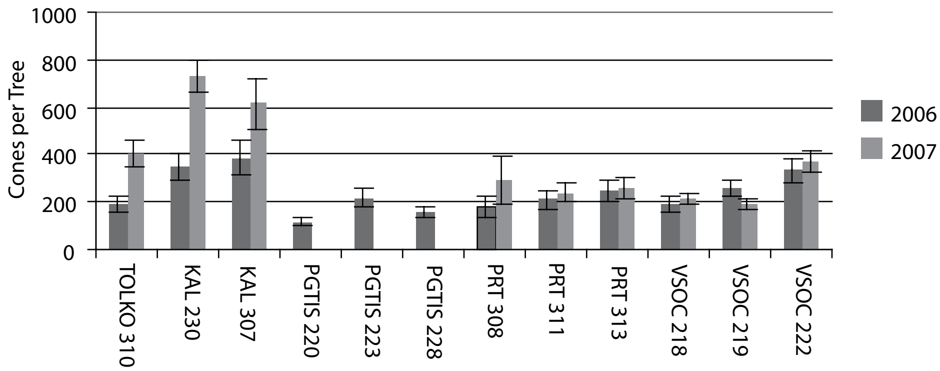


Figure 22. Mean whole tree cone numbers per tree (± standard error) for 12 lodgepole pine seed orchards sampled in 2006 and 2007.

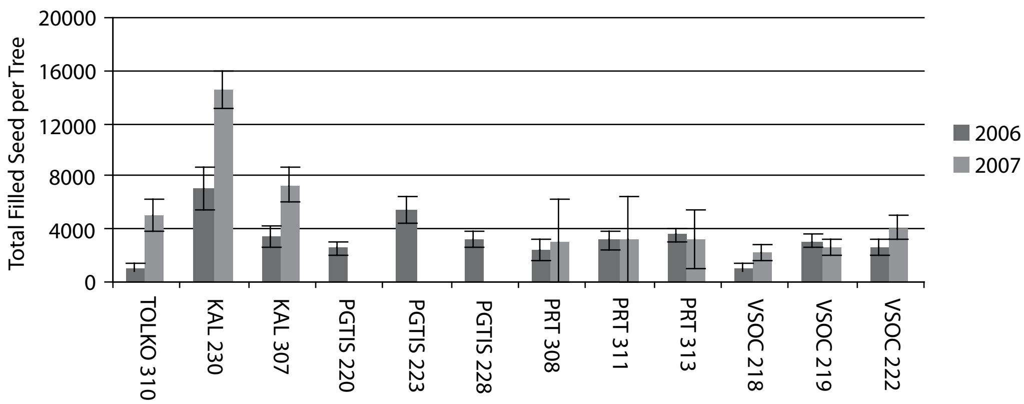


Figure 23. Mean filled seed production per tree (± standard error) for 12 lodgepole pine seed orchards sampled in 2006 and 2007.

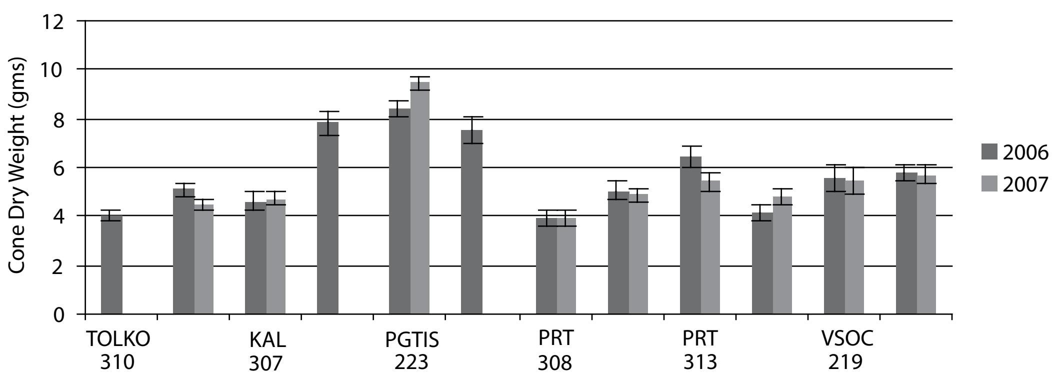


Figure 24. Mean cone dry weight (± standard error) for each of 12 lodgepole pine seed orchard sampled in 2006 and 2007. Note data for orchards 310, 220 and 228 were not taken in 2007.

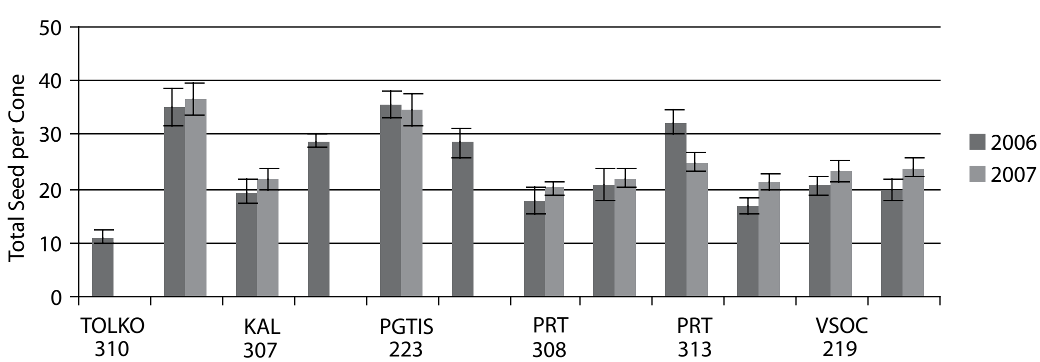


Figure 25. Mean total seed per cones (TSPC ± standard error) for each of 12 lodgepole pine seed orchards in 2006 and 2007. Note data for orchards 310, 220 and 228 were not taken in 2007.

orchards ranging between five and 15.

One of the principal causes of the loss of seed in the north Okanagan lodgepole pine seed orchards is insect predation (*Leptoglossus*). Figures 27 and 28 show the differences between TSPC and FSPC for bagged and unbagged cones respectively for each of the nine Okanagan orchards. Prince George showed no losses due to insect damage in 2006, and data for 2007 was not available.

The heaviest loss of TSPC from insect damage occurred at Kalamalka in both 2006 and 2007, but losses were down in 2007 for VSOC and Tolko. Loss of filled seed in unprotected cones also followed the same trend observed for TSPC (Figure 27), although losses were down at KAL and up at two VSOC orchards. No significant losses for either TSPC or FSPC were found for the Prince George orchards (no *Leptoglossus* effect).

Conclusions

The purpose of this orchard statistics project was to standardize the methods for estimating cone and seed production in all producing lodgepole pine seed orchards. The method of estimating cones per tree based on cone weight made comparisons between orchard sites and individual orchards more meaningful. This is also true for estimates of cone analyses (FSPC, TSPC, cone mass), general orchard production (30-cone sample), and insect effects.

After two years of sampling, trends in cone production and cone yields for Prince George and north Okanagan orchards are becoming apparent. Although the Prince George orchards produced the highest seed yields (FSPC), they also produced the fewest cones per tree but had no losses due to insect predation. This made production from the north Okanagan orchards and Prince George orchards more equitable (not including KAL orchard 230).

There is a consistent trend for Okanagan orchards to have smaller cones with fewer TSPC and FSPC. In general, the yields per cone from these orchards range from 10 to15 fewer FSPC. About four to five FSPC are lost to insect predation, leaving about five to 10 seed losses that may be attributed to fewer potential seed from smaller cones.

Since we now know that cone differentiation and development in the north Okanagan occurs earlier (beginning in July) than previously expected, we may infer that cones developing during the hot dry weather of mid-summer may lead to fewer ovuliferous scales and therefore fewer potential seed. Certainly, more work on development as affected by weather is warranted.

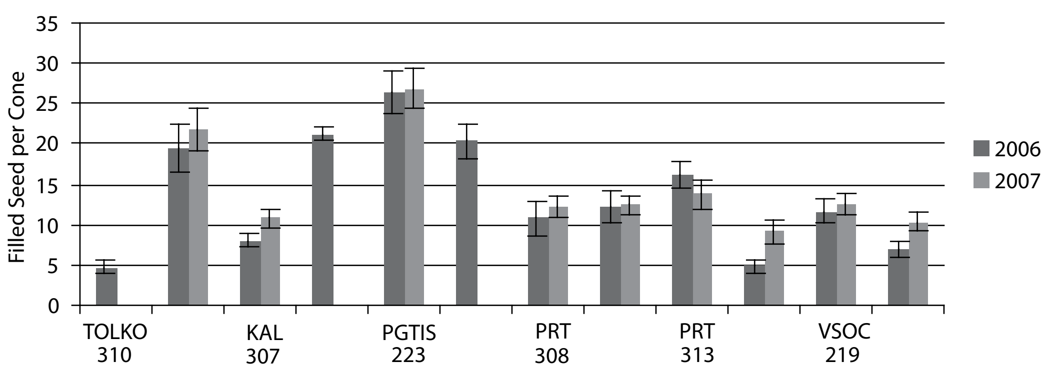


Figure 26. Mean filled seed per cones (FSPC ± standard error) for each of 12 lodgepole pine seed orchards in 2006 and 2007. Note data for orchards 310, 220 and 228 were not taken in 2007.

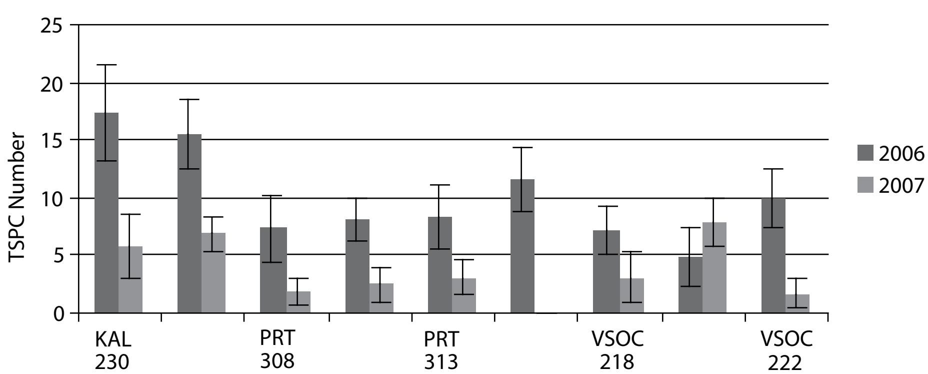


Figure 27. Mean total seed per cone (TSPC ± standard error) losses due to insect predation in 2006 and 2007 for each of the nine north Okanagan orchards.

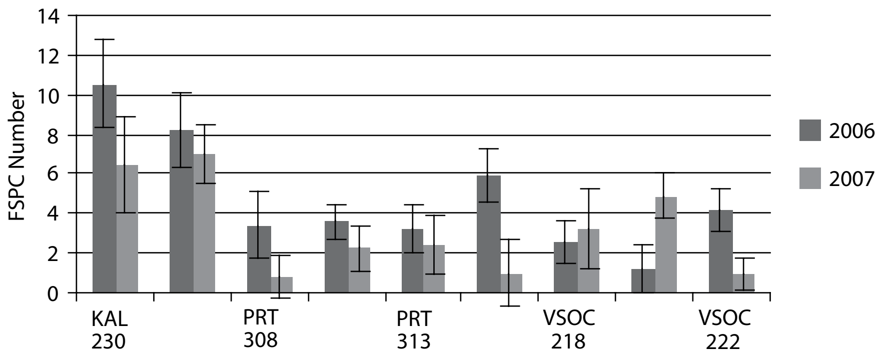


Figure 28. Mean filled seed per cone (FSPC ± standard error) losses due to insect predation in 2006 and 2007 for each of the nine north Okanagan orchards.

5.3 Mountain Pine Beetle Incremental Projects

5.3.1 Protecting Orchard Trees from Mountain Pine Beetle (MPB) Attack

Gary Giampa

Objectives

To protect 4,625 pine trees in three seed orchards from mountain pine beetle (MPB) attack and preserve seed production capacity

Activities

In consultation with the Interior Seed Orchard Pest Management Biologist, we applied insecticide to tree stems in seed orchards 230, 307 and 335 prior to the 2007 MPB flight. An Integrated Pest Management monitoring program was initiated to evaluate continuously the efficacy of the pre-flight spray through the growing season. The monitoring program consisted 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.

Results

Monitoring data indicated that all mature interior pine seed orchards were exposed to potentially harmful population levels of MPB in the summer of 2007. The prophylactic spray provided almost total protection. We lost only two out of 4,625 susceptible trees to MPB in 2007. However, about 100 unprotected pine trees were attacked on the Kalamalka Forestry Centre grounds in 2007.

Output and Deliverables

Results from the 2007 MPB protection program give us a very strong indication that seed orchard pine trees can be protected from MPB attack. While protection programs in interior seed orchards probably will need to be carried out at most locations for the next three to ten years, we are confident that the sources of seed needed to replant the pine forests of the province can be preserved until the ultimate collapse of the MPB populations around BC.

5.3.2 Removal of Mountain Pine Beetle-killed Trees from Kalamalka Orchard 307

Gary Giampa

Objectives

Remove and dispose of up to 200 mountain pine beetle (MPB) infested Pli trees from Kalamalka Orchard 307, while preserving the trees that survived attack by the beetles.

Activities

Approximately 200 ramets were severely attacked by the mountain pine beetle in Orchard 307 in 2006. When we proposed this project, we were not sure how many of these trees would survive. In consultation with the Interior Seed Orchard Pest Management Biologist, we introduced a monitoring program to determine which trees were going to die and which ramets would survive the attack by the mountain pine beetle. Any trees that posed a threat to productive orchard ramets were removed and destroyed.

Results

Thirty-one trees were removed from Orchard 307. Only three of these trees had active MPB brood. The other 28 trees removed were found to exhibit a hypersensitive defensive reaction to the MPB attacks. While these trees may have survived, we needed to remove these ramets in order to understand how seed orchard Pli trees react to MPB attack. Another eighty-nine landscape pines in close proximity to Orchard 307 were attacked in the summer of 2007 and had to be removed. In total, 120 trees were cut down and had their boles chipped to destroy MPB brood.

We ended up removing fewer trees than expected. The unused portion of the funds awarded was returned to the FGC.

Output and Deliverables

The removal of MPB infested trees from the site and identification of trees that successfully resisted beetle attack will minimize losses of Pli ramets from Orchard 307. This program will allow us to continue to maximize the production of high quality Pli seed for seed users in the NE zone.

6.0 Extension and Communications

6.1 ETAC Activities

Diane Douglas

Workshops

- Joe Webber conducted a Coastal Crown Management Workshop on October 4, 2007 at Western Forest Products, with 18 people in attendance.
- The Whitebark Pine in Western Canada Workshop August 21-24, 2007 held in Whistler was a great success with 36 persons attending from BC, AB, OR, ID, CO, and CA. As a result of this meeting, a series of initiatives have been developed.
- ETAC gave presentations at the Tree Seed Workshops offered in five locations in BC in November and December, 2007. David Kolotelo and Michael Peterson led the workshops.
- ETAC provided lunch and refreshments for the MPB workshop for Seed Orchardists offered by Jim Corrigan at Kalamalka April 17, 2007.
- ETAC contributed to the Coastal Silviculture Committee since a forest genetics component was included in the CSC summer workshop June 21-22, 2007, Courtenay BC.

Publications

- One FGC extension note was published. The Inland Empire Tree Improvement Community and FGC co-published and printed the FGC Extension Note #8 on The Reproductive Biology of Western Larch (February 2008) by Dr. John Owens.
- An article entitled "Forest Genetics: The Seed for Reforestation" by Kathie Swift, Barry Jaquish and Diane Douglas was published in the January-February, 2008 BC Forest Professional.
- Spruce Manual – the second stage of the Spruce Manual was completed, with new maps and background data.
- TIC*talk* (December 2007) consisted of 46 pages and featured articles varying from "Paper Birch Makes the Team" to "Seed Orchard Conference in Sweden."

- A Whitebark Pine Backgrounder draft publication was developed as an action item from the Whitebark Pine Conference.
- The FGC booth and display was part of the Federation of BC Woodlot Association annual meeting and conference in Port Alberni, September 27-29, 2007.
- FGC became a Grizzly member of the Whitebark Pine Ecosystem Foundation.

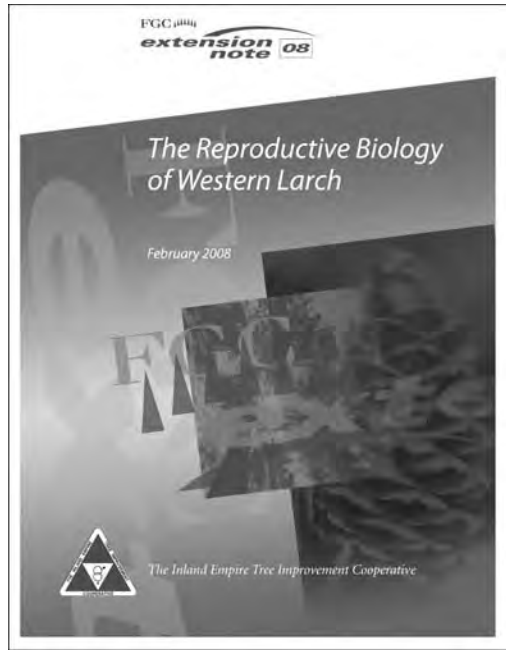


Plate 30. The Inland Empire Tree Improvement Community and FGC co-published and printed the FGC Extension Note #8 on The Reproductive Biology of Western Larch (February 2008) by Dr. John Owens.

Plate 31. The Whitebark Pine workshop in Whistler August 2007.

7.0 Seed Orchard Pest Management

Robb Bennett

The Seed Orchard Pest Management Subprogram supports research, extension activities, and pest management operations to increase orchard yields of high quality seed. Ministry of Forests and Range (MFR) Research Branch scientist Dr. Ward Strong leads the research component. MFR Tree Improvement Branch personnel (Jim Corrigan and Dr. Robb Bennett) deliver extension services. Seed orchard personnel handle operational activities. The Pest Management Technical Advisory Committee (PMTAC) guides investments and activities and is comprised of members from the MFR Research and Tree Improvement branches, the Canadian Forest Service, private seed orchards, universities, and the Forest Genetics Council.

Research plans and budgets are established through an annual process of proposal development and discussions by the PMTAC. In the 2007-08 fiscal year, the PMTAC administered projects on conifer seed bug, fir cone worm, *Fusarium* fungi, conifer adelgids, systemic pesticides, and a cone and seed insect field guide. Additional projects (pine pitch moth and Douglas-fir cone gall midge) were administered directly by Research Branch. Projects are summarized below.

Project	Species primarily impacted	Progress
Conifer seed bug (*Leptoglossus occidentalis*): host-finding mechanisms	All Pinaceae	Our collaborators' groundbreaking discovery that seed bugs use infrared wavelengths to find hosts was published in Proceedings of the Royal Society B. Based on this discovery, new traps for monitoring and management of seed bugs are in development. Other host-finding mechanisms are being explored.
Fir coneworm (*Dioryctria abietivorella*): life history and reproductive behaviour	Fd, Sx, Lw, Pw	Flight phenology, larval stages, and in-field sex ratio were determined, and a fir cone worm laboratory colony was established. This was the first summer of a three-year M.Sc. project.
Fusarium fungi: reducing infections in orchard seed and determining infection mechanisms	All species	Research completed. Summary report encapsulating results of several related projects is under revision prior to publication.
Conifer adelgids (*Adelges* and *Pineus* spp.): species composition, gall formation, and life history	Sx, Lw, Fd, Pw	Species composition and population parameters analyses were completed. Determined the seasonal flight patterns of different species and the life stages required for gall initiation. This was the second year of a three-year M.Sc. project.
Pine pitch moth (*Synanthedon sequoiae*): damage and control	Pli, Sx	Permanent sample plots were established to measure multi-year effect of pitch moths on tree health. Control through carbaryl stem sprays was demonstrated to be ineffective.
Douglas-fir cone gall midge (*Contarinia oregonensis*): population studies	Fdi	Cone gall midges have recently become an issue for Fdi crops. Gall midge distribution and phenology are being studied in preparation for minimizing potential economic losses to Fdi crops.
Cone and seed insect control: systemic insecticide injection trials	All species	The first year of pesticide trials using new formulations and novel injection hardware produced inconclusive results: insect populations were generally too low to demonstrate significant effects, and trials were hampered by logistical problems. Treatments had no effect on seed germination. New trials using modified equipment and simpler protocols were carried out in 2008/09.
Cone and seed insect field guide	All species	New images of a variety of cone and seed insects have been made. Fact sheets for eight high-priority insects have been drafted and are under review.

Table 16. Seed Orchard Pest Management Projects.

Appendix 1 FGC Seed Planning Unit

SPU Unit (OTIP)	Seed Planning Unit (SPU)	Species	Seed Planning Zone (SPZ)	Elevation Band (metres)	
		Common name		Min	Max
1	FDC M LOW	Douglas-fir	M	1	700
2	CW M LOW SOUTH	Western redcedar	M	1	600
3	HW M LOW SOUTH	Western hemlock	M	1	600
4	SX NE MID	Interior spruce	NE	800	1500
5	SX NE HIGH	Interior spruce	NE	1500	1900
6	SS M LOW SOUTH	Sitka spruce	M	1	500
7	PLI NE LOW	Lodgepole pine	NE	700	1400
8	P W M LOW	Western white pine	M	1	1000
new	PW M HIGH	Western white pine	M	1000	1400
9	BA M LOW	Amabilis fir	M	1	700
10	PLI TO LOW	Lodgepole pine	TO	700	1100
new	PLI TO MID	Lodgepole pine	TO	1100	1400
11	YC M ALL SOUTH	Yellow-cedar	M	1	1100
12	PLI PG LOW	Lodgepole pine	PG	700	1200
13	LW NE LOW	Western larch	NE	700	1400
14	SX PG LOW	Interior spruce	PG	600	1200
15	PW KQ ALL	Western white pine	KQ	500	1200
16	PLI TO HIGH	Lodgepole pine	TO	1400	1600
17	PLI BV LOW	Lodgepole pine	BV	700	1200
18	PLI CP LOW	Lodgepole pine	CP	700	1100
19	FDC SM LOW	Douglas-fir	SM	200	1000
20	PLI NE HIGH	Lodgepole pine	NE	1400	2000
21	FDI NE LOW	Douglas-fir	NE	400	1000
22	FDI NE HIGH	Douglas-fir	NE	1000	1600
23	SX SM ALL	Interior sitka hybrid	SM	1	1800
24	HW M HIGH SOUTH	Western hemlock	M	600	1100
25	SX EK ALL	Interior spruce	EK	750	1700
26	PLI PG HIGH	Lodgepole pine	PG	1200	2000
27	CW SM ALL	Western redcedar	SM	200	1000
28	SX TO HIGH	Interior spruce	TO	1300	1900
29	PLI EK HIGH	Lodgepole pine	EK	1500	2000
30	SX TO LOW	Interior spruce	TO	700	1300
31	FDC M HIGH	Douglas-fir	M	700	1200
32	PLI EK LOW	Lodgepole pine	EK	800	1500
33	CW M HIGH	Western redcedar	M	600	2000
34	LW EK ALL	Western larch	EK	800	1500
35	SX BV LOW	Interior spruce	BV	500	1200
36	BG M LOW	Grand fir	M	1	700
37	FDI QL LOW	Douglas-fir	QL	700	1200
38	HW M LOW NORTH	Western hemlock	M	1	600
39	FDI EK ALL	Douglas-fir	EK	700	1400
40	SX PR LOW	Interior spruce	PR	450	650
new	SX PR MID	Interior spruce	PR	650	1200
41	FDI PG LOW	Douglas-fir	PG	700	1000
42	SX PG HIGH	Interior spruce	PG	1200	1550
43	FDI CT LOW	Douglas-fir	CT	600	1200

Source: Ministry of Forests, Tree Improvement Branch (SPU, Version 3.0; April, 2005)

Appendix 2 Tree Species

CONIFERS	LATIN NAME	ABBREVIATIONS
western redcedar	*Thuja plicata*	Cw
yellow-cedar	*Chamaecyparis nootkatensis*	Yc
Douglas-fir	*Pseudotsuga 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
lodgepole pine	*Pinus contorta*	Pl
lodgepole pine	*Pinus contorta* var. *latifolia*	Pli
ponderosa pine	*Pinus ponderosa*	Py
shore pine	*Pinus contorta* var. *contorta*	Plc
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/s)	*Picea cross* (Se and Sw mixtures)	Sx
Sitka x unknown hybrid	*Picea sitchensis* x	Sxs
western (Pacific) yew	*Taxus brevifolia*	Tw

HARDWOODS		
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

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