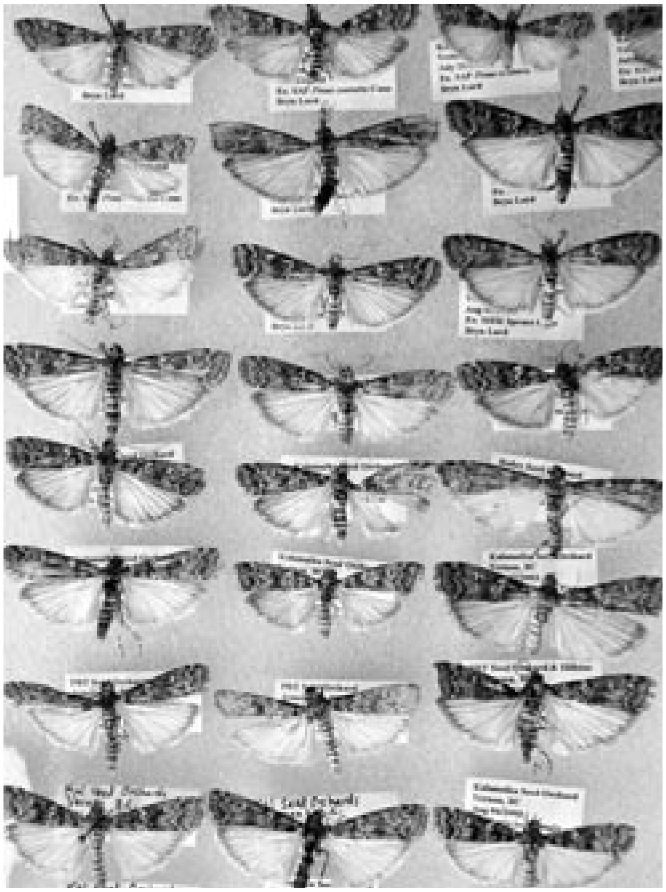


2004/2005

Forest Genetics Council of BC

Tree Improvement Program Project Report

Front Cover

Research collection of the douglas-fir cone worm, *Dioryctria abietivorella*, reared from infested spruce and douglas-fir cones.

Adult females of the spruce seed chalcid, *Megastigmus piceae*. The one on the right is ovipositing into an ovule.

Sporulating lesion of White Pine Blister Rust, *Endocronartium ribicola*, on a white pine branch.

Forest Genetics Council of BC

Tree Improvement Program Project Report

Coordinated and compiled by:
Beacon Hill Communications Group Inc.

and

Roger Painter
Tree Improvement Branch
British Columbia Ministry of Forests

Acknowledgements

It is my pleasure to present this report for the eighth year. The Tree Improvement Program has proven to be one of the most enduring and successful partnerships sponsored by our provincial government. What started out as a short-term funding source to augment current budgets and increase annual production has expanded into a complex, progressive, and successful public-private partnership that encompasses all aspects of tree improvement. This is now been recognized by other areas within the provincial government. It was nominated by the Ministry of Forests for the Premier's award and was one of three programs reviewed under the Auditor General's report on Managing for Results. In the past year we have again added yet another sub-program to target a broad need within tree improvement. The newest effort is specifically geared to answer problems about seed pest management by investing in longer-term research and problem solving in that vital area. We look forward to results from seed pest research to provide us with more valuable tools for protecting our seed orchards and crops.

The Forest Investment Council continues to recognize the value of investing in tree improvement. There is little doubt that this support is providing us with the resources to continue with a vibrant and robust long-term program. We continue to build on the management processes of the program. These approaches, including business planning and performance management and long-term strategic planning, are key to the success of the program. Other organizations in addition to the Forest Genetics Council (FGC) view them as a successful model for developing investment programs on the co-operative partnerships model.

I would like to acknowledge the project leaders for their contributions to this report. This publication continues to provide a well-deserved display of our work, and the program receives numerous compliments on the successes of tree improvement from various people in the forest industry. My congratulations to you all for an excellent eighth annual report. I hope you enjoy it. My sincere thanks for the hard work of our editorial review team for taking the time to look over our submissions. They include Diane Douglas, Ward Strong, Ron Planden, and Greg O'Neil.

Our sincere thanks to Dr. Robb Bennett and the Seed Pest Management Program for their valuable contributions to the front and back covers of this year's report. Seed Pest Management has expanded in the past year and now is looking forward to an increased presence in providing a strong research element in their work.

Again, my thanks to all those who have worked on this program in the past year, including the review committees, species committees and various Technical Advisory Committees (TACs). You are the reason that this program has a strong technical direction. To all the project leaders, I hope 2005/2006 is as successful as the previous year.

Roger A. Painter
Tree Improvement Co-ordinator
Forest Genetics Council

Forest Genetics Council Co-chairs

Once again we thank the many industry and government staff who contribute to the provincial gene resource management program for their cooperation and dedication over the past year. Although forestry in BC is changing quickly, there is a consistent and solid base of support for tree improvement, and a well-established planning process in place.

During the 2004/05 fiscal year, substantial progress was made in several important areas:

- Chief Forester's Standards for Seed Use, in support of the new *Forest and Range Practices Act*, were completed. The Standards consolidate existing policy, guidelines, and practices and result in efficiencies for both industry and government stakeholders. Many members of council and affiliated committees contributed to and improved the Standards during the past year.
- Council membership changes were completed, allowing long-serving councillors a rest and new energy to be brought to bear.
- Under the direction of the recently appointed Chief Forester Jim Snetsinger, the FIA – Tree Improvement Program continues to support the long-term goals of Council for increased seed quality and seed production in seed orchards.

The coming year will continue to present additional challenges for Council. As programs mature and industry continues to feel pressure to increase competitiveness in global commodity markets, the need to realize value from all silviculture investments will increase. Seed pests in our British Columbia seed orchards took a significant toll on interior species and will be the focal point of a new Forest Genetics Council sub-program. Climate change is a growing challenge to forest management policy development, and we can expect that seed selection and use will need to be reviewed in this regard in the short term. This will allow us to meet the public expectations regarding stewardship of the genetic resource on public lands. Your program Co-chairs are confident that Council and its affiliated committees will rise to meet these challenges in 2005/06.

On a final note, this year marks the final contribution of Shane Browne-Clayton to the Forest Genetics Council as Industry Co-Chair. Shane has worked tirelessly and with consistent co-operation since the onset of the newly structured council in 1996. As Ministry Co-Chair, I extend my thanks and that of countless others for the contribution and friendship offered by Shane over this period.

Shane Browne-Clayton
Industry Co-chair

Dale Draper
Ministry of Forests
Co-chair

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:

TIP Program Administrator
Ministry of Forests
Tree Improvement Branch
PO Box 9518 Stn Prov Govt
Victoria, B. C. V8W 9C2

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

Forest Genetics Council	http://www.fgcouncil.bc.ca
Ministry of Forests, Tree Improvement Branch	http://www.for.gov.bc.ca/TIP/index.htm
Ministry of Forests, Research Branch	http://www.for.gov.bc.ca/research/

Table of Contents

List of Figures

List of Plates

Tree Improvement in British Columbia

Ministry of Forests Program Overview

Forest gene 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 gene resource management program that is implemented by stakeholders in the forest industry: the Ministry of Forests (MoF), Canadian Forest Service (CFS), and universities.

The Forest Investment Account, (FIA), is a major funding agency for forest gene resource management in British Columbia. Through the Tree Improvement Program (TIP), FIA invests in forest gene 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 B.C.

The Forest Genetics Council of British Columbia (FGC) is a multi-stakeholder group representing the forest industry: the Ministry of Forests (MoF), Canadian Forest Service (CFS), and universities. Council's mandate is to champion forest gene resource management in British Columbia, to oversee strategic and business planning for a co-operative provincial forest gene resource management program, and to advise the province's Chief Forester on forest gene resource management policies. FGC members provide strategic direction to the provincial forest gene 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 gene conservation program, developing long-term production capacity, doubling the average volume 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 MoF leads tree breeding activities and private industry leads operational production of reforestation materials. The Canadian Forest Service, MoF 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.

FIA – Tree Improvement Subprograms

The Forest Investment Account (FIA), Tree Improvement Program is consistent with the provincial strategy for forest gene 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.

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

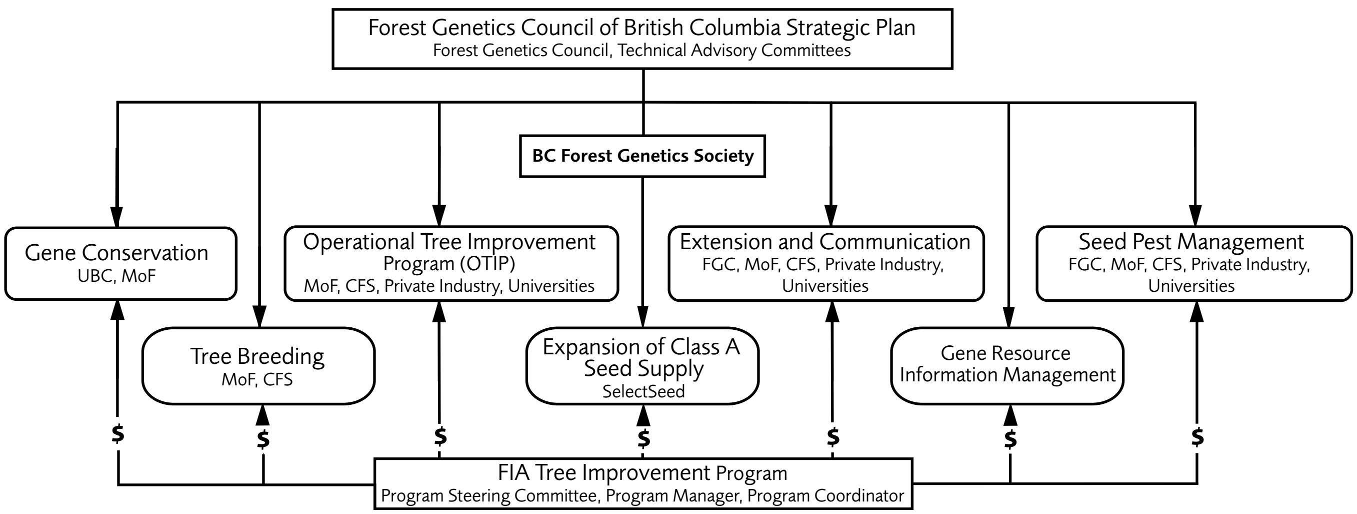


Figure 1. Relationship between FGC Strategic Plan, FIA-TIP, and participants in various forest gene resource management areas

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

Jack Woods

The Subprogram for the Expansion of Orchard Seed Supply was initiated by the Forest Genetics Council (FGC) to ensure sufficient orchard capacity to meet objectives. Coastal and Interior Technical Advisory Committees (CTAC and ITAC) of the FGC estimate total seed orchard capacity needs for each seed planning unit (SPU) through the process of developing species plans. This process identifies substantial gaps that are being met through this subprogram.

All SelectSeed orchards are developed through long-term contracts with private seed-orchard companies. During the fiscal year ending March 31, 2005, activities focused on the completion of propagation and planting, as well as the management of 14 orchards. Progress is summarized in Figure 3.

All orchard developments mandated to SelectSeed are well underway. In total, 33,333 ramets have been planted out of a total 35,291 planned (94%). Because of winter mortality and graft incompatibility, there will be some reduction in the number surviving. Losses will not be known until spring surveys are completed. During the 2004/05 year, 3,314 grafts were made and kept in holding beds. Surviving grafts were planted in orchards in the late summer of 2004; approximately 340 ramets were held for early spring planting in 2005.

Orchards are maturing, and cones are beginning to appear on many ramets. A small crop of Douglas-fir seed was obtained from orchard #321 (Fdi Nelson low elevation); however, losses to the Douglas-fir cone worm reduced potential yield. Future years will see the completion of planting and a continued shift of focus to site management and crop production.

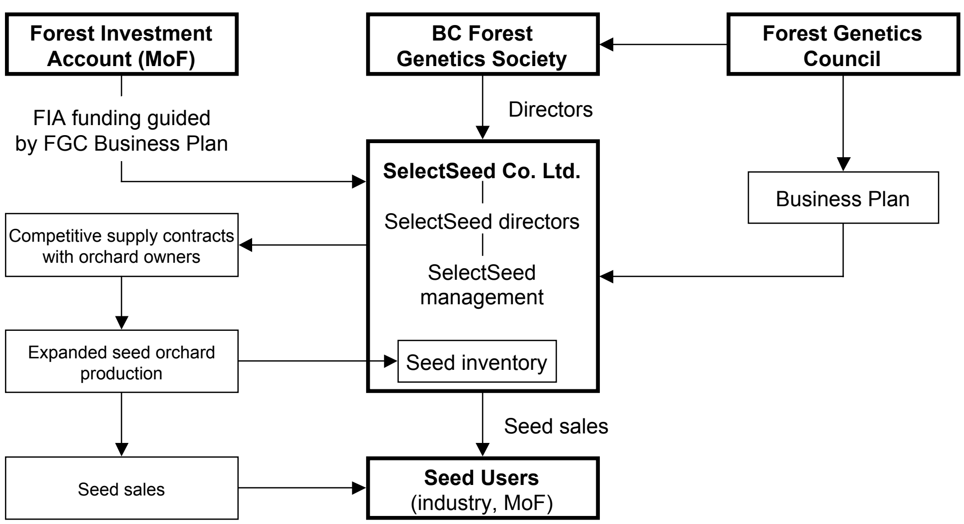


Figure 2. Schematic of organizational relationships among FGC, FIA, SelectSeed and seed users

Seed planning Unit						311 Grafting		312 Holding		313 / 314 Orch. Planting		315 Orch. mgt.		
Spp.	SPZ	Elev	Orch #	Location	Final size	KPI planned	KPI done	KPI planned	KPI done	KPI planned	KPI done	KPI planned	KPI done	% complete
Fdi	NE	< 1000	321	PRT	2200	97	97	97	97	242	218	2150	2,139	97%
Fdi	QL	all	232	VSOC	975	50	0	50	0	40	6	960	787	81%
Fdi	PG	all	233	VSOC	786	0	0	0	0	40	40	770	749	95%
Pli	NE	< 1400	337	PRT	1000	0	136	100	136	98	28	990	980	98%
Pli	TO	< 1400	338	PRT	4780	701	688	701	688	1,432	1,214	4750	4,589	96%
Pli	PG	<1200	236	VSOC	4500	734	780	734	780	390	416	4470	4,228	94%
Pli	PG	<1200	237	KRSO	4871	653	638	653	638	441	407	4840	4,690	96%
Pli	TO	> 1400	339	Riverside	3473	419	471	419	471	280	357	3440	3,100	89%
Pli	BV	1200	234	VSOC	3000	227	230	227	230	250	164	2970	2,876	96%
Pli	BV	1200	240	Sorrento	3100	0	0	0	0	5	3	3070	2,900	94%
Pli	CP	<1000	238	KRSO	3100	126	140	126	140	119	115	3070	2,900	94%
Pli	CP	<1000	241	Sorrento	2000	69	84	69	84	80	30	1980	1,910	96%
Sx	TO	1300-1	343	Riverside	1052	35	30	35	30	10	18	1040	1,040	99%
Sx	TO	< 1300	342	Riverside	454	25	20	25	20	10	20	445	445	98%
		Total			35,291	3,136	3,314	3,236	3,314	3,437	3,036	34,945	33,333	94%

Figure 3. Summary of SelectSeed orchard developments, and progress in propagation and planting during the year ending March 31, 2005

2.0 Gene Resource Information Management

Leslie McAuley

Gene resource information management (GRIM) forms a critical link to the long-term stewardship and sustainable resource management of the province's forest tree gene resources over future generations. The key objectives of GRIM are to:

- Develop a provincial GRIM framework to support land use and forest development/stewardship plans, forest regeneration (planting) programs, forest genetics research, and gene resource management (gene conservation/seed deployment) (GRM) strategies.
- Support and maintain GRM registries and data repositories.
- Provide access to tree improvement program products (seed and vegetative material for operational use).
- Build an effective GRM monitoring program integrated with broader forestry (i.e., Criteria & Indicators) and land-based resource management initiatives.
- Develop a means to incorporate genetic gain into timber supply analyses through forest inventory update procedures, forest simulator modelling tools, and the use of GIS-ready spatial and attribute GRM data sets.

GRIM project accomplishments in 2004 /05 included:

- Strategic planning initiated for the development of a Resource Information Strategy for the province's genetic resources, including preliminary development of Gene Resource Management plans (for each data set).
- Development of a web-based parent tree registry and on-line registration functions in support of the new Chief Forester's Standards for Seed Use. Both new features will be accessible through the Seed Planning and Registry system (SPAR).
- Enhancement of genetic resource data sets in support of the new Chief Forester's Standards for Seed Use, including revised Seed Planning Unit data sets and development of new Tested Parent-Tree Areas-of-Use data subsets for species plans and seed registration.
- Development of draft resource attribute and mapping criteria to assist in the superior provenance resource

feature (source, quality) review project.

- Development of quick, easy-to-view and printable Look Up theme maps to assist resource managers.
- Enhancement of the web-based SeedMap tool to adopt a standardised look and feel (SILV, VEG, FOR HEALTH, GENETIC RESOURCES map layer folders) and incorporate new spatially enabled queries (e.g., SEED deployment).
- Development of land-based queries (Source: RESULTS system) to support indicators (Genetic Diversity, Gene Conservation, Forest Productivity) required for national Criteria & Indicators reporting and provincial State of the Forests and Forest Resource Evaluation program reporting.
- Integration of GRM within broader government-wide strategic planning and forest management initiatives and analyses (Mountain Pine Beetle, Inventory Update, Silviculture, Timber Supply).
- Development of GRM results-based information reporting requirements under the new *Forest and Range Practices Act* (on-going).
- Development of web-based training modules, tutorials, and on-line Help (on-going).

Figure 4. Natural Stand Seed Planning Zones

3.0 Centre for Forest Gene Conservation (CFGC)

Sally Aitken

The Centre for Forest Gene Conservation at the University of British Columbia continues to work towards the gene conservation objectives of the Forest Genetics Council. Our projects address strategies and theory for gene conservation, evaluate current levels of protection of forest genetic resources, assess the potential impacts and opportunities for mitigating the effects of climate change on forest genetic resources, and investigate species-specific genetic issues associated with at-risk and rare tree species. We also strive to meet the needs for extension in the area of gene conservation. Here we highlight our recent progress and publications in these areas.

Cataloguing and Documenting Protection of Forest Genetic Resources

The evaluation of the current *in situ* conservation status of all tree species in BC through modelling ranges and species density and the estimation of the representation inside and outside of protected areas are both fairly complete. Two publications have been completed (Hamann et al. 2004, Hamann et al. submitted), and analyses are complete for a third. However, ground-truthing is required for some species in some areas. This will require field work in the upcoming fiscal year. The *ex situ* resources in seed storage at the Tree Seed Centre have been analyzed spatially and will be strategically evaluated along with *in situ* genetic resources.

Climate Change and Gene Conservation

This project area is currently the largest we have underway, and Andreas Hamann, Tongli Wang, and Pia Smets have made enormous progress in the past year (note that this research is partially funded through an NSERC Strategic/BIOCAP Canada grant). We now have an excellent fine-scale climate model for British Columbia (Hamann and Wang 2005). This model has since been developed to incorporate and downscale regional climate-change predictions in collaboration with David Spittlehouse. A software tool called ClimateBC is nearing release that will allow users to predict current and future monthly and annual climatic means for any location in BC The development of these models and tools has been the focus of our climate-change research in 2004-05. In 2005-06, we will be able to move on to further applications of these models. Two important ones are evaluating the future protection of tree species in protected areas given climate change and revising SPU boundaries for seed transfer based on climatic rather than geographic information.

Genetic Structure of Minor Species

1. The PhD research of Andy Bower on whitebark pine genecology, inbreeding depression, and the interaction between inbreeding depression and disease resistance is nearing completion. Whitebark pine has tremendous mid-winter cold hardiness (LT50 below -70°C) and a greater degree of cold hardiness during the active growing season than most conifers (LT50 -9°C). Populations show significant variation in fall, but not spring, cold hardiness, with higher hardiness in more northern populations. This geographic pattern will need to be considered when planning restoration activities for this species. Earlier CFGC research found high levels of inbreeding in two BC populations of whitebark pine. In extending this assessment to provenances from further south, it appears that inbreeding rates decline with latitude. Inbreeding levels in conifers usually decline as stands age. However, there is a tendency for inbreeding levels to increase with age in whitebark pine in stands that are heavily infected with white pine blister rust.
2. A project on genetic diversity and the mating system of Pacific dogwood was initiated in 2004 by Karolyn Keir, who successfully developed six micro-satellite markers for this species from those developed for Florida dogwood. Her preliminary work indicates this species has very low levels of genetic diversity. There is anecdotal evidence from Idaho that low genetic diversity contributed to high mortality due to the disease Anthracnose. She will be returning to start an M.Sc. degree in September, 2005 on this project.
3. Five hundred Garry oak seedlings from 12 families were grown at UBC in the past year for a preliminary look at quantitative variation and to give us experience in the cultivation of this somewhat recalcitrant species. Joanne Tuytel has established a small, common-garden experiment in raised nursery beds this spring. Extra seedlings will be used to establish a Garry oak meadow at the UBC Botanical Garden. If acorn crops are good this year, collections will be made for initiation of a genecological study.

Extension

Our extension activities have grown exponentially in the past year. Requests for information, analyses, and presentations, particularly on the climate-change research, are high, coming from provincial government agencies in BC and Alberta, from the Canadian Forestry Service, and from other countries and organizations. Our website (www.forestry.ubc.ca/cfgc) has summaries of all projects and extensive electronic resources for others. We are nearing completion of a major upgrade in both the structure and the design of the website.

CFGC Publications in 2004-05

Aitken, S.N. 2004. Genecology and adaptation of forest trees. Pp. 197-204 *In*: Jeffrey Burley, Julian Evans, and John A. Youngquist (eds.), Encyclopedia of Forest Sciences. Four-volume set. Elsevier.

Bennuah, S.Y., T. Wang, and S.N. Aitken. 2004. Genetic analysis of the *Picea sitchensis x glauca* introgression zone in British Columbia. For. Ecol. Mgmt. 197(1-3): 65-77.

Gapare, W. J., S.N. Aitken, and C.E. Ritland. 2005. Genetic diversity of core and peripheral Sitka spruce (*Picea sitchensis* (Bong.) Carr) populations: implications for conservation of widespread species. Biological Conservation 123: 113-123.

Hamann A. and T.L. Wang. 2005. Models of climatic normals for genecology and climate change studies in British Columbia. Agricultural and Forest Meteorology 128 (3-4): 211-221

Hamann, A., S. N. Aitken, A. D. Yanchuk. 2004. Cataloguing *in situ* protection of genetic resources for major commercial forest trees in British Columbia. For. Ecol. Mgmt. 197(1-3): 295-305.

Bennuah, S.Y., T. Wang, and S.N. Aitken. 2004. Genetic analysis of the *Picea sitchensis x glauca* introgression zone in British Columbia. For. Ecol. Mgmt. 197(1-3): 65-77.

4.0 Tree Breeding

4.1 Coastal Douglas-fir

Michael Stoehr, Keith Bird, Clint Hollefreund

Coastal Douglas-fir (SPU 01 and SPU 31)
Breeding work in the spring resulted in four breeding-population sublines being fully completed and three sublines being partially completed (general combining ability component only). In total, over 100 full-sib families and over 65 half-sib (general combining ability test) were sown in the fall for out-planting in early spring of 2006. Site maintenance was carried out on 10 progeny test sites and five realized-gain sites. Increment cores, for the determination of wood density in second-generation progeny tests (EP 708) were collected and are being analyzed. This completes the collection of cores from 66 sites. High-elevation tests were analysed and breeding values determined. These were used to rogue CANFOR orchard #116.

Sub-maritime Douglas-fir (SPU 19)
A total of 91 (half-sib) families created from polymixes from orchard #181 were grown for the establishment of three progeny tests in the coastal-interior transition zone. Test sites selected are in the D'Arcy and Pemberton areas at elevations from 500 to 1,100 m. From these tests, a total of 15 parents will be backward selected starting at age 5. Orchard #181 will be supplemented with 10 forward selections of the genecology tests planted in 1996 on four transition-zone sites (EP 1200). The four EP 1200 sites in the transition zone were maintained.

4.2 Sitka Spruce

John King, Dave Ponsford

Weevil resistance program
Last year we established the first phase 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. The trials were established in the Adam's River drainage on north Vancouver Island and at Jordan River, south Vancouver Island. Another site that we held over was established this spring (2005) on Queen Charlotte Island. We sowed a second series of the F1s this spring to be established in spring 2006.

Selection and breeding work continues, but our focus in the future for the breeding program will be to identify parents 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 resistance 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.

In the past we have relied strongly on the Canadian Forestry Service for entomology back-up for this program. With their new directions we expect to rely more on the universities, although of course Dr. René Alfaro still provides major input.

Ongoing trial assessments for weevil attack have continued, including 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 MoF Coast regional entomologist, and we hope to provide regional guidelines for spruce over the next year.

Major articles published in the last year include:

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

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

Other Components – QCI, NW Hybrid Program

The Queen Charlotte Island (QCI) program allows us to assess Sitka growth free from weevil attack and to support the Seed Orchard program (SO 142 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. This year we spent a good deal of time cleaning up, tagging, and removing browse protection from the trials we have established there.

The transition program is designed mainly to test seed transferability in a very environmentally heterogeneous area with pressures from both frost and weevil. We completed a five-year assessment this year and had a very successful extension trip showing local foresters in the northwest our program. We have continued some selections of good hybrid weevil-resistant trees for possible orchard deployment.

4.3 Western Hemlock and True Fir Forest Genetics Programs

Charlie Cartwright

Low-elevation Maritime Hemlock (SPU 03)

Hemlock is the most under-utilized, widely used species for regeneration in BC. The breeding program hopes this will be rectified as higher-gain seed becomes available. Since the genetic worth of first-generation orchard seed lots has now levelled at around 16% gain, higher gains can occur only through moving to the next generation of selections. To this point, 220 trees have been chosen from advanced-generation HEMTIC (Hemlock Tree Improvement Co-operative) trials based on age 5 height (the tests incorporate the best parents from first-generation programs in Washington, Oregon, and BC). As age 10 results are tabulated starting in the fall of 2005, about half of these early picks will be culled. It was apparent that the heritability of growth for individual trees was low, as was expected for this species. This means that the value of the selections relies much more on their family performance than on that of individuals within the family. To remedy this for later advanced-generation tests, clonal trials are used. In these, several copies of each individual are planted to allow highly accurate within-family selection. In 2005 three test sites of this type were planted. In the meantime, methods of producing a desirable balance of male and female strobili with young selected material in small pots has commenced in order that breeding with the new material can begin as soon as the age 10 figures are available.

Note: Participation in HEMTIC by the BC Ministry of Forests has been terminated. As per the Memorandum of Understanding with which the co-op was established, age 5 data from the HEMTIC tests have been sent, thus securing access to all HEMTIC-improved material. Continued cooperation with the current members of the co-op is planned. Hopefully further exchanges of data (age 10) can be arranged.

High-elevation Hemlock (SPU 24)

The advantages of high-elevation hemlock include faster growth than yellow cedar and better wood quality than balsam fir. The species plan calls for first-generation testing of about 300 parents to achieve a 15% level of genetic gain in growth traits. To this point results are available for 240 parents, with new breeding values provided this year for 212 of those parent trees.

All Hemlock SPUs – Seed Transfer Concerns

Further gains from the hemlock breeding program may be achieved through expansion of the planning units. The limits to seed transfer for wild stand seed lots can also be established. At this point it is uncertain how high in elevation and latitude the tested material may be moved. The advanced-generation trials are relatively complex and need good survival to produce useful results. Also, because the environment is quite variable, many small tests are required, whereas in progeny trials a few large tests in good growing conditions produce good results. For this reason, about 35 small hemlock seed transfer tests comprised of wild-stand and tested seed sources have been widely dispersed in BC over the last ten years. Highlights of staff activities this year in these trials include weeding eight of the younger sites and measuring seven. Next year another two test sites will be measured, and then an analysis with the purpose of revising seed transfer boundaries will commence.

Pacific Silver Fir (SPU 09)

Four Pacific silver fir provenance sites were planted in 2002, and eight in 2003. Of the trials, one near Hope was destroyed by wild fire, and a second was inaccessible due to a bridge being out. First data beyond nursery results will be taken on the older series in the 2005/06. As well, replacement planting of the site that burned is planned, along with beefed-up planting of the others.

Grand Fir (SPU 36)

The species subcommittee considered declaring a superior seed source based on age 20 data from eight provenance test sites. The top source (Salmon River) produced 12% more volume than other well-adapted sources for the seed planning unit. Once juvenile/mature correlations were considered, the advantage of this provenance was 8%. The species sub-committee will not recommend the use of this source for B+ seed until it can be ascertained that enough trees remain at the source to make seed collection feasible.

Sub-alpine Fir

Four nursery trials for this species were established in 2002. One had to be abandoned due to poor survival. Of the remaining three, two were in need of intensive maintenance. Measurements for growth on two sites and for Christmas tree traits on one site will be carried out in 2005-06. To cover gene conservation concerns and long-term growth data, excess replacement stock will be out-planted to two new field sites in the coming year. The Balsam Wooly Adelgid quarantine will limit the scope of this, so sowing of new tests targeted at the northern interior of BC will also be undertaken next year.

Noble Fir

As with grand fir, identification of superior provenance to produce B+ seed is under consideration by the species subcommittee. Based on age 16 data from 12 sites, the top source was 11% in volume beyond averages for other well-adapted provenances. After consideration of juvenile/mature correlation, the achievable gain was about 6%. Similar to the situation for grand fir, the viability of using the chosen superior seed source near Mount St. Helen's (French Butte) will be checked in the field. Other good provenances are in ecological reserves/ parks, or on logged sites; the Mt. St Helen's trees are USDA National Forest and young mature.

4.4 Western Redcedar Breeding Program

John Russell, Craig Ferguson

The last series of first-generation polycross testing for the maritime-low SPU have been planted. In total, this project involved the testing of 938 parents across seven annual series and 46 test sites (Figure 5). Breeding values for volume at rotation are currently available for series 1 and 2 based on seven-year heights (288 parents) and series 2, 3, and 4 based on five-year heights (327 parents). Approximately 55 parents from the first four series have been selected for advanced generation breeding and have been established into breeding orchards.

Needle terpene concentrations are currently being evaluated on all 930 parent trees in progeny tests. In addition, sixty within-family selections for high-needle monoterpene concentration/deer resistance were made at the Holt Creek, SVI family/population study. These selections will be bred using a combination of selfing and outcrossing, and the resultant progeny will be screened for monoterpene concentration and deer resistance. Both backward and forward selections can then be incorporated into a deer-resistant production population.

Heartwood tropolone concentrations have been evaluated for approximately 300 parent trees from the first three series, and the top 50 backward selections have been established in breeding orchards. Tropolone concentration has been shown to be related to wood durability. Further durability screening needs to be developed prior to the operational release of these clones for seed production and further breeding.

			# of test sites/SPU[1]						
Series	**Year**	**#parents**	**ML**	**MH**	**QCI**	**NM**	**SM**	**INT**	**Total**
1	1998	150	3	1	-	-	-	-	4
2	1999	138	4	-	-	-	2	-	6
3	2000	110	3	-	1	1	1	-	6
4	2001	57	4	1	1	-	-	-	6
5	2003	160	3	2	1	1	1	-	8
6	2004	168	2	3	-	1	1	2	9
7	2005	147	4	1	1	-	1	-	7
Total		**930**	**23**	**8**	**4**	**3**	**6**	**2**	**46**

1. ML= Maritime low (under 600 m); MH=Maritime high (>600m); QCI=Queen Charlotte Islands; NM=North Maritime;SM=Submaritime;INT=Interior.

Figure 5. Summary of western redcedar polycross tests

Plates 1 and 2. PNW parents from Series 4 exhibit frost damage at a high-elevation coastal site near Harrison Mills

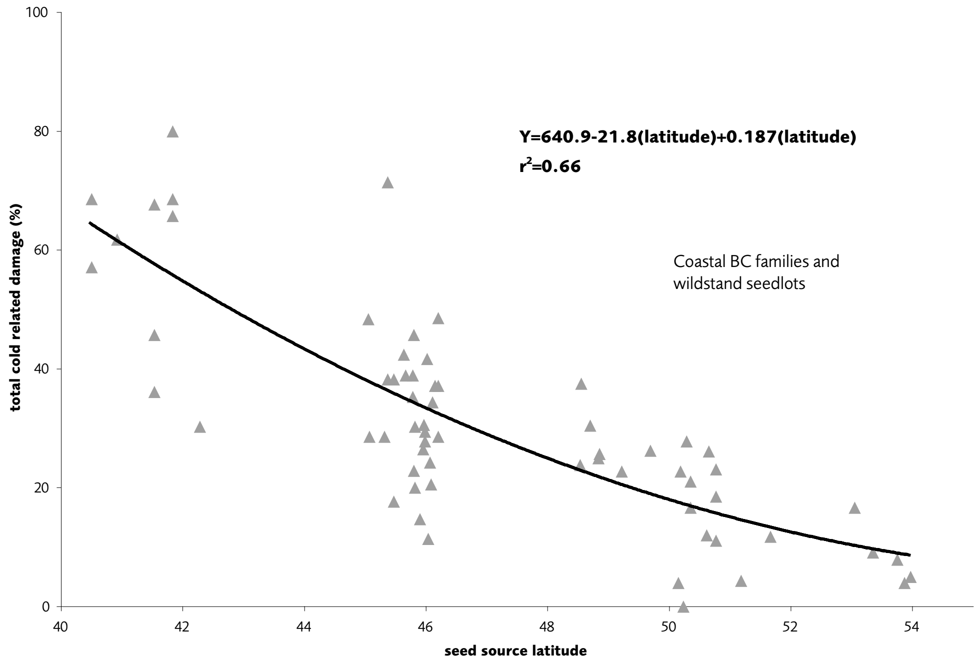


Figure 6. Relationship between cold-related damage and seed source at a high-elevation coastal polycross test near Harrison Mills

4.5 Yellow-cedar Breeding Program

John Russell, Craig Ferguson

There are currently clonal values from approximately 5,000 clones represented in three series of annual testing. Nine-year data from the first series of cloned progeny tests have shown that the top 1% of the clones results in 15% volume gain at 60 years. These new clonal selections are currently being re-propagated for eventual operational release. As new selections come on line from all studies, breeding orchards – both low and high elevation – are being updated. Maintenance continued this year in both field trials and breeding orchards. In addition, the project was engaged in monitoring 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. Provenance trials were also maintained. Breeding continued for a deer-resistance heritability study.

4.6 Coastal White Pine

John King, Rich Hunt (CFS), Dave Ponsford

In the fall of 2004 we established the first phase (with 90 families) of the F1 breeding program. Three sites were established – one on Texada Island and two on the Sunshine Coast. A second phase is currently growing at the Surrey nursery to be established in the fall of 2005. A third phase is to be sown in the spring of 2005. 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. Whether we will still have the services of Gary Roke waits to be seen. Ongoing pathology support by the CFS is seen as vital, especially with the establishment of the F1 generation. The university replacement that we see as viable with the entomology support (see Sitka spruce) is not such a clear option with the blister-rust-resistance program.

We are still working with Stefan Zeglan on the regional deployment guide. This has been temporarily stalled because we hope to make it compatible with a similar guideline for Sitka spruce, but we hope to see it out early in 2006.

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.

4.7 Interior Douglas-fir

Barry Jaquish, Val Ashley, Gisele Phillips, Bonnie Hooge

Breeding: One hundred and thirty-five controlled crosses were completed, and 222 pollen lots were collected, processed, and stored for future crossing. Most of these crosses and pollen lots were from the high priority Nelson SPU.

Progeny Testing: Four 15-year-old sites in the Mt. Robson test series (Quesnel Lake SPU) were maintained and measured. Parental breeding values for individual tree volume (in percent gain over the average wild-stand population) at age 60 based on the measurement trait height at age 15 ranged from -62.6 to 41.8.

***Armillaria* Resistance Screening:** The joint BC Ministry of Forests/Forestry Canada pilot project to screen interior Douglas-fir families for resistance to *Armillaria* root disease continues to produce promising results. To date, overall mortality attributed to *Armillaria* is 75 percent; however, there appears to be considerable variation in mortality among families (range 39-100 percent). Interestingly, there appears to be a positive relationship between mortality and elevation of the parent tree. This experiment will be terminated in fall 2005.

Site	Elevation (m)	Num. of Trees	Mean height (cm)	Survival (%)	Damage (%)	Range family of mean heights (cm)	Heritability (individual)	Heritability (family)
Kinbasket Lk	760	5797	428.7	87.6	2.6	306 - 573	29+/-.05	58+/-.10
PGTIS	760	4798	462.4	72.6	8.0	299 - 575	36+/-.06	56+/-.10
Tete Jeune	914	2582	363.4	75.3	1.9	175 - 537	54+/-.09	53+/-.10
Valemont	914	6053	565.9	91.5	1.3	410 - 657	35+/-.05	62+/-.10

Figure 7. Summary of the 15-year results from the Mt. Robson interior Douglas-fir progeny tests (209 families) measured in fall 2004

4.8 Interior Spruce

Barry Jaquish, Val Ashley, Gisele Phillips, Bonnie Hooge

The interior spruce tree improvement program is the oldest program in the BC interior. It began in the mid-1960s with parent-tree selection and open-pollinated progeny testing in three selection units. It expanded rapidly in the late 1970s to encompass other important seed planning zones in the interior. The program focuses on improving traits related to tree size, certain wood traits, and resistance to terminal weevil (*Pissodes strobi*) through recurrent selection for general combining ability. It has progressed to the point where improved first-generation seed orchards are in full production for most zones, and second-generation full-sib progeny tests are in place for three seed planning units (SPUs). The emphasis of much of the recent breeding work is to maintain and measure the vast array of progeny tests, to bring together populations from the two programs to accommodate new and larger seed planning units, and to predict population responses to predicted global climate change.

Progress During the Last Fiscal Year

Breeding: Twenty controlled crosses were completed in the newly expanded Prince George SPU. This crossing program completes the amalgamation of breeding populations from seven smaller seed zones. Seeds for field testing will be sown in spring 2005. In addition, 13 crosses were completed and 25 pollen lots were collected from parents in the Nelson mid-elevation SPU. Twenty-one crosses were completed by Riverside Forest Products staff in the Armstrong Thompson-Okanagan seed orchard.

Progeny Testing: Four six-year-old and three ten-year-old progeny tests were maintained and measured in the Fort Nelson and Nelson SPUs, respectively (Figure 9). Ten-year measurements were recorded from the Thompson Okanagan high-elevation progeny test at the Skimikin Seed Orchard. This test was subsequently terminated and removed to make way for establishment of the Fort Nelson spruce seed orchard. Wood relative density was determined by the oven-dry weight/green volume method on wood disks collected from 16 trees per family in the Shuswap Adams progeny test at the Skimikin Seed Orchard (Figure 8). In the second-generation test series, the four six-year-old Bulkley Valley tests were maintained and measured, while the East Kootenay and Prince George sites were maintained.

In the support research program, three 10-year-old East Kootenay realized-gain tests were maintained and measured, and five candidacy tests of somatic emblings were maintained and measured. In the two-year-old raised bed Prince George genecology study at Kalamalka, shoot elongation was measured 25 times throughout the growing season. The three accompanying field sites near Prince George were also maintained. Seedlings for the new climate change study were also grown, lifted, and cold-stored and will be planted this spring on 18 climatically contrasting sites in BC, Alberta, and Yukon Territory.

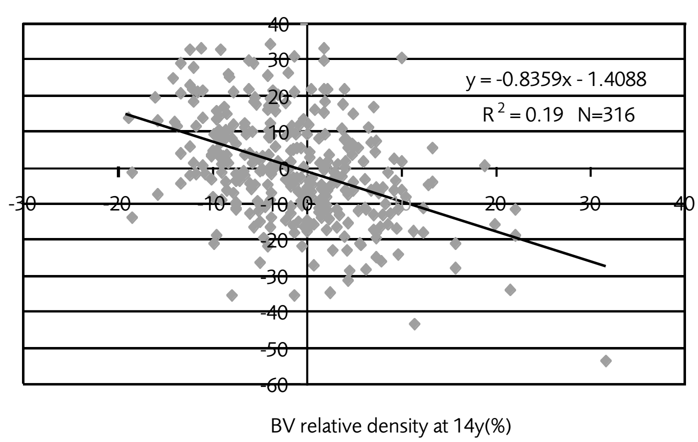


Figure 8. Relationship between predicted parental breeding values for wood relative density (age 14) and individual tree volume at age 80 in Shuswap Adams interior spruce at the Skimikin Seed Orchard

Site	Elevation (m)	Num. of Trees	Mean height (cm)	Survival (%)	Damage (%)	Range family of mean heights (cm)	Heritability (individual)	Heritability (family)
1. Fort Nelson open-pollinated tests: six-year results 209 seedlots								
Cridland Ck	450	5526	96.3	84.1	4.6	64 - 130	.18+/-.04	.46+/-.11
Inga Lake	820	5720	83.4	86.1	11.4	63 - 108	.14+/-.04	.36+/-.11
Martin Ck	1140	3586	59.4	54.1	24.0	39 – 78	.25+/-.06	.47+/-.11
Muskeg Lake	1030	5646	56.2	86.3	13.6	39 – 73	.15+/-.04	.43+/-.11
2. Nelson polycross tests: ten-year results								
Low-elevation population (< 1100 m): 77 families								
Cortiana Ck	1830	2191	144.4	74.9	3.7	99 – 175	.26+/-.08	.58+/-.18
Duhamel Ck	1475	2213	161.4	71.5	4.6	121 – 197	.24+/-.08	.53+/-.17
Hall Ck	1200	1571	153.9	50.4	7.7	119 – 188	.17+/-.08	.39+/-.17
Mid-elevation population (900 - 1600 m): 261 families								
Cortiana Ck	1830	7817	150.7	80.5	3.9	116 – 185	.23+/-.04	.55+/-.09
Duhamel Ck	1475	7658	161.0	73.5	3.5	121 – 206	.24+/-.04	.53+/-.09
Hall Ck	1200	4978	148.8	49.7	9.6	109 – 198	.22+/-.05	.43+/-.09
High-elevation population (> 1400 m): 169 families								
Cortiana Ck	1830	5545	153.1	83.0	3.9	119 – 182	.19+/-.04	.52+/-.11
Duhamel Ck	1475	5047	162.3	74.7	3.5	128 – 206	.21+/-.05	.51+/-.11
Hall Ck	1200	3085	148.3	48.4	10.2	117 – 190	.10+/-.05	.26+/-.11

Figure 9. Summary of results from the Fort Nelson and Nelson interior spruce progeny tests measured in fall 2004

Plate 3. Barry Jacquish presents Douglas-fir provenance results at the Skimikin Seed Orchard to CTIA participants

4.9 Genetic Resistance for Western Gall Rust (*Endocronartium harknessii*) in Lodgepole Pine

Michael Carlson, John Murphy, Vicky Berger

Western gall rust is a serious disease pest of lodgepole and ponderosa pines throughout much of the range of both species. In lodgepole pine the disease gains entry to branches or main stems thru needles of the current year's shoot extension. After infection, a gall forms on the branch or stem. If a disease gall grows more rapidly than the branch or stem, it will girdle and kill the appendage at that point. Although stem galls may not kill a tree, they often result in breakage of the stem at the gall, rendering the tree non-merchantable.

In our first cycle (generation) of lodgepole pine progeny testing across several SPUs our focus has been on improving stem-volume growth. When measuring a particular progeny site, we have assessed damaging agents (diseases and insects) only if 10% or more of the trees were affected. Most of our Pli test plantations are healthy and exhibit few disease or insect pest problems. Three of our thirty-nine first-cycle test sites have shown western gall rust infection rates exceeding 10% of trees tested. Disease severity surveys of two progeny test sites north of Mackenzie in 2004 (with the technical guidance of Richard Reich, northern region pathologist) are providing insights into patterns of genetic resistance to western gall rust in lodgepole pine.

Although most of the progeny tested parents are from central interior origins, we tested parents from a range of 50 to 60 degrees north, 119 to 129 degrees west, and from a wide range of elevations. Disease resistance as measured by the total number of galls per tree varied weakly with geographic variables of latitude, longitude, and elevation of parent-tree origins. Although some provenances exhibited greater average levels of resistance than others, the variation in resistance among families within provenance was the major source of variation in disease resistance (see Figure 10). Family resistance values measured on two sites were highly positively correlated, suggesting little GxE (see Figure 11). Apparent high heritability for gall rust resistance and low GxE suggest the possibility of selecting for a rust-resistant seed orchard for this high-rust-hazard area in the north central interior. There appears to be no correlation between rust resistance and breeding value for growth (see Figure 12). Selecting solely for rust resistance (i.e., no improvement in growth) may be the best strategy for the Mackenzie area.

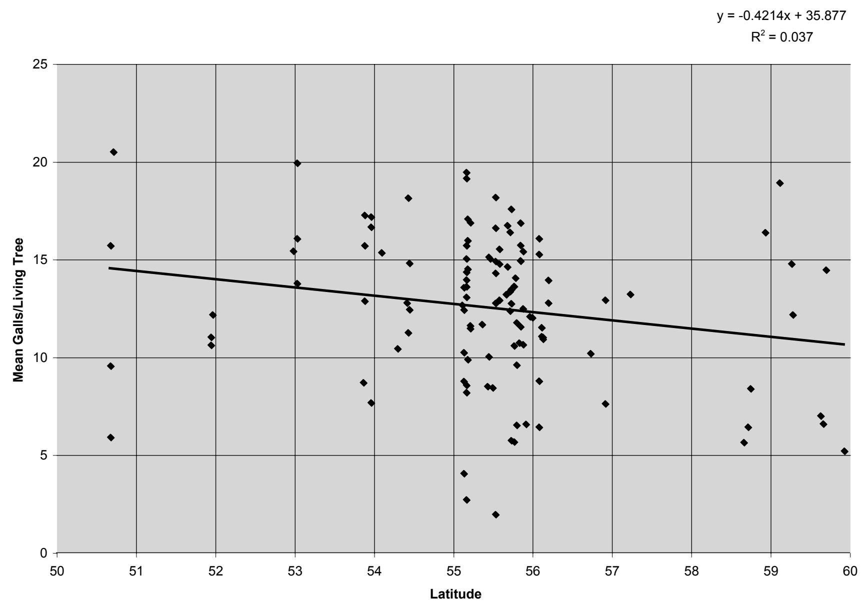


Figure 10. Blackwater Creek 118 OP Families

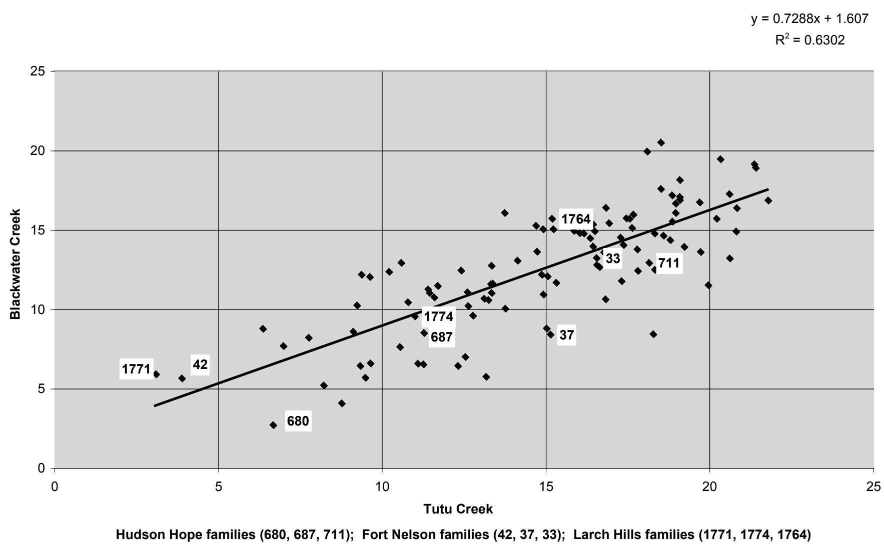


Figure 11. Blackwater on Tutu (Mean Galls/Living Tree) 112 OP Families

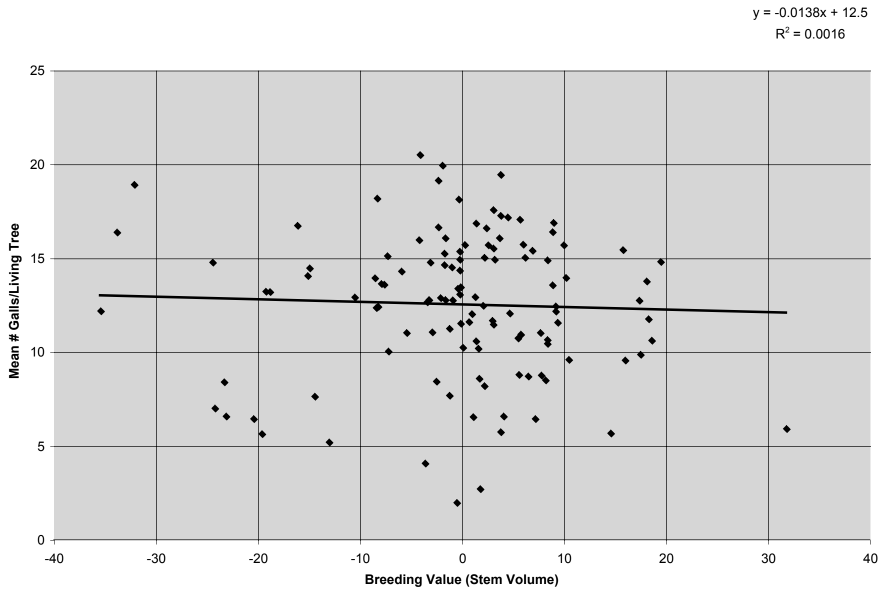


Figure 12. Blackwater Creek 118 OP Families

4.10 Western White Pine Blister Rust Resistance Screening: Ongoing in the Interior

Michael Carlson, Vicky Berger, John Murphy

Nursery screening for blister rust resistance in western white pine control-pollinated families began in the year 2001 in the interior at the Skimikin seed orchard site. The screening process requires six to seven years to complete. One-year-old seedlings of control-pollinated families are potted-up into styro 615s. Near the end of their second year they are subjected to a heavy inoculation treatment under rust-infected Ribes plants at the seed orchard site. Early in their third year they are evaluated for needle spotting and later for canker development. Early in their fourth year they are further evaluated for canker development (see photo). Those with well-developed/sporulating cankers are discarded; those with early canker formation and those with no visible cankers are outplanted in a nursery bed for further observation in their fifth and sixth years. If by the fifth year well-developed cankers are evident, the seedling is discarded. If a seedling has a slow growing canker or no canker in the fifth year, it is retained for evaluation in the sixth year. If canker growth remains slow or no canker has developed by the seventh year, the seedling is considered a candidate for our advanced-generation seed orchard.

With our last 61 families sown this year and scheduled for inoculation in the summer of 2006, we will have tested a total of 177 families.

4.11 Ponderosa Pine Reselection Work at the Skimikin Seed Orchard Site

Michael Carlson, John Murphy, Vicky Berger, Keith Cox, Chris Walsh

In 1992 we planted a Ponderosa pine provenance trial with seed sources from the U.S.A. (42) and B.C. (31). In year 2000, based on nine-year stem volume measurements, the Skimikin plantation was thinned to the top 20% of trees. An index score based on provenance mean and individual trees within provenances was used to rank trees for culling. The resulting plantation of 460 trees became our first Ponderosa pine seed orchard.

Discussions of climate change scenerios predicting drying and warming conditions for much of the southern interior of B.C. have prompted new interest in Ponderosa pine for reforestation planting. At the end of the 2005 growing season (13th), we will again measure stem volumes and rank provenances and trees within provenances. A small, select number of trees (see candidate tree photo) will be clonally propagated (grafted) over a two-year period to provide for a future seed orchard(s).

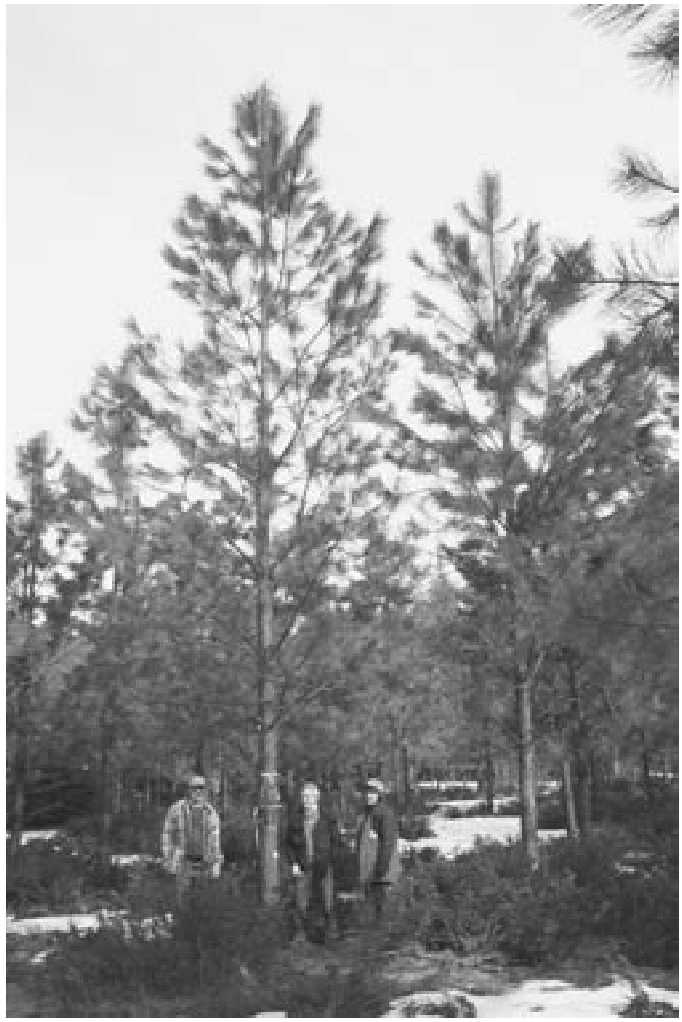


Plate 4. Ponderosa pine Reselection Work at the Skimikin Seed Orchard Site

Plate 5. Western White Pine Blister Rust Resistance Screening

4.12 Western Larch

Barry Jaquish, Val Ashley, Gisele Phillips, Bonnie Hooge

The BC western larch program was initiated in 1987 and has advanced rapidly. The program strives to improve tree size through recurrent selection for general combining ability.

The main components of the program are phenotypic selection of parent trees in wild stands, open-pollinated progeny testing, soil-based seed orchards, and second-generation crossing. To date, 609 parent trees have been selected and wild-pollinated families of 607 of these parents have been established in progeny tests across 14 sites in two SPUs (East Kootenay and Nelson).

Two grafted seed orchards were established in 1990 and are now in full production. Presently, over 70% of the 6.5 million western larch seedlings planted annually in BC originate from Class A seed orchard seedlots. Second-generation crossing is over 45 % complete.

Breeding: In the second-generation crossing program, 30 and 14 crosses were completed in the East Kootenay and West Kootenay SPUs breeding orchards respectively. Eighty-eight pollen lots were collected, processed, and stored for future crossing.

Progeny Testing: Four 10-year-old sites in the East Kootenay Series II test were maintained and measured. Parental breeding values for individual tree volume (in percent gain over wild-stand seedlots) at age 60 based on the measurement trait height at age 10 ranged from -31.8 to 22.6.

Realized Gain Testing: Three realized-gain test sites were established in the Nelson SPU. The main objective of these tests is to estimate yield of western larch seedlots of different genetic quality on an area basis. The experiment was established in a randomized complete-block design with three levels of site quality (low, medium and high), four levels of genetic quality (composite elite full-sib crosses, high genetic-worth seed orchard, low genetic-worth seed orchard, and composite operational controls), three levels of espacement (1.5 x 1.5 m; 2.5 x 2.5 m; and 3.5 x 3.5 m), and two replicate blocks per site. Plots consisted of 144 trees planted in 12 x 12 tree configuration.

Site	Elevation (m)	Num. of Trees	Mean height (cm)	Survival (%)	Damage (%)	Range family of mean heights (cm)	Heritability (individual)	Heritability (family)
Angus Ck	1140	4168	472.0	85.7	1.7	330 - 563	.27+/-.06	.51+/-.13
Lower Lamb Ck	1145	4677	400.7	96.1	1.2	254 - 474	.39+/-.07	.64+/-.13
Semlin Ck II	1035	4066	474.2	83.4	2.8	258 - 462	.42+/-.08	.62+/-.13
Upper Lamb Ck	1370	4269	391.1	88.1	1.4	327 - 567	.25+/-.05	.54+/-.13

Figure 13. Summary of the 10-year results from the East Kootenay Series II western larch open-pollinated progeny tests (160 families) measured in fall 2004

5.0 Operational Tree Improvement – The Eighth Year in Review

Roger Painter

In many ways this has been a watershed year for this program. 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. Seed requests in 2004-5 have now reached 50% of provincial reforestation needs, and our genetic gain is close to meeting the overall target set for 2007 by the Forest Genetics Council in 1997. This sub-program represents the strategic device that we have employed to invest in existing orchards and bring them up to their potential. This, coupled with the development of replacement stock from the breeding programs, has raised the genetic worth of orchards to more acceptable levels. At the same time, this program relies on 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 over achieved.

Although 2004-5 was a lighter than normal year for most species crops, considerable work was done in stock replacement and studies on seed supply issues. Unfortunately, some crops sustained large attacks by insects, specifically *Dioryctria*, that reduced yields. This underlined the need to focus more attention on Seed Pest Management, along with establishing a stronger mandate for research in that field and further development of the Seed Pest Management Technical Advisory Committee and its associated sub-program. Future research and development projects that used to come through OTIP will now be sent to that sub-program. This is an example of the continued definition of focus and planning procedures within the overall program that has allowed us to concentrate our efforts despite limitations in funding. The Forest Investment Account continues to show strong support for our program and to keep funding constant at current levels. Available supplies of seed from our seed orchards continue to increase, and the genetic quality of seed crops continues to improve. In the long term, our province will enjoy a future supply of excellent wood products and a healthy resource as a result of the foresight of investing now.

In 2004-5, the two technical review committees reviewed a total of 76 requests for funding in OTIP. The total amount of proposals received was approximately $930,000. The Coastal and Interior technical committees recommended that $694,813 be approved. The breakdown of investment by region for all of OTIP is as follows:

Interior projects	44	$455,837
Coastal projects	30	$238,797
Overall total	**74**	**$694,813**

Figure 14. Number of projects and funding by region

The Forest Genetics Council has the support of various species committees that review annual projects and develop priorities. These reviews give direction to both the Tree Breeding and the Operational Tree Improvement programs. Similarly, the Extension and Gene Conservation TAC's have developed their own priority review procedures. Tree Breeding, as a Ministry of Forests responsibility, is not part of the OTIP "Call for Proposals" process. Priorities for the Tree Breeding sub-program are still developed through the species sub-committees, but decisions on projects to be undertaken are reached through co-ordination with the Tree Improvement and Research branches of the Ministry of Forests and the FGC Program Manager. Considerable investment is needed in this sub-program, which will continue to receive strong levels of support to ensure the development of new production stock for future orchards. New orchards will focus on producing seed for Seed Planning Zones in which production capacity is low and/or priorities for genetic- quality seed are high. These new orchards will also help produce stock to replace older, less advanced stock in existing orchards. Work in Tree Breeding has already provided much of the genetic material to establish a number of new orchards recently and to enhance existing ones. The development of a long-term investment program through SelectSeed Ltd. has produced over 35,000 grafts for new orchard establishment so far.

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 has been an excellent example of focused investigations to solve serious problems affecting tree improvement. Listed below is a project breakdown by areas of investment for 2004-5:

Tree Breeding	36
Gene Conservation	7
Operational Production	57
Technical Support	17
Seed Pest Management	4
Extension and Communication	4
Seed Planning and Information Tools	2

Figure 15. Number of projects by areas of investment

The tree improvement industry represents a broad spectrum of partners, including forest companies, the provincial government, the Canadian Forest Service, universities, private bio-technical companies, and individuals. In 2004, the Tree Improvement Program involved 37 separate contributors from all parts of our industry. The Forest Genetics Council continues to provide sound leadership and management through its technical committees and through the use of a strong business management approach for setting priorities and goals for investment. It also offers a strong sense of renewal through review of program goals and strategic planning.

5.1 Orchard Projects

5.1.1 Saanich Forestry Centre

Annette Van Niejenhuis

Western Forest Products Inc. manages production tree seed orchards for eight seed planning units, together with hedge orchards for one seed planning unit at the Saanich Forestry Centre. As a co-operator in the Forest Genetics Council programs aimed at delivering quality seed in quantity to the coastal forest regeneration programs, WFP has employed OTIP funds for incremental management techniques in six seed planning units.

SPU 0107:

Our low-elevation coastal Douglas-fir orchard is being improved with replacement clones. One hundred and seven ramets of fourteen clones have been acquired (ten new clones and four orchard clones). These ramets will be planted in the orchard, replacing mortality and very poor genetic quality clones. Aggressive roguing and pursuit of gain is deferred until more seed is banked in this SPU. With the addition of these ramets, the average breeding value of this orchard is raised from 11.1 to 12.1.

Only a small crop was available for management in 2004, and insect damage of cones was the highest ever recorded in this orchard. For these reasons, crop management was minimized. High-gain pollen (6.2 litres) was harvested, extracted, and banked for future deployment.

SPU0206:

An improved western redcedar replacement orchard was planted in 2004. With this stock, the average breeding value is raised from 5.4 to 6.5. This orchard includes clones from the first three series of western redcedar polycross progeny tests. As additional results from these trials are received, about 50% of the ramets will be rogued and replaced with clones from the final three series of progeny tests, with the expectation of improving the breeding value to 10 or higher.

The 2004 western redcedar crop was infested with cone midge. Trees with significant crop were treated with dimethoate under SUP 111-210-04/04. On sprayed trees all midge were killed, but few seeds developed and no crop was harvested. It is unknown whether the treatment, the damage from the midge prior to the treatment, or other factors such as poor pollen success caused the poor seed set. The treated trees showed foliar damage.

SPU0304:
Supplemental mass pollination was applied to the western hemlock crop, focussing on clones with a high propensity to self-pollinate. The resulting seedlot has a genetic worth of 14 and is estimated to produce 110 thousand seedlings. High-gain seed is needed in this SPU; little seed of genetic worth of 9 or greater is banked.

SPU0601:
Seed production in the weevil resistant Sitka spruce orchard continued to increase. Supplemental mass pollination to improve seed set was applied. The resulting crop, including surplus seed from past controlled pollination, has a weevil resistance rating of 86% and is being deployed to the 2005 nursery crop for 74 thousand trees.

Ramet replacement will continue with the addition of 31 ramets. Our intent is to include all clones for which testing is underway. When test results are known, roguing will maintain high weevil resistance, combined with volume selection.

SPU1104:
More than 900 donor stock replacements were established in the yellow cypress production hedges. With these replacements, the average clonal value of the hedge is increased from 19% to 20%. Spot treatments for trisetacus mites were required to maintain cuttings production, and pruning of young hedges was implemented to improve the quantity and quality of the material. The 2005 nursery crop includes 314 k of yellow cypress cuttings with a clonal value of 19 or greater.

SPU1110:
A study of the optimum rooting strategy for technical support in deploying yellow cypress was initiated. Cuttings from the TimberWest and Western Forest Products hedges harvested and set at Sylvan Vale and Arbutus Grove nurseries on four dates will provide information about optimum timing for setting. The expectation is that optimum timing will result in improved nursery recoveries. This will lead to maintaining present stock prices and prevent increased stock prices. It will also improve the deployment of the high-gain material available through this clonal regeneration program.

SPU1112:
A clonal rootability study of the MoF high-gain yellow cypress clones will permit selection of good rooters in the production hedges. A selection of nine MOF clones from TimberWest and Western Forest Products hedges and twenty-two WFP clones from Western Forest Products hedges were set clonally in November of 2004 at Arbutus Grove and Sylvan Vale nurseries. These trials will be repeated to determine which high-gain clones are poor rooters (<50% success). These will be removed from production hedges to improve the overall nursery recoveries in the yellow cypress rooted-cuttings program. Those poor rooters with extremely high clonal values will be included in breeding orchards to determine if rootability is heritable and if breeding can alleviate the poor rootability and lead to new high-gain selections with high rootability.

SPU2401:
No crop was available for management in the high-elevation western hemlock orchard. Ramets were acquired for replacement and are maintained, but the planting is deferred until site problems are addressed.

Western Forest Products has been tracking the genetic worth of SelectSeed deployed to the nursery (Figure 16). Significant gains in the average genetic worth of yellow cypress have been achieved since 1996, with the 2004 nursery crop averaging 20% volume gain. Douglas-fir and western hemlock also display strong gain trends in this period. Western redcedar orchards will soon be delivering significant volume gain to the regeneration programs. The Sitka spruce program is geared to weevil resistance ahead of volume; thus, it will be a decade before volume gains are delivered there. The weighted average volume gain of all A-class SelectSeed deployed by Western Forest Products is now above 6%. Factoring in the wild stand seed deployment with the A-class SelectSeed deployment, average volume gain drops to just under 5%. Throughout this period the deployment level has increased from 65% to 75% across all of our coastal regeneration programs, with 100% deployment in most seed planning units for which orchards exist. The Forest Genetics Council's Operational Tree Improvement Program assists the development and production of high-quality seed for deployment in our coastal regeneration programs.

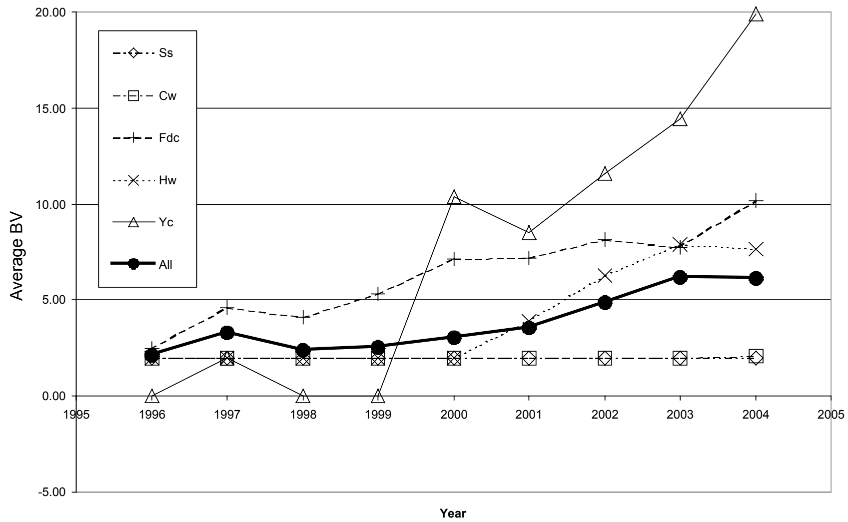


Figure 16. Weighted Average gain for SelectSeed in WFP orchards only

Plate 6. Yellow cypress clonal trial selections

Plate 7. J. Russell discussing wood quality and breeding at Coastal Silviculture Committee meeting

Plate 8. Our first weevil resistant seedlot from Ss 172

5.1.2 Sechelt Seed Orchard

Patti Brown

Douglas-fir

Orchard #177 produced its first crop in response to the 2003 inductions. Although 10 litres of cones were collected from controlled cross-pollinations, only 1 kg of seed with a GW of 18 was extracted. Despite being bagged during pollination and after for insect protection, *Dioryctria* must have been present on the branches prior to bagging, and most of the crop was destroyed.

One hundred fifty ramets in orchard #116 were induced in June 2004 in response to a lack of availability of high-elevation Douglas-fir seed.

Western redcedar

The ramets in the holding beds were fertilized monthly and pruned to increase the surface area. Those parents with a GW of >6 were induced, along with the main orchard (#186), in July. Orchard #186 and the holding beds were rogued in February to remove ramets from Series 2 with age 7 results of GW<5. Pollen from the top ten parents was collected for reapplication to females in orchard #186 and seed-producing ramets in the holding beds. The sunny dry weather in February 2005 caused the males to shed pollen early and the females to lag behind, resulting in less selfing but also less seed set from natural pollinations.

Project SPU0211 advanced the breeding program material into orchards by grafting Series 3 and Series 4 material. In November 2004, 5,292 grafts were completed, and these will be incorporated into orchard holding beds in 2005.

Western white pine

The goal of SPU0801 was to increase the slow-canker-growth resistance value of orchard #174 in the long term and to produce a crop with > 50% major gene resistance (MGR) in the short term.

This year's MGR crop (> 50% resistance) was monitored and closely spot treated for *Leptoglossus* from May to August. The resultant high-yield crop has the potential to produce 300,000 plantables. The 2005 crop was hand pollinated with either MGR pollen or an elite mix of slow-canker pollens.

Eighty lower-resistance-value trees were removed from orchard #174 in the summer of 2004, and they will be replaced with the survivors of the 245 higher-value, slow-resistance clones that were grafted in April 2004.

Yellow-cedar

SPU1101 continues with the goal of producing 300,000 stecklings with a GW of > 12% annually for our coastal operations. To achieve this, donors are grown and cultured at Cairnpark Nursery. The top selections from the Ministry of Forests Series 2 and 3 breeding programs plus Western Forest Products' breeding program were obtained in 2004/05 and are being cultivated at Cairnpark to produce large numbers of future donor plants, thereby increasing the average GW value of our vegetative lot from 12 to 18.

5.1.3 Mount Newton Seed Orchard

Tim Crowder

Seven Operational Tree Improvement projects (OTIP) were carried out at Mount Newton Seed Orchard this year.

Enhancing Productivity and Gain in Four Coastal Douglas-fir Orchards (SPU 0106)

SMP was carried out in orchard #183, and on early- and late-flowering clones in orchards #134 and #154.

Cones were monitored for *Contarinia* midge during the pollination season, and because infestation levels were high, all three orchards were treated with dimethoate.

Over 800 ramets were induced by stem injection of GA4/7 to produce a crop in 2005. This included some ramets from orchard #197 for the first time.

Following the harvest of the 2004 crop, 40 ramets with low BV were rogued from the orchards, and 250 grafts were planted in vacant orchard locations. Grafts that were too small to plant out were maintained in a holding bed.

In the fourth quarter, 1,200 grafts of high BV clones were made for future upgrading of the Douglas-fir orchards.

Enhancing Productivity and Genetic Gain in Two Western Redcedar Orchards (SPU 0205)

The genetic worth of the 2004 seed crop in orchard #140 was 7%, the highest gain so far for an open-pollinated seedlot from this orchard.

Upgrading programs continued in 2004 in orchards #140 and #152. Vacant spots in both orchards were de-stumped and planted with high-ranking clones from the holding beds. Top-ranked clones from all three test series were included.

Orchard #152 was induced for a seed crop in 2005 through foliar application of GA3.

Increased Production and Gain from Western Hemlock Orchard #182 (SPU 0310)

Two clones with BV less than 4 were rogued from orchard #182 and replaced with a total of 30 ramets from several clones with BV of 15 or greater. An additional 100 ramets were grafted to provide replacement stock for future roguing operations.

Because the ramets in orchard #182 are still relatively small, SMP was used to supplement the insufficient pollen cloud. The genetic worth of the 2004 seed crop in orchard #182 was 14%.

One-quarter of the trees were large enough to be induced for the first time, and so were injected with GA4/7 to produce a crop for 2005.

Management of Western White Pine Orchard #403 (SPU 0808)

Three hundred ramets were transplanted from the holding bed into empty spots in orchard #403, and 300 grafts from the previous year were transferred into the holding bed. Two hundred new grafts were made of clones that had failed to take or were not available previously.

MGR pollen was obtained from CanFor and applied to most of the developing cones for the 2005 seed crop.

Leptoglossus bug continued to be a threat in 2004 and required frequent monitoring and control.

Maintenance of *Abies amabilis* Orchard #129 (SPU 0901)

Because orchard #129 is the only remaining Ba orchard in the province, the objective of this project is to maintain and manage the orchard to increase the knowledge base for seed production in this species. In addition, Ba seed for reforestation is produced.

2004 was a light crop year for orchard #129, following the exceptional crop of 2003. The 1,115 ramets were maintained with irrigation, pruning, and vegetation control.

Yellow-cedar Hedge Management (SPU 1109)

The objectives of this project are twofold: 1) to continue to produce 300,000 cuttings annually with a GW of 12% or greater, and 2) to bulk-up and hold 120 clones from series one and two of the MoF testing program.

These objectives were achieved through maintenance of the productive field-based hedge of 3,000 donor plants, and maintenance of 2,000 potted ramets in a greenhouse.

Management of High-elevation Western Hemlock Orchard #130 (SPU 2402)

A crop for 2005 was induced by stem-injecting non-crop trees with GA4/7. The 2004 crop had a GW of 6%. Cones on non-tested trees in the orchard were not harvested.

5.1.4 Bowser Seed Orchards

Dan Rudolph

Genetic Upgrading and Enhancing Seed Yields and Quality From Second-generation Douglas-fir Seed Orchards (SPU 0110)

This project is a multi-year effort and is being conducted in three second-generation seed orchards, #149, #162 and #168 (a micro-orchard containing the same clones as #162), at the Ministry of Forests' site at Bowser.

There are two main objectives:

1. To upgrade the genetic composition of the orchards by roguing the lowest-ranked clones and replacing them with higher-ranked parents, and
2. To enhance the seed yield and genetic worth of the seedlots produced by:
   -using cone-induction techniques on all suitable candidates in each orchard.
   -using controlled-pollination techniques in both orchards in order to produce elite seedlots.
   -using orchard-management techniques to optimize growing stock vigour and crop health and so maximize yields.

Results

1. Upgrading

At the Cowichan Lake Research Centre, 2,451 grafts from 17 of the highest-ranked clones (breeding values between 18 and 26) have been propagated. Twelve hundred of these ramets will be transplanted into a holding area on-site during the fall of 2005; the balance of the stock is to be transplanted into a similar holding bed at the Saanich site for eventual inclusion in an orchard to replace orchard #149, which is currently at Bowser. The holding area at Bowser is to be developed during the fourth quarter of this fiscal year.

2. Enhancing seed yield and genetic worth

Controlled crossing: 89 ramets from 17 of the highest-ranked parents in each orchard were identified, and isolation bags were put on 1,030 branches of these ramets. Controlled crosses using pollen mixes with high genetic worth were made. Pollination bags were replaced with insect bags after orchard receptivity had passed.
Induction: Suitable candidates for induction were identified in each orchard. Criteria used to establish a candidate list included negligible current year's crop, no crop from last year, no induction treatment last year, sufficient vigour, and an adequate number of cone-bearing sites. Induction treatments consisting of a double overlapping girdle and application of fertilizer at the rate of 300 kg N/Ha were applied. Irrigation was withheld until mid-July in order to increase drought stress on the trees.
Orchard management: All orchard trees were maintained through appropriate cultural practices.
Insect management and control: surveys were conducted for *Contarinia oregonensis* and *Leptoglossus occidentalis*.

Output and deliverables

1. Upgrading

The removal of the lower-ranked clones in orchard #162 during the first year of this project raised the overall genetic worth of the orchard from 12.5% to 15%. When the new clones are established in the orchard, the overall genetic worth of the orchard will rise to 20%.

2. Enhancing seed yield and genetic worth

Controlled crossing: Seedlot #60395 was produced from the controlled crosses done in spring 2004. Seed yield was 0.464 kgs of seed with a genetic worth of 18.6.
Induction: A total of 275 trees were induced – 62 from orchard #149, 138 from orchard #162, and 75 from orchard #168. Bud surveys to rate efficacy of the treatments are to be done in late March 2005.
Orchard management: Foliar nutrient samples were taken; fertilizer was applied for both growing stock and crop maintenance; irrigation was applied when necessary; trees were basal-pruned, top-pruned, and inter-nodal-pruned, and identity tags were upgraded prior to cone collection.
Insect monitoring/control: Because *Contarinia* levels were within the acceptable threshold level, no control measures were necessary. *Leptoglossus* levels were also low; therefore no control measures were undertaken.

5.1.5 Kalamalka Seed Orchards

Chris Walsh

Ten OTIP projects were approved under the operational production sub-program for 2004/2005 at Kalamalka Seed Orchards. 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 collection of high-breeding-value pollen from clone banks and the application of Supplemental Mass Pollination; and

- improving orchard productivity through pest management and other management activities.

Pest management activities funded included:

- use of Safer's Soap sprays to control galling adelgids,
- removal of weevil-infested spruce leaders to reduce weevil populations,
- removal of 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,
- dormant oil application to control larch adelgids,
- sprays to control *Cydia* and *Strobilomyia* in Sx cones,
- sprays to control *Leptoglossus*, and
- sprays to control spittle bugs and *Zelleria* in lodgepole pine orchards.
- other funded management activities to boost productivity and gain included foliar analysis to determine the nutrient status of orchard trees and crown management of orchard trees.

The OTIP funding was instrumental in increasing both the quantity and quality of seed produced. At Kalamalka in 2004 we produced approximately 180 kg of interior spruce, western larch, lodgepole pine, and western white pine seed, equivalent to over 25 million seedlings, with an average GW of +19. Kalamalka seed is being used over large areas of the interior of the province.

Project	Species	SPZ	Orchard	Pollen Collected (litres, dry)	Trees Pollinated
SPU0401	Sx	NE	305	3.0	581
SPU0502	Sx	NE	306	3.0	486
SPU0701	Pli	NE	307	5.0	1,687
SPU1302	Lw	NE	332	1.5	676
SPU1501	Pw	KQ	335		1,400
SPU2201	Fdi	NE	324	1.5	
SPU3501	Sx	BV	620	2.0	521
Totals				16.0	5,351

Figure 17. Pollen management activities by project

Project	Species	SPZ	Orchard	Roguing	Grafts Made	Maintained	Rootstock	Transplants
SPU0401	Sx	NE	305	51	150	339	100	210
SPU0502	Sx	NE	306	40	200	277	150	128
SPU0701	Pli	NE	307			46		
SPU1302	Lw	NE	332	30	150	502	150	171
SPU1501	Pw	KQ	335		28	239	150	41
SPU2201	Fdi	NE	324			67	100	77
SPU2501	Sx	EK	304	158				22
SPU3201	Pli	EK	340		125	379	100	16
SPU3401	Lw	EK	333	295	100	397	100	126
SPU3501	Sx	BV	620		60	247	50	32
Totals				574	813	2493	900	823

Figure 18. Orchard composition activities by project

5.1.6 Vernon Seed Orchard Company (VSOC)

Tim Lee

The seven funded projects approved for this year were an important part of our programs. Funding enables our staff to undertake projects that promote the complete management of all one-and-a-half-generation production orchards on site. Young orchards require additional activities to keep orchard seed production at its highest level each year. Our mature orchards that required upgrading were funded for the roguing of lower breeding-value or production-challenged families, and now the grafting and planting of replacements for the benefit of the Seed Planning Unit are completed.

VSOC manages eight orchards for production. These orchards were the first phase of our site development. The second phase included the addition of five more orchards. These orchards are not expected to be a part of the seed supply for eight to ten more years.

Individual Items

- **Pollen work** – Our young orchards have a limited supply of natural pollen, and with the processed frozen pollen from previous years, we can aid the early or late flowers. VSOC historically has picked, applied, stored, and frozen many litres of pollen for all our orchards. Our mature spruce orchards, on the other hand, are now left to the natural pollen cloud that has developed.
- **Supplemental Mass Pollination (SMP) treatments** – SMP is used in our orchards. The timely application of pollen can make the difference in ensuring the production of seed. Helicopters have proved to be a key factor in pollen management in large young orchards where pollen clouds are only beginning to be detected. Our pollen applications are getting more pollen into the receptive female flowers. Previously we were receiving only marginal pollen uptake into pollen tubes of pine.
- **Grafting** – Timely ramet replacement is dependent on an active, well-planned program that is aware of the needs of each SPU. Rootstock holding beds are managed with regard to a projected need for the continued improvement of each orchard. Information on family rankings and the advancement of the next generation of selections are always in the back of each orchard management team's mind. Orchards evolve as the breeder and orchard management teams see the next generation of ramets included into the orchard, but the team is always mindful of how to manage the transition periods that affect seed supply from each orchard.
- **Ramet replacement** – Replacement of rogued positions within an orchard are also important to orchard development.
- **Insect and disease control** – An important part of seed production is the control of such insects as *Leptoglossus occidentalis*, European pine shot moth, pine pith moth, and adelgids. These are a few of the insects that are monitored and controlled for the protection of our orchards' health and production.

Activities undertaken each year affect the quantity and quality of seed produced for this province. Funding made available has had a positive effect on the Forest Genetics Council's goals of 12% gain and 75% use of Class A seed for our province.

Break down of projects

Vernon Seed Orchard Company				OTIP- 2004				
SPU Project#	Species	Orchard	Pollen Litres	SMP - Treatments	Insect & Disease	Grafts Made	Holding beds	Planted
1201	All	Site	Nutrient Analysis for all Production Orchards					
1202	Pli	222	15	2000	4389	1650	1650	1362
1701	Pli	219	25	5000	5850	560	560	467
1801	Pli	218	12	3000	4300	350	350	275
3702	Fdi	226	8	300	351			
4102	Fdi	225	4	200	540			
4301	Fdi	231	10	600	1020			
Totals			62	11100	16450	2560	2560	2104

Figure 19. Break down of projects

5.1.7 Grandview Seed Orchards

Hilary Graham

Grandview seed orchards are located on Grandview Bench, about 20 km southwest of Armstrong, BC. At this site, three lodgepole pine orchards and one Douglas-fir orchard received OTIP funding for activities to increase the yield and genetic gain of seed produced. Orchards 308 and 311 provide seed for the Pli Thompson-Okanagan low-elevation seed planning unit (SPU), orchard 313 provides seed for Pli Nelson low-elevation SPU, and orchard 321 provides seed for Fdi Nelson low-elevation SPU.

Pli orchard 308 is a provenance-based orchard with an estimated genetic gain of 6%. Pli orchards 311 and 313 are 1.5 generation orchards each with an estimated genetic gain of about 16%. Fdi orchard 321 is a 1.5 generation orchard with an estimated genetic gain of 26%.

In 2004, OTIP funded a number of activities in these orchards. OTIP projects 0702, 1001, 1002, and 2101 covered activities in orchards Pli 313, 311, 308, and Fdi 321 respectively. These activities included insect and disease control, rodent control, crown management, foliar analysis, pollen monitoring, pollen collection, and supplemental mass pollination (SMP).

Pli Orchards – 2004 activities

In early spring 2004 foliar samples were taken to determine the appropriate fertilizer mix for spring application. Foliar samples were taken again later in the season for fall fertilization. These analyses helped direct fertilizer applications to ensure optimal nutrition.

Pollen monitoring began in May with monitors set up within all three Pli orchards and between orchards. Pollen monitoring indicated that there was a substantial pollen supply in orchard 308, and therefore SMP was not conducted in this orchard. The natural pollen cloud was much smaller in orchards 311 and 313, but SMP was not conducted due to operational limitations.

No protandry was observed in any of the Pli orchards; the shedding of pollen and flower receptivity coincided well. As the volume of pollen being shed increased, an air-blast sprayer (blowing a very fine water mist) was used on calm days to ensure good distribution of pollen in the orchards.

During the pollen flight period, pollen was collected from orchards 311 and 313 for future use. Whole pollen buds were manually collected by clone and brought into the laboratory for drying and processing. Over 12 litres of pollen with an average BV of 24.3 was put into storage.

Throughout the season, all Pli orchards were monitored for insect, rodent, and disease problems. This ensured that measures were taken to protect ramet health and seed quality. Pesticide sprays were applied as necessary to control *Leptoglossus* seed bug. Surveys indicated that fungicide sprays were not required in 2004. Poison baits were set out to control rodents feeding on tree roots, and pitch moths were removed by hand.

A small amount of crown pruning in each orchard encouraged branching and maintained the trees at a manageable height without compromising flower production.

Fdi orchard – 2004 activities

Pollen monitoring began at the first flight of pollen in the orchard. Pollen monitors were erected in a number of locations within the orchard, and they were monitored daily until the pollen flight was completed. Pollen shed and female receptivity were monitored throughout the pollination period, indicating the timing for SMP applications.

Pollen was applied three times in April with stored pollen from a 2003 collection (previous OTIP project). Pollen for future use was collected by a PRT crew at the Kalamalka Forestry Centre. Thanks to Barry Jaquish and Valerie Ashley for providing access to their clone banks for pollen collection and assisting the PRT crew. The pollen was processed and dried at PRT and put into freezer storage. Approximately half a litre of pollen is now available for SMP efforts in 2005.

With the exception of SMP in the Pli orchards, all projects were completed as planned. In the Pli Thompson Okanagan Low, 19.3 kg of seed was collected in 2004, with the potential to produce 3.2 million seedlings. In the Pli Nelson Low, 6.8 kg of seed was collected, with the potential to produce 1.1 million seedlings. The Fdi Nelson Low orchard produced a small crop of approximately 300 grams of seed with the potential to produce 15,000 seedlings.

The activities conducted in 2004 with the assistance of OTIP funding ultimately move us closer 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 Tolko Industries – Eagle Rock Seed Orchards

Greg Pieper

Tolko Industries manages the Thompson Okanagan high and low interior spruce and the Thompson Okanagan high lodgepole pine orchards to meet the Forest Genetic Council's objectives for delivery of improved seed for these seed planning zones.

Spu 1601 – Sx orchard #303 Activities

- There was no collectable cone crop in this orchard in 2004.
- Cone induction slated for this orchard was not completed because we felt the ramets were already under stress from the extreme summer weather over the past two seasons.
- Most of the activities in this orchard this year revolved around ramet health and insect control.
- *Dioryctria* was a problem this year.
- Foliar analysis samples were taken in the fall.

Spu 2801 – Pli orchard #310 activities

- A small crop of 14 hectolitres was collected from this orchard. Seed-set issues are still a major concern for us.
- During the pollination period, a helicopter was used to enhance the pollination cloud.
- Insect control is still the prime concern for this orchard, and six pesticide applications were applied for the control of *Leptoglossus*.
- *Sequoia* pitch moth was controlled by hand removal of the insect larva.
- Foliar analysis samples were taken in the fall.

5.1.9 Prince George Tree Improvement Station (PGTIS)

Rita Wagner

SPU 1203, 1802, 1702

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

Three Operational Tree Improvement Projects (SPU 1203, 1802 and 1702) were conducted at the Prince George Tree Improvement Station in 2004-2005.

High-gain pollen was applied to early and late-flowering clones in orchards #220, #223, and #228. Tractor towed air-blast equipment was used to facilitate pollen movement. Phenology surveys were completed to identify early/late-flowering clones.

Foliar samples were taken and analyses of nutrient status were completed in the fall.

Trees in all orchards were surveyed for western gall rust, *Lophodermella* needle cast, and mountain pine beetle.

Some strategies to increase flowering, including crown pruning and hormone application, were carried out.

The 2003 GA4/7 application had a strong positive effect on female flowering in all orchards, with no phytotoxicity. For ease of application and to further improve flower production, a standardized dose of 30 mgs GA/tree was recommended for older orchards #220 and #228 and 25 mgs for orchard #223. GA4/7 was applied twice (mid-July and mid-August) in 2004 as per recommendation. Some phytotoxicity was noted on some ramets of two clones in orchard #220 and #223. Flowering will be assessed in spring 2005 to decide whether or not to continue at these dosages.

Bottom branch pruning in orchards #220 and #228 was completed to facilitate better equipment and treatment access and better air circulation and weed control. About one-third of orchards #220 and $228 were topped to facilitate cone collection. Branches and tops were mulched to avoid burning of debris.

The fall 2004 cone harvest from the three orchards yielded 14.5 kg of seed and 2.5 million potential seedlings with a genetic worth of 6%.

SPU 1412

Management of interior spruce clone banks at the Prince George Tree Improvement Station is designed to ensure the availability of scion to replace existing orchard ramets or develop new orchards to boost productivity and gain.

The Interior Spruce Clone Banks at the Prince George Tree Improvement Station provide vital support to the orchard and tree-breeding programs in BC. The clone banks are a centralized source of scion material for the grafting of new and improved seed orchards. They contain the only copy of many of the interior spruce parent-tree selections found in seed orchards and breed arboreta.

Some fill planting was done to replace dead ramets.

Three hundred grafts were made in our greenhouse and transplanted into the holding area in mid-summer for planting in 2006. Five hundred ramets, grafted in 2001, were weeded, watered, fertilized, pruned, and monitored and treated for insects and disease. These grafts will be planted into the clonebanks in 2005.

Similar management activities were carried out in the 12,000-tree clone bank.

Plate 9. Cone collection with girette manlift

Plates 10 to 15. Equipment activities at PGTIS

5.1.10 Skimikin Seed Orchard

Keith Cox

Projects 404, 411, 501, 3502, 4002, and 4201

Work was funded in the research plantations and eight of the seed orchards at Skimikin in 2004.

The West Kootenay (Nelson mid and high) spruce orchards had 286 replacement grafts made in the spring and planted in the holding area. The orchards were surveyed for insects and disease and a total of 24 rust brooms (*Chrysomyxa arctostaphyli*) were removed and 203 of the smaller trees were sprayed for spider mites.

The white pine orchard (#609) was sprayed for the conifer seed bug (*Leptoglossus occidentalis*). The pollen collected, to be used in orchard 335 at Bailey Road, yielded 34.8 litres of dried pollen. Six blister rust cankered trees were checked by Rich Hunt, shortly before he retired, and rogued in the fall.

In the three spruce orchards for the Bulkley Valley Low, the crop was sprayed for spruce cone maggots, the conifer seed bug, and spruce cone rust. In the spring, 326 high breeding value trees in orchard 207 were injected with the flowering hormone GA. They were also drought stressed, along with the trees in orchards 208 and 229. In the fall, 371 trees were removed from orchard 207, increasing the average breeding value from eight to twelve. The trees were hauled to the nearby Salmon River for stream-bank restoration.

In the spruce orchard for the Peace River mid elevation zone (#212) the 2,723 trees were monitored for insects, disease, and rodents. Ninety weevil damaged tops were removed and the young orchard was baited extensively for rodents. Replacement grafts were maintained in the holding area and one-half litre of pollen was collected from the clone bank at PGTIS.

In orchard 206, for the Prince George High Spruce SPU, 348 trees were injected with GA and drought stressed to produce a crop in 2005. The trees were monitored for insects and disease. A total of eleven rust brooms were cut out and rodents were baited. In the late fall a total of 630 trees were removed, increasing the average breeding value from seven to eighteen. These trees were also shipped to the Salmon River.

The on-site research plantations were also monitored for insects and disease, baited for rodents, and two young plantations were irrigated. Approximately 3,500 white pine seedlings were also planted, as part of a rust resistance screening trial, and a site was prepared for about 3,500 more to be planted in 2005. The *Ribes* garden was maintained and white pine seedlings were inoculated in September. About 2500 trees from a Douglas-fir genecology trial were thinned and mulched. A total of 9,138 trees were removed from plantations no longer required, and a site was prepared for the planting of a spruce provenance test in 2005. The plantations were the main portion of the Canadian Tree Improvement Association (CTIA) summer tour here in July.

Plate 16. Trees being removed from old plantations

Plate 17. Preparing the site for a spruce provenance trial

Plate 18. Spraying in the Bulkley Valley spruce orchards

Plate 19. Mike Carlson discusses the results of birch provenance trials at the Skimikin Seed Orchard with CTIA participants

Plate 20. Planting replacement grafts in the holding bed

5.1.11 Saanich Seed Orchards

Carolyn Lohr

Four Operational Tree Improvement Projects (OTIP) were carried out at Saanich Seed Orchards this year.

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

Five, seven-day recorders were established at locations throughout the Saanich Peninsula. The objective of this project was to provide consistent estimates of local pollen contamination to Douglas-fir seed producers in the area, in order for them to determine the effect on the genetic worth of the seedlots produced. Pollen flight was monitored from March 30 to April 26. Data were counted and averaged, and counts were forwarded to local Douglas fir seed producers.

Genetic Upgrading and Enhancing Seed Yields and Quality from Rust-resistant White Pine Seed Orchard #175 (SPU 0804)

The objectives of this project were twofold: to re-graft and re-establish orchard #175 up to pre-vandalism numbers with genetically upgraded stock and to operationally manage the existing orchard trees to increase the yield of filled seed.

Fourteen new clones consisting of 238 ramets were grafted at Kalamalka, and 180 ramets from CLRS are now being maintained in holding beds at Saanich Seed Orchard. Larger ramets will be planted into empty spots in orchard #175 in spring 04 or fall 05.

To increase yields of filled seed, bud and phenological surveys were conducted. Three litres of pollen were collected and re-applied to female flowers. Collection of 15,197 cones (45.2 Hl) yielded 23.1 kg of seed (results of 2003/04 SMP). This is an average of 70 seeds/cone, which is considerably higher than the 50 seeds/cone if no SMP is applied.

Two hundred and seventy five trees were maintained by irrigating, fertilizing, and controlling insects and vegetation.

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

Orchard #181 is a 95-clone 1,037-ramet, first-generation SM, mid-elevation Fdc orchard with progeny being planted in spring 2005 for testing. Five-year measurements will be available in 2009/2010. At that point in time, the orchard will be rogued to a BV greater than 5.

Management operations included surveys for health and vigour, graft maintenance, rootstock pruning, mortality replacement, fertilizer and irrigation application, foliar nutrient sampling, and pest surveys for foliage and cones. Pollen was collected and stored. The crop was not managed due to low numbers of female flowers and high numbers of insects.

Genetic Upgrading and Enhancing Seed Yields and Quality from High-elevation Western Hemlock Orchard #196 (SPU 2403)

Orchard #196 consists of 12 clones (79 ramets) of high BV moved from Campbell River Seed Orchard #143 and 12 clones (172 ramets) planted this season of high BV material from CLRS. The mean BV of this orchard is now 11. Ramet numbers were increased to reach effective Ne and high BV.

To increase seed yields, bud and phenological surveys were conducted. Three hundred and thirty-three mls of pollen were collected and re-applied. Three hundred and seventy-three grams of seed (62.5 litres of cones) were collected. The 2004 seedlot was blended with the 2003 seedlot because Ne was not high enough in 2004. The resulting seedlot has an Ne of 10 and a BV of 8%.

Management of the orchard included surveys for health and vigour, graft maintenance, rootstock pruning, mortality replacement, fertilizer and irrigation application, foliar nutrient sampling, and pest surveys for foliar and cones. A small N fertilizer/seaweed extract (kelp) application study was conducted for control of woolly adelgids over the 2004 season. Levels remained low, and because natural predators were present, no pesticide control was necessary.

5.2 Technical Support Projects

5.2.1 Cone and Seed Pest Management – Interior Operations

Robb Bennett

This project describes operational activities for the Interior seed pest management biologist, including all expenses associated with lab, field, and office work. Included in this description are activities for one co-op student (one term) and auxiliary technical support (as needed) to assist with operational pest management trials, data analysis, and development of new operational techniques.

Between April 1, 2004 and 31 March 2005 the Interior seed pest management biologist and the co-op student performed the following services.

1. Performed – 200 site visits, pest surveys and identification, and damage predictions and assessments.
2. Delivered – 50 written pest-survey reports to orchard managers and other seed production personnel.
3. Performed – 40 other pest identifications and management recommendations to Ministry of Forests personnel.
4. Dealt with – 25 requests for information from members of the public.

Work continued on in-house and collaborative development of protocols for seed bugs, seed wasps, coneworms, mountain pine beetle, and other insects of importance to Interior cone and seed production. In summary, the Interior pest management biologist:

1. initiated, continued, or completed seven in-house pest management research projects,
2. collaborated with university, government, and other research personnel on five other projects,
3. assisted in the preparation of mountain pine beetle risk assessment documents for PGTIS and Skimikin seed orchards, and
4. assisted in creating post-harvest management protocols for coneworm-infested cones.

As well as training provided for biology co-op students and orchard technicians, the Interior pest management biologist provided the following training experiences:

1. nine extension education presentations to grade school, college, and university students,
2. two professional presentations – Inland Empire Tree Improvement Cooperative, Canadian Tree Improvement Association, Superior Woods Tree Improvement Cooperative, the Forest Genetics Council Species Committee (two), and the Forest Genetics Council (two),
3. four pest management workshops for orchard staff, and
4. numerous “tail-gate”-type extension presentations to operational personnel.

The following publication resulted from this project.

Strong, W.B. 2004. Seed Orchard Pest Management and Insecticide Deregistration. Canadian Tree Improvement Association Tree Seed Working Group News Bulletin 39: 9-11.

5.2.2 Western Redcedar Pollen Monitoring, Saanich Peninsula and Sechelt (SPU0212)

Joe Webber, ProSeed Consulting

Introduction

The Chief Forester’s (CF) Standards for Seed Use in British Columbia have 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). Calculations for estimating a seed lot’s GW include female and male gamete contribution (including non-orchard sources of pollen and SMP).

Currently, only coastal Douglas-fir seed orchards must report contamination levels. However, other coastal orchard species (and interior lodgepole pine), including western redcedar, western hemlock, and Sitka spruce may also be at risk from contamination, but data to assess this risk is not available. We do not know the magnitude (pollen cloud density) and extent (duration of pollen flight) of any of these species. This report summarizes the first year results for monitoring western redcedar pollen flight in two orchard locations: Saanich peninsula and Sechelt.

The Ministry of Forests' seven-day pollen monitors, mounted on rotating platforms at 3 m height, were used in each of two orchard locations; the Saanich peninsula and Sechelt. Two replicates were counted on each chart, and the total number of pollen grains for the two replicates were averaged for the two replicates and then divided by 44 mm^2 (the area of the chart counted) to represent the number of pollen grains (captured) per mm^2 for a 24-hour period.

Figures 20 and 21 show the mean western redcedar pollen catch for five stations on the Saanich peninsula and three stations at Sechelt, respectively.

In 2005, western redcedar pollen shed on the Saanich peninsula ranged from February 1 to February 28 with peak shedding occurring on February 19. It is likely that more pollen shed occurred later than February 28, but it was mixed with other species (predominately red alder pollen), which is the same the same size and shape. In terms of extent and magnitude, redcedar pollen shed on the Saanich peninsula is as great as or greater than Douglas-fir.

For the two western redcedar orchards on the Saanich peninsula (Western Forest Products, Saanichton and TimberWest, Mount Newton), the range of orchard receptivity was February 25 to March 9 and February 22 to March 11, respectively. This also corresponds to the maximum average daily pollen shed for contaminate pollen.

In 2005, western redcedar pollen shed at Sechelt ranged from February 10 to March 9 with peak shedding occurring on March 4. The magnitude and extent of other species (red alder) shed at Sechelt was less than on the Saanich peninsula. Douglas-fir pollen shed has not been monitored with the seven-day recorders at Sechelt, so we cannot make the same comparison as for the Saanich peninsula.

For the western redcedar orchards at Sechelt (Canfor), the range of orchard receptivity was February 18 to March 9. This also corresponds to the maximum average daily pollen shed for contaminate pollen.

Summary

At x100 magnification, it is possible to identify redcedar pollen, but it is very difficult to separate it from other species, in particular, red alder. Red alder is slightly smaller (20 to 25 microns in diameter), with pores. It looks very similar to redcedar at x100 magnification but with smaller orbicules. Positively 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.

The pollen counts for western redcedar are as great as those observed for Douglas-fir on the Saanich peninsula, and the possibility of contamination exists. Whether this is a serious problem is not known. Any orchard clone sired with contaminated pollen could have a small reduction in selfing. However, the breeding value of contaminate pollen would at best be neutral, so any contamination will have a negative effect on higher-breeding-value clones.

This is the first attempt to monitor western redcedar pollen shed from indigenous stands surrounding the three orchard sites. The pollen monitoring technique used for monitoring Douglas-fir pollen in the orchards may not be applicable for western redcedar. Most orchards use dissecting microscopes with magnification ranges of x40 to x60. This is not suitable for monitoring western redcedar pollen. If orchard monitoring will be considered, then at least, a transmission microscope with a minimum of x100 magnification will be needed. Even then, distinguishing between redcedar pollen and other species, principally red alder, will be difficult, and the errors associated with the counts will be higher.

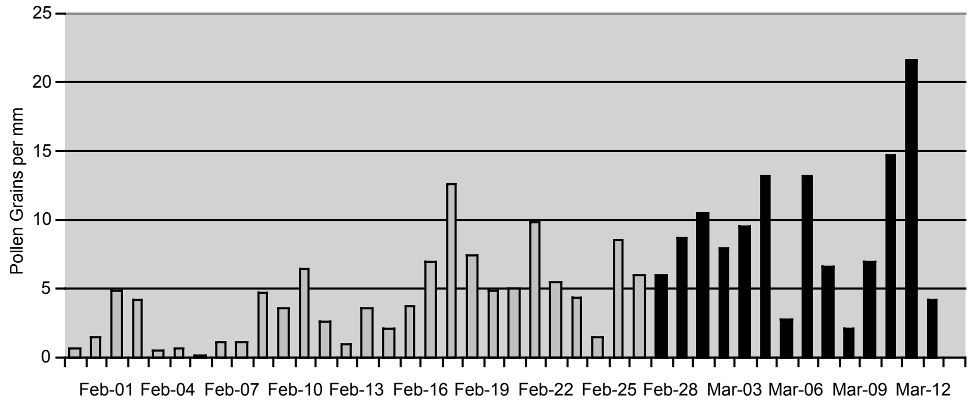


Figure 20. Mean daily western redcedar pollen catch (pollen grains/mm²) for three stations at Sechelt. Black bars include other species of the same size and configuration (predominately red alder)

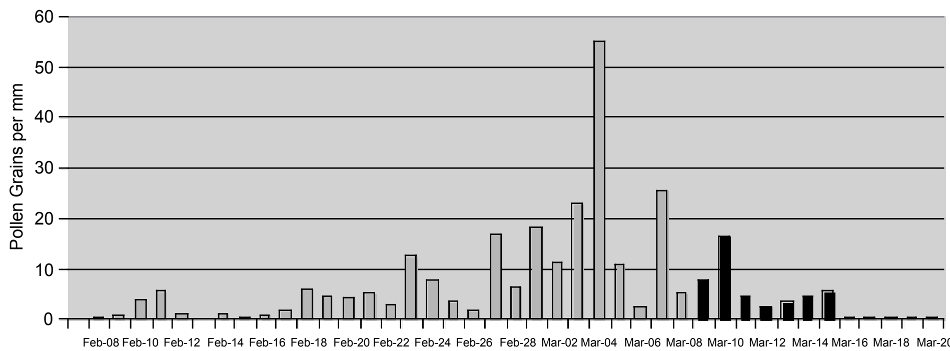


Figure 21. Mean daily western redcedar pollen catch (pollen grains/mm²) for five stations on the Saanich peninsula. Black bars include other species of the same size and configuration (predominately red alder)

5.2.3 Damage Potential of Field Densities of *Leptoglossus occidentalis*

Ward Strong

The Western Conifer Seed Bug, *Leptoglossus occidentalis*, is the most serious pest in conifer seed orchards in the interior of BC Tests over the past six years have shown that it routinely reduces seedset by 10 to 50% and is capable of reducing seedset by up to 80%. *Leptoglossus* is one of the main factors contributing to the low-seedset problem in lodgepole pine orchards in the southern interior. It also feeds on white pine, Douglas-fir, spruce, hemlock, and larch, though the problem is less well characterized in these tree species.

Management of the seed bug depends on the use of broad-spectrum insecticides. Despite years of study, no other control methods, such as biological controls, trapping methods, or cultural techniques, have come to light. Appropriate use of insecticides requires two techniques: a method of estimating field densities of *Leptoglossus* (monitoring technique) and a method of relating these densities to damage potential (density-damage relationship). A visual-sample monitoring technique has been developed that consistently estimates seed bug densities. This project is designed to develop a density-damage relationship so that the damage potential of field densities of *Leptoglossus* can be estimated. 2004 was the final year of this three-year project

Methods

Leptoglossus densities were monitored weekly from early May through late July, 2004 at each pine orchard in the southern interior of BC Large pine orchards were divided in half, and each half was monitored separately. In total there were 15 orchards and half-orchards (“replicates”). Monitoring consisted of half-hour transects through the orchard on foot, visually examining cones and counting *Leptoglossus*. Monitoring in each orchard was also conducted in 2002 and 2003.

For each orchard replicate, accumulated *Leptoglossus*-days (LDs) were computed to estimate feeding pressure in that replicate. LDs were computed by taking the average of the current monitoring count and the previous monitoring count and multiplying it by the number of days between counts. For example, if the count on June 10 was 12 *Leptoglossus*, and the count on June 17 was six *Leptoglossus*, LDs accumulated in that period was (12 + 6)/2 x (17 - 10) = 63 LDs.

In each orchard replicate, feeding damage was assessed with insect exclusion bags. On April 28, 2004, exclusion bags were placed over second-year cones to protect them from *Leptoglossus* feeding. On July 30, bagged cones and nearby unbagged cones (exposed to *Leptoglossus* feeding) were collected. Seeds were extracted by the boil, bake, and shake method, and seedset (filled seeds per cone) was computed for each sample. Seedset loss (the difference in seedset between exposed and bagged cones) was a measure of feeding damage. Seedset loss was also calculated for 2002 and 2003 data.

Feeding damage was then graphed against LDs to indicate the relationship between monitored densities of *Leptoglossus* and feeding damage. A regression line was generated to describe the relationship mathematically. A close relationship is indicated by a high r^2 value of the regression. The closer the relationship between LDs and damage, the more reliably we can estimate damage from monitored densities.

Results

The bagged and unbagged treatments have been harvested from each orchard replicate, and the seeds extracted and X-rayed. The filled and empty seeds were counted. Seed loss due to *Leptoglossus* for each orchard replicate was then calculated. For the rest of this report, results from all years of the study will be discussed together (2002, 2003, and 2004 combined).

Scatterplots of feeding damage as a function of *Leptoglossus*-days were generated. Figure 22 shows the reduction in seedset (filled seeds per cone) as a function of LDs. Lepto days were calculated in three ways:

A. Total LDs: all *Leptoglossus* were counted equally (females, males, and nymphs)

B. Female LDs: Only the females were included. This is because the females feed much more than males or nymphs and cause the greatest amount of damage

C. Low-male LDs: Males and nymphs feed about one-third as much as females, so LDs were calculated by counting each female as one lepto and each male or nymph, as 0.3 lepto.

On the scatterplots, each point represents one orchard replicate in one year. Female LDs resulted in the poorest relationship, and low-male LDs resulted in the best relationship, as identified by the higher r^2 value for the low-male plot.

The r^2 value for low-male LDs is still low, however: $r^2 = 0.1134$ (Figure 22C), which is a relatively poor relationship. Several other factors contribute to seedset reduction, such as the crop size. A certain number of *Leptoglossus* will reduce the FSPC in a small crop more than in a large crop. Crop size estimates (by the orchardists) were used to generate an estimated number of seeds lost for each orchard replicate in each year. Seeds lost were then plotted against LDs; these are shown in Figure 23.

The relationship is much tighter than with the FSPC reduction data. This means predictions of damage can be made with more accuracy. Total LDs and low-male LDs had about the same r^2 values, at about 0.18. These figures can be used to estimate seed loss due to varying densities of *Leptoglossus*. For example, using the total LD graph (Figure 23A), we can estimate that if we have 600 LDs of feeding pressure, we will lose approximately 1.25 million seeds from that orchard.

Because of the poor relationship (low r^2 value), this estimate is not very accurate though. Other factors that contribute to variability in the density-damage relationship fall into three categories:

A. Orchard influences – e.g., crop size, orchard size, orchard age, tree size, spacing

B. Monitoring influences – factors that contribute to monitoring results: e.g., temperature, cloud cover, wind, time of day

C. Seasonality – In a related experiment in 2004, I found that feeding in spring caused far more damage than feeding in summer.

These factors will be incorporated into the density-damage relationship as data analysis proceeds. The orchard influences are known and easily incorporated. The monitoring influences and seasonality have now been characterized and can also be included.

Once an accurate density-damage relationship has been described, we will be able to make more accurate predictions about seed loss due to monitored numbers of *Leptoglossus*. This will help us make well-informed decisions about managing *Leptoglossus*. Pesticide spray thresholds will be the main decision-making tool. We might be able to say, for example, that “x number of *Leptoglossus* found in our half-hour search indicates a potential seed loss of y%, and therefore a spray is not warranted.” In this way, pesticide applications will be minimized and will be used only when and where necessary.

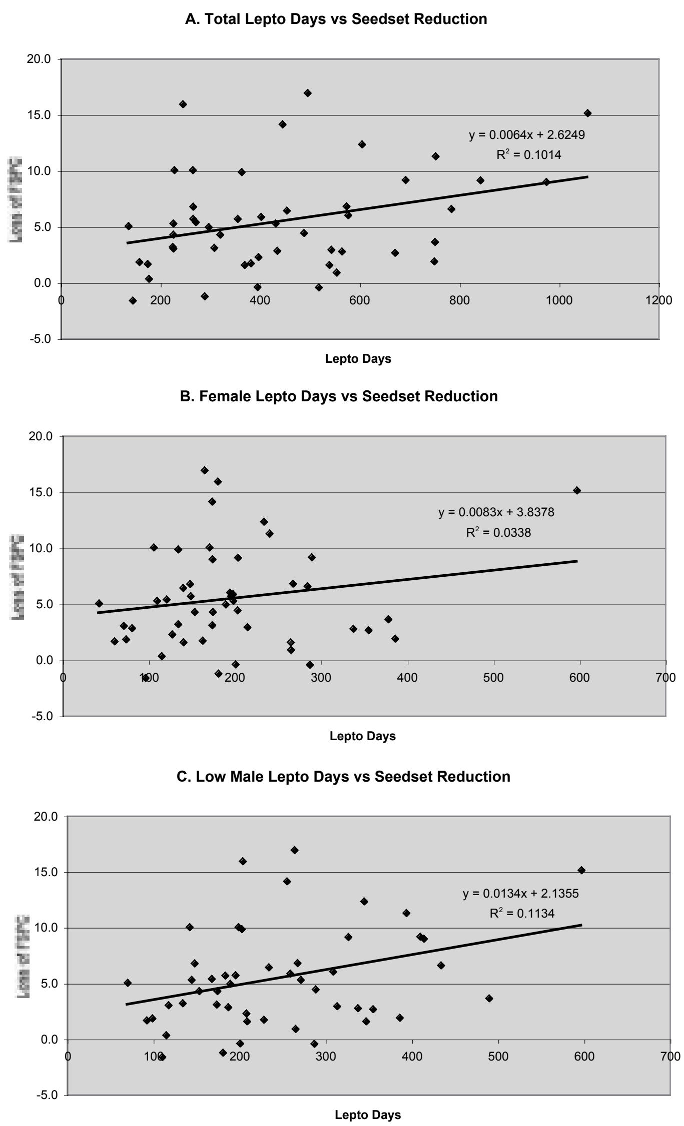


Figure 22.

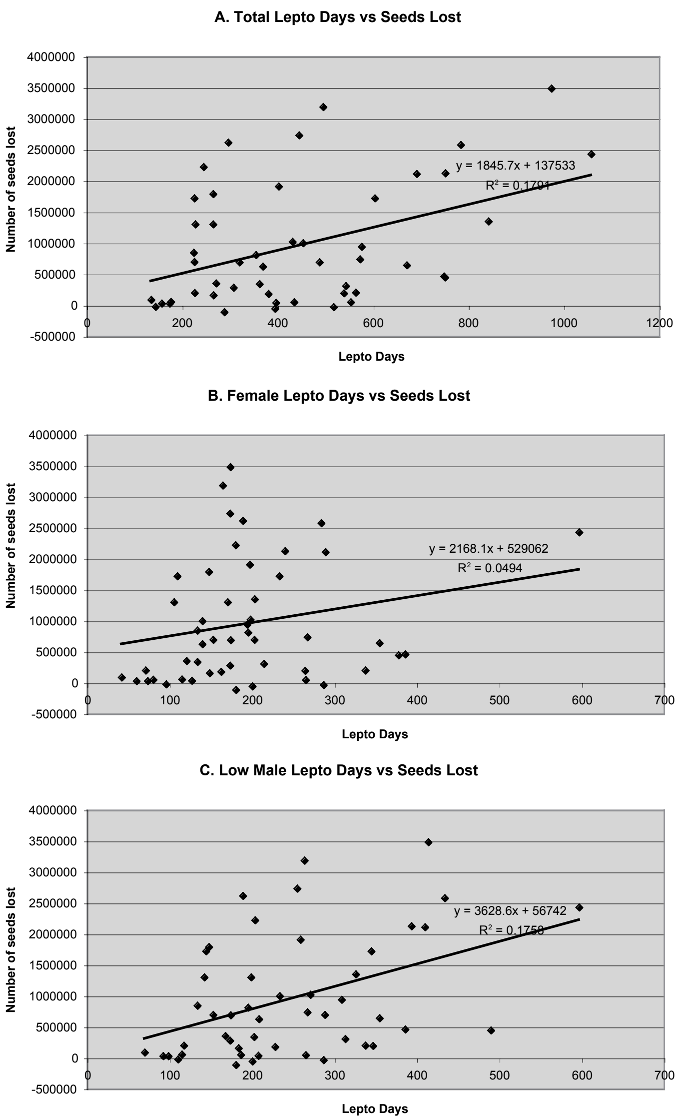


Figure 23.

5.2.4 Douglas-fir and Western Redcedar Cone and Seed Insect Pest Monitoring Services to Coastal Conifer Seed Orchard Managers.

Robb Bennett

Douglas-fir cone gall midge and western redcedar cone midge are the two most important insect pests in coastal British Columbia conifer seed orchards. Population levels of both these insects are routinely monitored each spring to determine damage potential and whether or not control options need to be used. Orchard managers are now responsible for monitoring these insects on their sites. Formerly, Ministry of Forests Seed Pest Management staff provided this service. This project was initiated to ease the transition process for coastal seed orchard managers.

In spring 2004, conelet samples from eight of eleven coastal Douglas-fir seed orchards at four sites were assessed by Applied Forest Science Ltd. for levels of Douglas-fir cone gall midge. Reports of results (Figure 24), including pest management recommendations, were sent electronically to respective orchard managers within 24 hours of receipt of samples. The remaining orchards were either unproductive in 2004 or were being monitored by on-site staff.

Redcedar conelet assessments were done in-house in March 2005 by orchard managers, following successful training in monitoring techniques provided by Seed Pest Management staff.

Orchard	ISCC	Orchard	ISSC
116	13.2	166	4.6
120	9.3	169	3.2
149	0.9	177	14.4
162	0.4	181	6.5

Figure 24. Average infested scales per conelet counts (ISCC) for eight of eleven coastal BC Douglas-fir seed orchards. Default "treatment threshold" (at or above which control measures are usually warranted): ISSC = $\geq$2.6

5.2.5 Estimation of Deleterious Effects of Different Levels of Inbreeding on Western Hemlock Seed Orchard Production

Oldrich Hak

In forward-selected advanced-generation seed orchards, and even in first-generation orchards where SMP is used, there is likely to be some reduced seed set due to inbreeding. The size of these effects for western hemlock is unknown, except for selfing. Previous studies have shown that the propensity of western hemlock orchard ramets to self-pollinate shows a strong family effect. This factor is particularly important in clonal row orchards. Once problem clones are identified, managers can avoid placing ramets of these clones adjacent to each other, or they can employ some form of pollen management: e.g., supplemental mass pollination.

Even low-level inbreeding has been shown to reduce seed production. It is logical to assume that there will be problems, but the size of these effects can vary considerably even within a botanical family such as the *Pinaceae*. It is therefore advisable to investigate a low-level selfing for a species before designing advanced-generation orchards since impacts on production should be taken into account. Minimizing selfing in orchard seed will ensure that inbreeding does not compromise the growth potential of high-gain lots and that there is minimal reduction in seed set.

In this project, 46 high-breeding-value orchard clones were tested. The clones were then ranked from the lowest to the highest level of selfing, based on their propensity to self. The final results are presented in Figure 25.

	Clone	% Full Seed Self*	% Full Seed Polymix*	Level of Selfing
1	554	1	70	very low
2	1004	2	79	very low
3	516	2	74	very low
4	766	2	74	very low
5	2009	3	75	very low
6	122	3	64	very low
7	2166	3	53	very low
8	699	3	37	very low
9	706	4	71	very low
10	41	4	50	very low
11	687	4	62	very low
12	4492	5	78	very low
13	4230	5	60	very low
15	2228	6	56	very low
16	1002	7	84	very low
17	2676	8	76	very low
18	810	8	87	very low
19	430	6	54	very low
20	196	7	56	very low
21	31	6	48	very low
22	2232	8	50	very low
23	298	9	57	low
24	446	9	56	low
25	2020	12	65	low
26	442	12	53	low
27	238	12	50	low
28	569	15	75	low
29	68	15	69	low
30	441	15	69	low
31	120	13	51	low
32	2357	17	84	moderate
33	268	17	75	moderate
34	2360	18	77	moderate
35	82	15	36	moderate
36	459	21	77	moderate
37	130	19	51	moderate
38	1016	21	68	moderate
39	457	27	71	high
40	39	25	54	high
41	1253	32	68	high
42	2365	34	70	high
43	199	35	73	high
44	1253	43	69	high
45	74	58	85	high
46	4191	53	79	high

*Plus empty seed=100%

Figure 25. Propensity to self. Ranking of Hw clones from the lowest to the highest level of selfing

5.2.6 Determination of Selfing Rates in a Top-pruned Interior Spruce Seed Orchard (SPU 410)

Michael Stoehr and Helga Mehl

Background

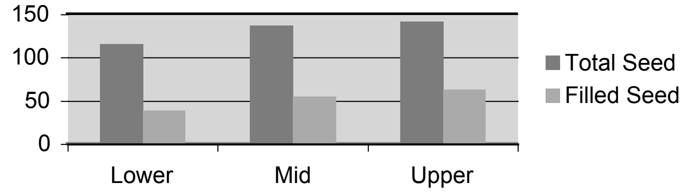
Interior spruce orchards are routinely top pruned for more efficient orchard management and increased safety during cone harvest. However, it is prudent to determine if this management practice affects seed yield and seed quality. Effectively, top pruning brings the male and female reproductive buds closer together, creating a wider zone of overlap which could potentially result in higher selfing rates. To assess actual selfing, this orchard was genotyped using chloroplast DNA markers (last year's project) and cones from ten candidate clones were collected from the lower, the middle, and upper sections of the crown.

Activity

Cones from two ramets each of ten clones that were identified as unique, based on our DNA analysis of last year, were collected in July 2004 from the lower, the middle, and the upper part of the crown. Cones were after-ripened in a growth chamber prior to seed extraction. All seeds were extracted from each cone and x-rayed to determine the proportion of filled seed.

Results

The molecular DNA analysis was not funded, and only the seed yield data are reported. Averaged over all tested clones (two ramets each), the number of seed per cone was lowest in the lower part of the crown, intermediate in the mid-crown, and highest in the upper crowns. The same trend held for the number of filled seed. The proportion of filled seed per cone ranged from 34% to 44% in cones growing in the lower and upper crown, respectively. In the absence of DNA data, it is difficult to interpret the results because the lower number of filled seed in cones growing in the lower part of the crown may be due to the lower vigour of lower branches and/or selfing.



	Lower	Mid	Upper
Total Seed	116	137	142
Filled Seed %	39.4	55.1	63.2

Figure 26. Effects of crown position on seed yield per cone in a top-pruned interior spruce seed orchard

5.2.7 Development of Pollen Management Guidelines for Yellow-cedar

Oldrich Hak

Poor pollen quality at pollination time may be one of the principal factors responsible for the failure of low-elevation orchards to produce sufficient quantities of viable seed. In a pollen quality study, significant differences in pollen viability ($p<0.001$) were observed between populations characterized by distinct environmental differences. There was a significant reduction in pollen development and in corresponding pollen quality as the elevation of the testing sites decreased (Figure 27).

All previous assessments of pollen quality were based entirely on *in vitro* testing, using pollen germination. These assessments should be interpreted only as an indication of pollen fertility. In the continuation of this project, the actual fertility of low-elevation males is being confirmed through control pollinations of females in natural stands. The level of fertility of low-elevation females is also being examined through control pollinations using high-quality pollen collected from natural stands.

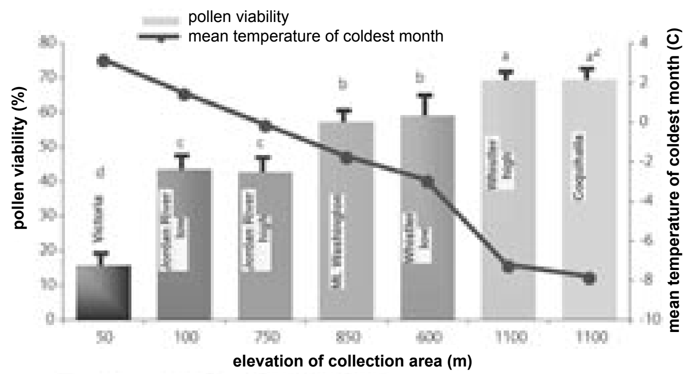
Results to date indicate that low-elevation yellow-cedar seed orchards are capable of producing viable seed. The study further shows that both low-elevation males and low-elevation females can produce viable seed

(Figure 28). For example, in a high-elevation stand, low-elevation males produced a similar percentage of filled seed and a similar number of seeds per cone as high-elevation males. Comparable results were obtained at low elevation where there was an insignificant difference in the percentage of filled seed or the number of filled seeds per cone between matings with high-elevation and low-elevation pollen.

Even though females were able to produce filled seeds at low elevation, the percentage of filled seed and the number of filled seeds per cone was significantly lower than at high elevation for the same mating types. However, when open-pollinated cones were collected at low elevation from the same trees used for control pollination, they all produced empty seed.

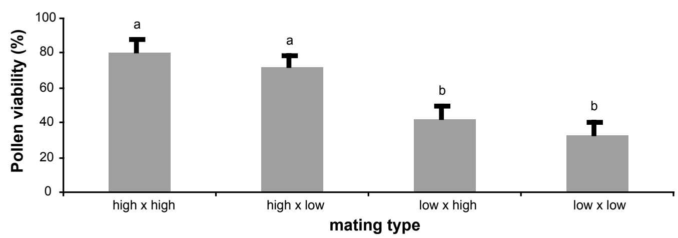
These results are contrary to earlier reports that low-elevation seed orchards on Vancouver Island are not capable of producing viable seed. One possible answer to this discrepancy lies in the pollination method employed. Open pollination was in effect in the early seed orchards at low elevation. Similarly, when open-pollinated cones were collected in the current study at low elevation, they also produced empty seed. However, when control pollination was used in the current study, viable seed was produced. There was an abundance of pollen on the tested trees and on surrounding trees during open pollination. This suggests that there may be several unknown and untested factors responsible for this failure.

Although there is no significant difference in filled seed between high x high and high x low mating types at high elevation, and between low x high and low x low at low elevation, it is almost significant and probably biologically significant. There was a lot of tree-to-tree data variation, and the number of trees at each location was reduced from ten to six trees at high elevation and from ten to eight trees at low elevation. Difficulties with environmental conditions encountered, especially at high elevation, reduced the number of tested trees and also introduced several other factors that may have influenced, to a certain degree, the results of the trial (see "Results" above). These problems are being dealt with in Sub-project 2.



1. population mean based on 2 years of data (2001 and 2002)
2. different letters denote significance at p<0.05) according to Fisher's LSD mean separation test

Figure 27. Relationship between yellow-cedar pollen viability at pollination[1] and population-origin elevation and mean temperature



1 = based on blowing/germinating
Different letters denote significant differences (p<0.05) between mating types according to Fisher's LSD mean separation test.

Figure 28. Yellow-cedar pollination study: % filled seed[1] for four mating types

5.2.8 Improving Seed Production in Yellow-cedar Seed and Breeding Orchards

Oldrich Hak

Sexual reproduction of yellow-cedar that has adapted to cold climates and short growing seasons may be negatively affected when grown at warmer, low elevations with longer growing seasons. The typical maturation of yellow cedar pollen in one growing season in cold climates, for example, is uncommon in temperate conifers, but this accelerated maturation may be a reproductive adaptation to the harsher climate the species experiences. Accelerated maturation allows pollen to be readily available for pollination when female flowers become receptive early in the spring. However, this adaptation may have an adverse effect on pollen development under warmer conditions. For example, there were substantial differences in pollen development and quality between warm, low-elevation sites and colder, high-elevation sites. The most extreme differences were observed between the Mount Newton low-elevation site and the Whistler high-elevation site. Developing pollen cones at Mount Newton were recognizable in the third week of July (morphological stage 1), while at Whistler the same stage was reached in the third week of August (Figure 29 and Figure 30).

At Whistler, pollen remained viable at the pre-dormancy level throughout the winter, while the viability of Mt. Newton pollen decreased significantly. At pollination time, Mount Newton pollen viability remained low, but in the mature Whistler pollen, viability increased significantly, from 7% to 72%.

Similar differences, though not as pronounced, were observed between the hot and the more moderate microclimates at the low-elevation Mount Newton seed orchard. In low-elevation seed orchards, pollen production on branches exposed to the full sun is high, while the production on fully shaded branches is low. According to visual observations, male cones produced on shaded branches appeared to be of better quality (bright yellow color) than those exposed to the full sun (brown or dried out). The results show that pollen on the fully sun-exposed branches developed faster and had low pollen viability (22%) at shedding time, while pollen on the branches fully protected by shade developed slower and had twice as high pollen viability (48%) at shedding time (Figure 31).

The effects of temperature on yellow-cedar pollen quality are not known and may be varied. One possibility is that pollen in its initial stages of development is more susceptible to temperature damage than during its mature dormant stage. Several investigators have concluded that extreme temperature conditions during pollen formation, of which meiosis is the most sensitive, play a significant role in the occurrence of pollen abnormalities in several tree species. On the other hand, the likelihood of similar high-heat damage to pollen on shaded branches may have been lessened because pollen development was delayed to a later date when temperatures are more moderate. It is possible that meiosis occurred under more moderate temperatures in September.

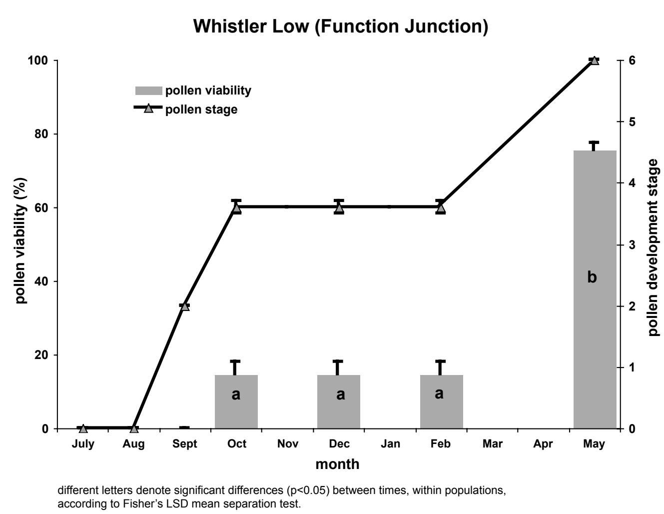
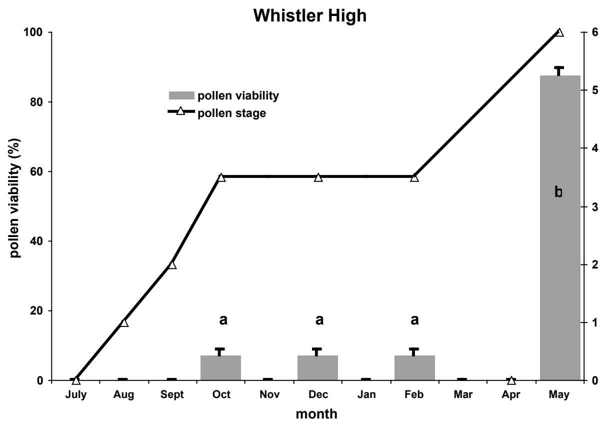


Figure 29. Yellow-cedar pollen development and viability (+/- s.e.) over time (2003 to 2004)



different letters denote significant differences (p<0.05) between times, within populations, according to Fisher's LSD mean separation test.

Figure 30. Yellow-cedar pollen development and viability (+/- s.e.) over time (2003 to 2004)

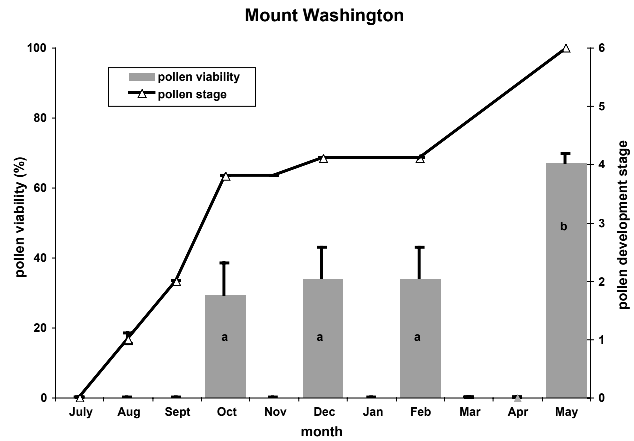


Figure 32. Yellow-cedar pollen development and viability (+/- s.e.) over time (2003 to 2004)

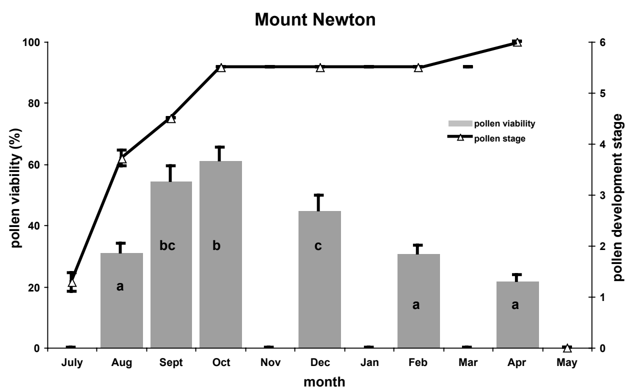


Figure 31. Yellow-cedar pollen development and viability (+/- s.e.) over time (2003 to 2004)

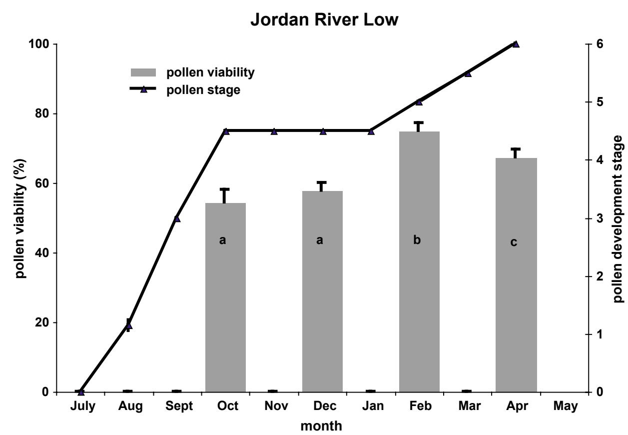


Figure 33. Yellow-cedar pollen development and viability (+/- s.e.) over time (2003 to 2004)

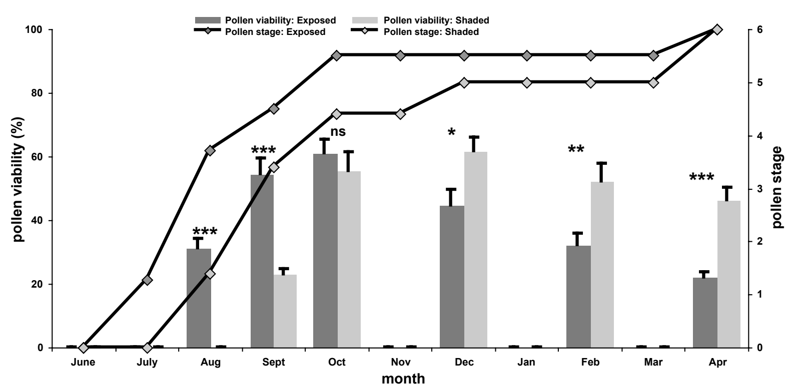


Figure 34. Yellow-cedar pollen development and viability (+/- s.e.) by site over time (2004 to 2005)

5.2.9 Operational Crown Management Trials in Various Orchards: Interior Spruce High-density Seed Orchard #620 and Interior Douglas-fir Orchard #324

Gary Giampa, Kalamalka Seed Orchards

Introduction

One objective of this project (funded as OTIP #SPU1301) is to determine which crown management techniques are most effective in controlling vegetative growth to allow for safe crop collection and efficient orchard management. In addition we are trying to determine the effects of various treatments on crop production. Trials are ongoing in the orchards, and treatments will be evaluated and refined based on survey results and observations.

Background

Beginning in 2001, we streamlined our approach to four treatments in the interior spruce micro orchard #620. 2004 was the fourth year that these treatments were repeated. Crop surveys were conducted to help evaluate the effectiveness of the different treatments.

Crown management was initiated in Douglas-fir orchard #324 in the fall of 2004. Orchard #324 was established at the Bailey Road site in 2001. The trees are now well established and growing vigorously. This orchard is not in production.

We decided to begin managing crown structures while this orchard was still young. Most operational crown management takes place after an orchard has reached maturity and becomes difficult to handle. It would seem that controlling crown structures while an orchard is still developing may allow for more management options in the future.

Several different treatments have been initiated in orchard #324. These treatments will be evaluated based on survey results and will be modified accordingly.

Activities

Trtmt #	Description	Prune Leader?	Prune Branches?	Train?
1	Height Control, Branch Train	To 3m. if unable to train	Only if extending past 0.5 m.into row	To other branches on same tree.
2	Freestyle	As seen fit	As seen fit	As seen fit
3	Operational Style Pruning	Prune 75% current leader growth. Not to exceed 3 m.	Remove 75% current growth to promote hedge effect	Prune or remove branches extending >0.5 m. into rows
4	Control	None	None	None

Figure 35. Treatments applied to ramets in the spruce micro orchard

Trtmt #	Leaders?	Major Laterals
1	Control (no action)	Control (no action
2	Pinch terminal bud	Pinch terminal bud
3	Clip terminal bud cluster	Clip terminal bud cluster
4	Prune 50% of 2004 growth	Prune 50% of 2004 growth
5	Prune 100% of 2004 growth	Prune 100% of 2004 growth
6	Prune just below top whorl	Prune 100% of 2004 growth
7	Prune just above second whorl	Do not prune

Figure 36. Treatments applied to ramets in FDI orchard #324 in 2004

Results

2004 was the first year that treatments were initiated in Douglas-fir orchard #324. There are no results to show this year.

Results shown for interior spruce micro orchard #620 reflect the year 2003 pruning regime. Cone and pollen surveys were conducted in the spring of 2004 before any treatments were conducted. Crown management treatments were applied in the fall after the cone crop had been harvested. It is worth noting that the flower crop in this orchard was rather light in 2004. The data presented are not necessarily conclusive.

As Figure 37 illustrates, the control group clearly yields a much greater pollen crop than the other methods. Leaving the trees unmanaged is definitely not an option in a micro orchard setting. Because space is limited, it is essential to manage the growth of each ramet so that it does not expand out of its allotted area.

The three crown management methods deliver reasonably close results. Operational-style pruning seems to yield the highest number of cones. This treatment is also the most efficient to implement because it does not require any labour intensive branch training.

Conclusion

We have been testing our current crown management techniques in orchard #620 for four field seasons. Because our survey results are based on three years worth of inconsistent flower crop data, we are reluctant to make any firm recommendations.

At this point it appears that operational-style crown pruning may be the most effective method to apply to the interior spruce micro orchard.

In 2005 we will continue to refine our techniques in both orchards and collect additional crop data.

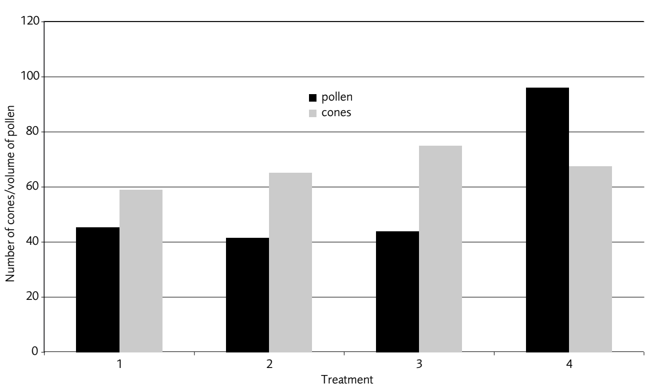


Figure 37. Sx crown management effect on crop

5.2.10 Testing the Effects of Upgraded Irrigation Delivery Systems in NE Mid-interior Spruce Seed Orchard #305 and Interior Lodgepole Pine Seed Orchard #307

Gary Giampa, Kalamalka Seed Orchards

Introduction

In 2003 OTIP funded revisions to the irrigation delivery systems in portions of interior spruce orchard #305 (SPU0412) and interior lodgepole pine orchard #307 (SPU0718). Our 2004 study is a logical continuation of these projects. We are interested in learning how the upgraded irrigation system impacts flower production and ramet health. This is intended to be an ongoing study that tracks and compares ramet performance throughout several growing seasons.

Background

Orchard #305 was established at Kalamalka in 1981. Orchard #307 was planted in 1984. Since their inception these orchards have been watered with a drip-style irrigation system. The trickle system seemed to work well enough when the orchards were young, but as the trees matured we began to question the efficiency of this type of irrigation delivery. Delivering water to the base of each tree limits root growth to the zone wetted by the emitter. As the tree grows larger this limited zone may constrict root volume expansion to the point where the roots cannot service the developing crown. This imbalance could have a negative effect on ramet health and might ultimately lead to decreased seed production.

A portion of each orchard has had its irrigation system converted to broadcast delivery as planned. We began watering operationally with the converted system in 2004.

The portion of the orchards serviced by the broadcast delivery system will be compared to the portion of the orchards irrigated with the drip system. These observations will allow us to determine how the different irrigation delivery systems affect ramet performance.

Activities

In the summer of 2004 permanent sample trees were chosen in each orchard (86 trees in orchard #305 and 84 trees in orchard #307). The sample trees were chosen in pairs based on establishment date: one tree is in the area irrigated with the micro sprinklers and the other is in the drip-irrigated area

Three major branches on each sample tree were chosen at random and marked with metal tags. Shoot elongation on each branch was measured during 2004 . We also measured stem diameter below all the branches on each sample tree. A survey was conducted to observe flower production. We will revisit these trees on an annual basis to repeat these observations.

Cone samples representing the two different irrigation regimes were harvested from each orchard. Seed has been extracted from these cones to compare seed production. Foliar samples were also collected to analyse nutrients.

Results

The new irrigation regime has only been in effect for one growing season and may not yet have made a large impact on ramet performance. None of the shoot or diameter measurements indicated any differences between the two irrigation treatments at this point. The data collected in 2004 will serve as a baseline for future observations.

Seed was extracted from the cone samples and X-rayed. At this point there is no significant difference in filled seed per cone or total seed per cone between the two treatments.

Nutrient uptake was one area where broadcast irrigation seemed to make a difference. 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.

Conclusion

We will continue to monitor the permanent sample trees on an annual basis. A set of comprehensive baseline observations will be collected 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 considering irrigation system upgrades.

5.2.11 Clonal Verification of a Spruce Weevil Orchard (#172) Using DNA Markers (SPU 0611)

Craig Newton and Tam Vo

Clonal propagation (CP), either by rooted cuttings, grafting, or more recently through somatic embryogenesis, is an essential component of some breeding and tree improvement programs. Through CP, individual trees with superior traits (genotypes) can be multiplied to create sufficient numbers of propagules for field trials, seed orchard establishment, and any other application for which identical genetic backgrounds are needed. All these applications are dependent on the fidelity of clonal propagation techniques and the labelling systems in place to track them through different seed orchards and test plots.

To test the fidelity of clonal propagation and identification management, a high-gain Sitka spruce weevil resistant seed orchard (#172, Western Forest Products) was tested using nuclear micro-satellite markers. This class of DNA marker is equivalent to those used in human forensics cases and can produce multi-locus genotypes that are unique to every individual tree. Therefore, for each orchard parental clone, the original ortet and all ramets produced from that ortet should share identical genotypes if clonal propagation and labelling systems are working as predicted.

In this study, 144 ramets representing 15 different clones (3-15 ramets per clone) were analysed with four nuclear micro-satellite loci. A total of 6/144 ramets (4%) were different at all four loci and therefore represent cases of non-clonal ramets. Figure 38 shows examples of non-clonal ramets identified with one of the four micro-satellite markers (Ss44). The origin of some of the verified non-clonal ramets was also determined – two of the 887 ramets were identical to clone 945, and two non-clonal 1056 ramets are identical to clone 1253. Ortet material from clones 887, 1056, and 1253 was also tested and found to be identical to the majority ramet genotype.

In conclusion, clonal fidelity in orchard #172 was 96%, and most (4/6) of the non-clonal ramets appear to be due to mislabelling rather than biological events such as rootstock over growth. Ortet material from three of the 15 families tested was also identical and indicate overall that clonal fidelity in orchard establishment is high.

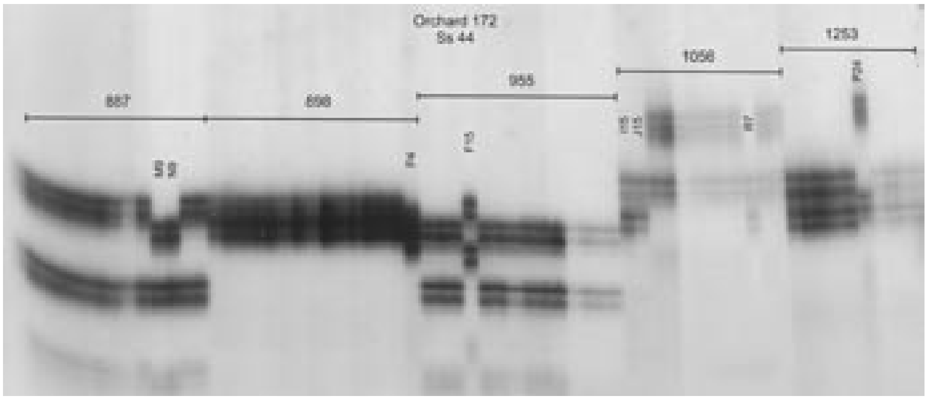


Figure 38. Clonal verification in Sitka spruce using micro-satellite markers

5.2.12 Enhancing Seed Production in North Okanagan Lodgepole Pine Seed Orchards (SPU 0719)

Chris Walsh and Joe Webber

This report summarizes the fifth year of the results from studying the effect of culture (irrigation and crown cooling) on seed set in the Kalamalka lodgepole pine seed orchard #307. After five years, results clearly show that operational quantities of seed (15 filled seed per cone) can be obtained if aggressive insect protection measures are taken.

Results from years 2000-2004 show no significant effect of enhanced culture on seed yields, although cone mass and seed weights were improved slightly. There still remains concern that hot, dry weather during the pollination period could result in poor pollen uptake and subsequently lower seed yields. Accordingly, objectives for 2004/05 focused only on treatment (irrigation and crown cooling) effects applied during the pre-pollination (mid-April to mid-May) and pollination (mid- to late-May) periods. Both irrigation and mist systems were activated in early April. Mist systems were deactivated after pollination (late May) and irrigation systems were deactivated at cone collection (early August).

Treatment effects on seed yields were measured (total seed per cone, filled seed per cone, and seed weight), cone mass (first-year conelets and second-year cone dry weights), and cone numbers. Meteorological data (temperature and relative humidity) were also recorded and expressed as heat sums and vapour pressure deficit.

Figures 39 and 40 show the meteorological data for the two test periods, pre-pollination and pollination, respectively. Included are sums of mean hourly temperature and vapour pressure deficit, as well as sums where the mean hourly temperatures exceeded 24°C (and the number of hours) or where vapour pressure deficit exceeded 2 (and the number of hours). Vapour pressure deficits exceeding 2 are associated with drought conditions. Precipitation is also shown.

The weather during the pre-pollination period was warmer than usual although not drier than previous years. However, during the pollination period, temperatures remained relatively warm while precipitation was about three times normal. After the pollination period, hot dry weather resumed.

Figure 41 shows the mean total seed per cone (TSPC), filled seed per cone (FSPC), and seed weight for cones from the control block (no treatments) with and without insect protection for the last five years.

Figure 42 shows the mean cone number per major whorl branch (pollen bud clusters, first-year conelets, and second-year cones), and cone weights (first-year conelets and second-year cones) for cones from the control block (no treatment) for the last five years.

Meteorological data in Figure 40 show that the pre-pollination period was warmer than usual but also considerably wetter. We were not able to test adequately the study objectives of hot dry weather during pollination on pollen uptake.

However, the data for seed yields (Figure 41) and cone numbers and weights (Figure 42) show some interesting trends. These data are for the control block only. This block was untreated (no irrigation or crown cooling). Although data for the treatment blocks do not substantially differ from those for the control block, the data for the crown cooling and irrigation blocks are available in the final report for this project.

The most significant loss of seed yields continues to be attributed to insect (*Leptoglossus*) damage. Over the five-year period, mean filled seed per cone for protected and unprotected cones was 22.8 and 15.8, respectively. Similar losses in total seed per cone were also observed (32.9 versus 26.9, respectively). Seed weight was not affected by insect feeding.

There is concern that seed cone numbers have steadily decreased over the study period. Pollen cone clusters, however, have increased. This trend is likely the result of two important factors. First, the same major whorl branches on each of the sampling trees were used for the five-year period. Cone numbers and seed yields are significantly greater in the upper crown. As the trees grew larger, the sampling branches became lower in the crown. Branch vigour became lower and more suited to pollen production. Second, weather conditions during the cone differentiation period for seed cones (September) has been cool and moist in the last three years. However, first-year conelet and second-year cone weights have remained reasonably consistent over the five-year period.

Our conclusions for last five years remain the same. Controlling *Leptoglossus* is the single most important management activity for lodgepole pine seed orchards in the north Okanagan. Cultural treatments (irrigation) do provide a modest increase to seed yields and cone size, but the beneficial effect of misting during the pollination period has yet to be determined. While the increased irrigation capacity provided only a slight improvement to seed yields and cone size (relative to the previous drip system), it seems prudent to maintain these systems knowing that the root volume for the matures trees is larger and the trees have a better chance of surviving extreme temperatures and drought when they do occur.

	2000	2001	2002	2003	2004
Tsum	na	4740	3673	4400	5365
Tsum>24	na	299	74	48	456
T>24 (hrs)	na	12	3	2	18
VPDsum	na	518	503	414	547
VPDsum>2	na	39	45	28	67
VPD>2 (hrs)	na	17	20	13	29
precipitation (mm)	na	16.9	13.9	73.4	60.4

Tsum=sum mean hourly T-5ºC
Tsum24=sum mean hourly T>24ºC
VPDsum=sum mean hourly VPD
VPDsum2=sum mean hourly VPD>2

Figure 39. Temperature (T) and vapour pressure deficits (VPD) sums and precipitation (mm) for the period of April 15 to May 15 for the study period of 2000 to 2004

	2000	2001	2002	2003	2004
Tsum	3466	4100	3603	3771	3631
Tsum>24	104	1515	304	48	578
T>24 (hrs)	4	54	12	2	18
VPDsum	313	424	283	414	283
VPDsum>2	23	163	50	54	67
VPD>2 (hrs)	10	56	22	22	29
precipitation (mm)	na	20.1	38.5	38.6	143.8

Tsum=sum mean hourly T-5ºC
Tsum24=sum mean hourly T>24ºC
VPDsum=sum mean hourly VPD
VPDsum2=sum mean hourly VPD>2

Figure 40. Temperature (T) and vapour pressure deficit (VPD) sums and precipitation (mm) for the period of May 16 to May 31 for the study period of 2000 to 2004

	2000		2001		2002		2003		2004	
	Bag	NoBag	Bag	NoBag	Bag	NoBag	Bag	NoBag	Bag	NoBag
TSPC	na	22.4	36.9	30.6	33.3	27.5	31.0	31.1	30.4	22.9
FSPC	na	9.7	25.5	18.8	24.3	16.7	21.4	19.8	20.1	13.9
Seed Weight (mg)	na	4.1	3.2	3.0	4.2	4.1	4.3	4.2	4.4	4.4

Figure 41. Mean total seed per cone (TSPC), filled seed per cone (FSPC) and seed weight for cones with (Bag) and without (NoBag) insect protection for the study period of 2000 to 2004.

	2000	2001	2002	2003	2004
Cone Numbers					
Pollen Clusters	37.6	46.7	61.1	70.6	74.6
Conelets	16.8	16.7	12.7	8.8	4.9
Cones	7.9	15.4	13.4	10.5	6.9
Cone Weights (g)					
Conelets	0.229	0.195	0.182	0.188	0.209
Cones	6.54	6.86	6.19	6.93	6.10

Figure 42. Mean cone number per major whorl branch (pollen cone clusters, first-year conelets, and second-year cones), and cone weights (first-year conelets and second-year cones) for the study period of 2000 to 2004

5.2.13 Chemical Control Techniques Against *Dioryctria abietivorella* in Interior Fd and Pw Orchards.

Ward Strong

Douglas-fir, spruce, and white pine orchards in the interior are now producing harvestable crops of cones. It has become apparent that *Dioryctria abietivorella* is a major pest of these crops. *Dioryctria* is a moth whose larvae bore inside cones, feeding on cone tissue and seeds. Losses in 2003 exceeded 40% in some crops.

This OTIP project was designed to meet the immediate need for control measures to protect crops until the *Dioryctria* are better understood. The project was to consist of two components: bagging studies and pesticide trials. Due to factors beyond my control, I was able to conduct only part of the planned pesticide trials. These are reported here.

Dimethoate is a systemic organophosphate registered against cone and seed pests in Douglas-fir. When sprayed onto a tree, the pesticide is translocated inside the cones, where it controls pests that feed on cone and seed tissue. Two experiments assessed its efficacy against *Dioryctria*: one with a backpack sprayer on individual trees and one with an orchard air-blast sprayer on large blocks of orchards. In each, dimethoate was applied once in late April or twice in late April and mid-June. The late April applications were at high and low rates, and the later application was at the low rate only. Cone damage was checked in mid-June and late July; damage on treated trees was compared with untreated checks.

Results are shown in the figures below. In both trials, the early spray reduced damage significantly on the mid-June check, but on the trees with early sprays only, damage was showing up by mid-July. Trees sprayed twice still had very low damage by 14 July.

It appears that *Dioryctria* moths continued to lay eggs throughout the experimental period, requiring active insecticide within the cones to kill hatching larvae. The early application provided control for perhaps six weeks, after which control declined, resulting in a higher percentage of infested cones by mid-July. When two applications were made, control continued through mid-July. Although no counts were made after this date, it was apparent at harvest that damage had started to increase in the trees with two applications, suggesting about six weeks of control from the second application as well.

Perhaps the best use of this chemical would be to wait until damage is first noticed, sometime in late May, before making the first application, then make a second application in six weeks, which should carry protection through the harvest period. However, the pesticide label allows an application only immediately following cone receptivity, thus the label must be amended before the desired use is possible. In 2005 we will be investigating an URMULE minor-use label expansion for this purpose.

Dimethoate	22 June	14 July
5% April 19	3%	39%
2% April 19	9%	36%
5% + 2% Jun 20	6%	4%
No spray	31%	60%

Figure 43. Orchard block trials. Percentage of cones infested with *Dioryctria* in blocks sprayed with different concentrations of Dimethoate 480E

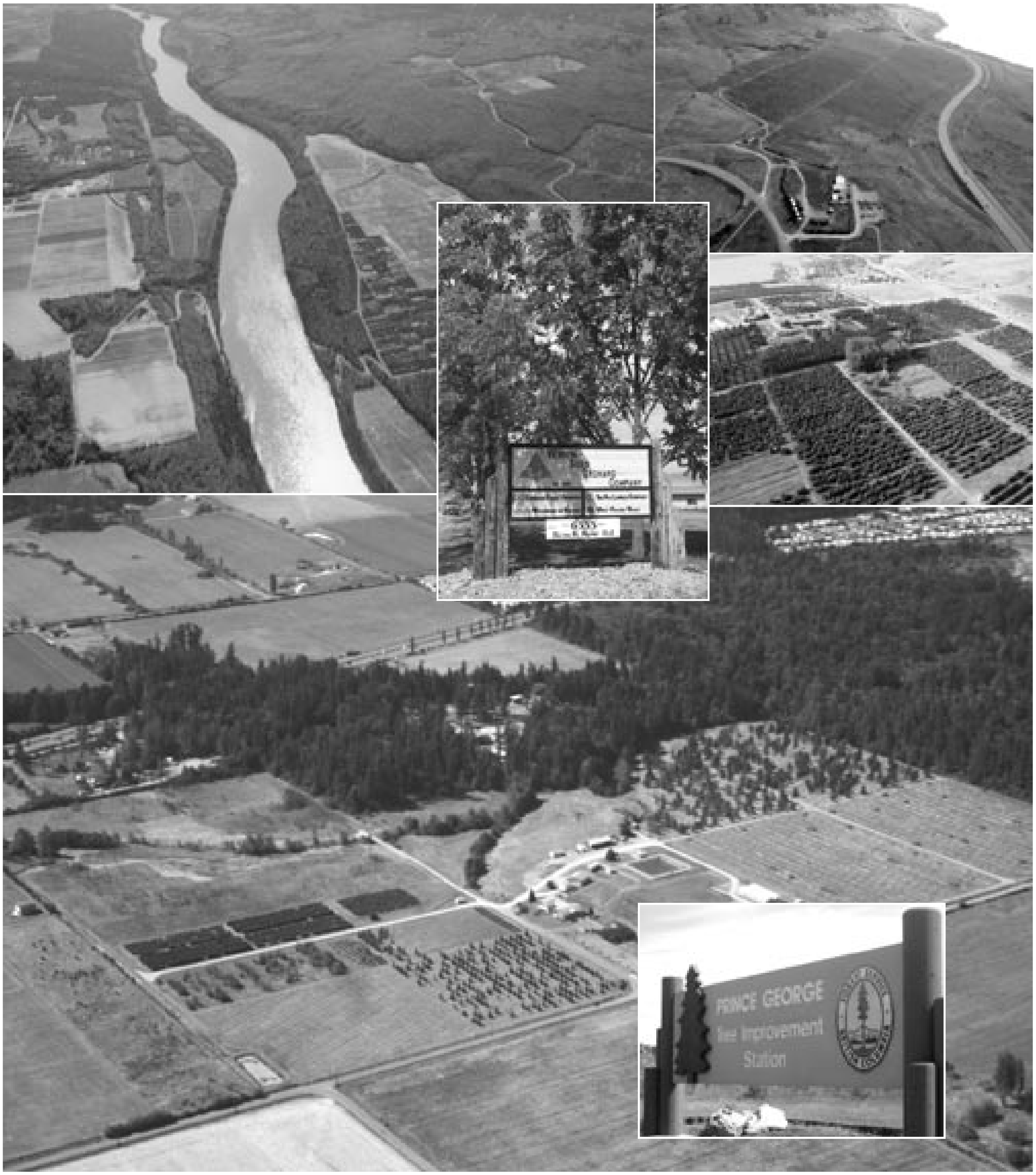
Dimethoate	15 June	21 July
2.5% April 22	0%	38%
1% April 22	1%	57%
2.5% + 1% Jun 15	1%	7%
No spray	44%	90%

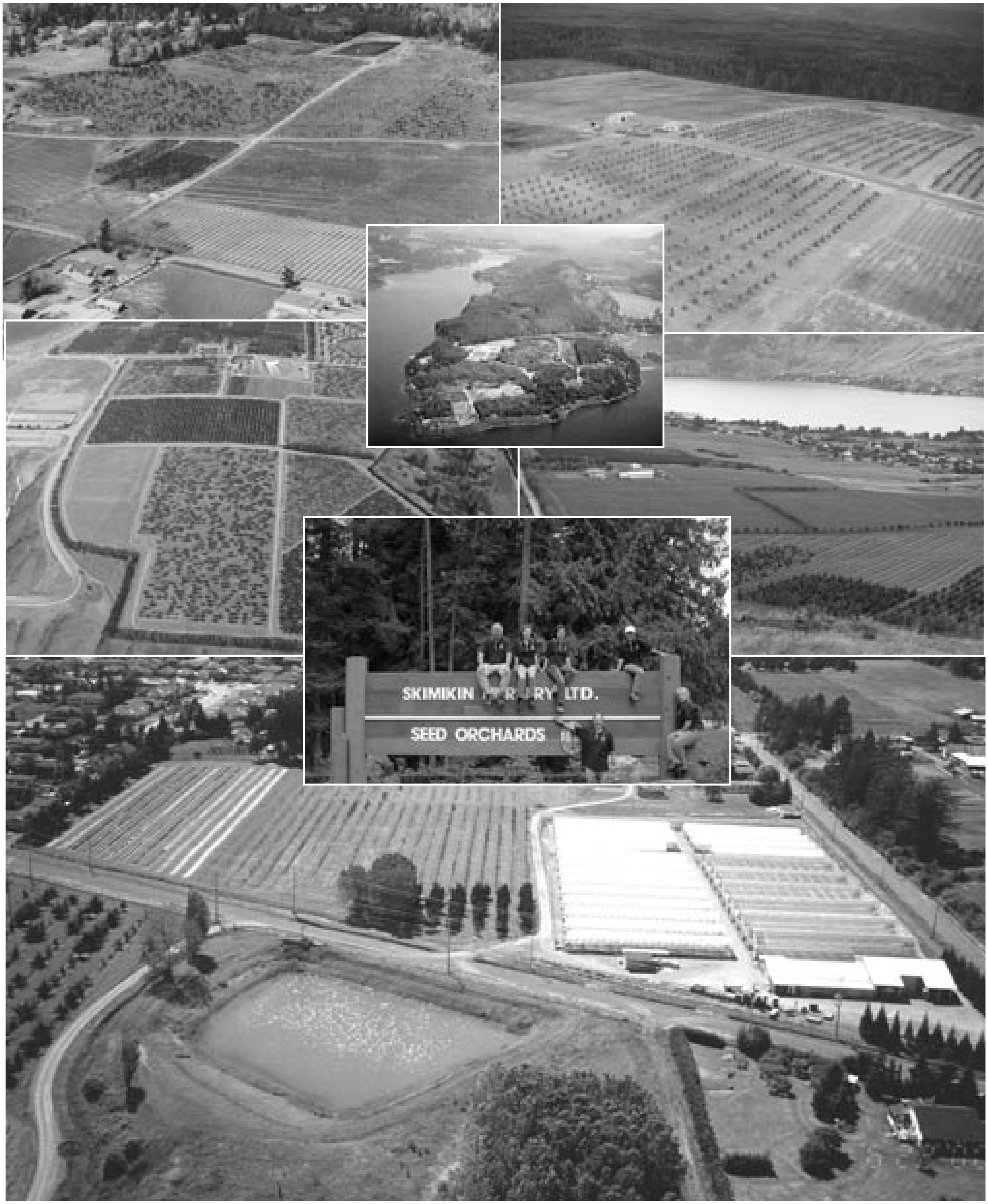
Figure 44. Individual tree trials. Percentage of cones infested with *Dioryctria* on individual trees sprayed with different concentrations of Dimethoate 480E

Plate 21. *Dioryctria abietivorella* adult

Plate 22. *Dioryctria* damage on Douglas-fir cones

Where We Work
Tree Improvement Program 2004/05




SEED ORCHARDS

6.0 Extension and Communications

6.1 Extension Technical Advisory Committee (ETAC Subprogram)

Diane Douglas

Annual ETAC meeting

The annual ETAC business meeting was held in Kamloops on November 9, 2004. Kathie Swift of FORREX gave a presentation on Extension Planning Workshops.

Extension Notes

Extension notes initiated over the past few years are now completed and available on the FGC website at http://www.fgcouncil.bc.ca/index.html

Extension Note 3, Benefits of Using Selected Reforestation Materials, Cortex and Jack Woods, January 2005

Extension Note 4, The Reproductive Biology of Western White Pine, April 2004 (100 copies of Extension Note 4 were printed.)

Extension Note 5, Environmental Effects on Yellow-cedar Pollen Quality, Oldrich Hak, April 2004

Extension Note 6, Applications of DNA Markers in BC Tree Improvement Programs, Craig Newton, April 2004

Extension notes in production this year are:

The Reproductive Biology of Lodgepole Pine

Use of DNA Markers to Evaluate SMP Efficacy in Lodgepole Pine

Cone Induction in Western Red-cedar Seed Orchards

Somatic Embriogenesis Project Report

ETAC Client Survey

The Forest Genetics Council Tree Improvement and Genetics information needs survey was developed by FORREX and delivered in January 2005 through a web-based program called zoomerang. SPAR, BCTS, woodlot owners, BCMoF, consultants, and other industry contacts comprised a client contact list of 316 persons. Results of the survey will be presented to the Forest Genetics Council and published. An Extension Planning Workshop will be the next step in developing an Extension Plan for FGC through ETAC.

Tree Improvement in BC brochure

This brochure is currently being revised and updated.

Northwest Forest Genetics Tour

A forest genetics tour was held October 6, 2004 to view some of the provenance/progeny trials in the Kitwanga/Kispiox area of BC. Issues that were discussed ranged from seed "transfer" guidelines, diseases of Lodgepole pine, Chief Forester's Standards for Seed Use, genetic gains, and genetics relative to site productivity and global warming.

Stops were at Mill Creek (hybrid spruce trials and results); Kitwancool Lake (western hemlock, yellow-cedar, western redcedar testing, and *Dothistroma* damage in Lodgepole pine); Kitwanga (species trials), and Helen Lake (hybrid spruce and western hemlock trials). Alvin Yanchuk, John King, Greg O'Neill, and Charlie Cartwright, Research Branch; Alex Woods, regional pathologist at Smithers, and Brian Barber, Tree Improvement Branch, made presentations. Representatives from BCTS, industry, BCMoF, and forestry consultants participated.

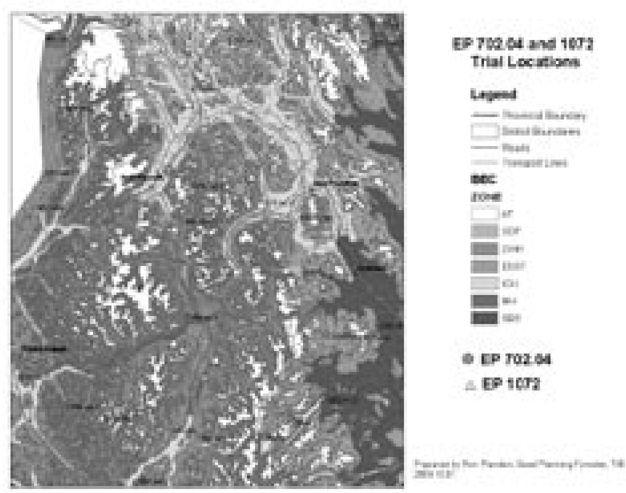


Figure 45. EP 702.04 and 1072 trial locations

Plates 23 and 24. Photos from the forest genetics tour held October 6, 2004 to view some of the provenance/progeny trials in the Kitwanga/Kispiox area of BC

7.0 Seed Pest Management

7.1 Operational Assay Program for Fungi Attacking Conifer Seed in BC

Robb Bennett (compiled from report submitted by Dave Kolotelo)

The BC Ministry of Forests Tree Seed Centre leads this project, with collaboration from Applied Forest Science Ltd. Now in its second year, the project's objectives are to:

- continue to perform fungal assays on seed lots from conifer species known to be at high risk to infection by a particular pathogen and
- make this information available to seed users through the Seed Planning and Registry System (SPAR).

The following fungal assays were performed in 2004/05:

- *Caloscypha fulgens* – 48 seed lots
- *Fusarium* spp. – 89 seed lots
- *Sirococcus* spp. – 46 seed lots

The results of these assays were posted on SPAR in preparation for the 2005 seed lot sowing requests.

7.2 Identification of an Effective Sex Pheromone Lure for the Fir Coneworm, *Dioryctria abietivorella*, and Demonstration of its Efficacy in Seed Orchards (SPM 0002)

Robb Bennett (compiled from reports submitted by Gary Grant and Jocelyn Millar)

Canadian Forest Service and University of California (Riverside) researchers led the second year of this project with collaboration from the BC Ministry of Forests. Primary objectives of this work are to:

- identify the sex pheromone of the fir coneworm and
- develop the pheromone as a tool for sampling fir coneworm populations and monitoring coneworm phenology in seed orchards.

Very significant progress was made in 2004/05. Problems identified in 2003/04 field and lab work with pheromone components were resolved. Exhaustive lab bioassays showed that the standard commercial preparation of one of the pheromone components was isomerically impure. Lab bioassays and field trials allowed identification of a previously unknown component of the fir coneworm sex pheromone. The new component was successfully synthesized and subsequently field-tested in conjunction with the two previously identified (and now stereoisomerically pure) components of the sex pheromone. For the first time, large numbers of male coneworm moths were captured. Results indicated that one of the previously identified compounds is actually inhibitory and that a blended ratio of the remaining two compounds is critical. In 2005/06, the final year of this project, simple synthesis techniques for the pheromone components will be developed, and field trials will develop the pheromone blend for operational field use.

7.3 Identification of Seed Chalcids Infesting Seeds of BC Conifers (SPM 0003)

Robb Bennett

2004/05 marked the second year of Forest Genetics Council support for this long-standing international collaborative project led by the Canadian Forest Service (CFS) and the Institut National de Recherces Agronomiques (INRA - France). The BC Ministry of Forests (BCFS – the Tree Seed Centre and the Seed Pest Management group) and Yellow Point Propagation Ltd. are major collaborators. The long-term objectives are to:

- clarify the identity and host range of the North American species of seed chalcids in general, and of those exploiting conifer seed in BC in particular, and
- determine the identity of and attack timing data for parasitoid insects attacking seed wasps.

The 2004 growing season saw poor cone crops in most natural stands across the province. Addressing the second objective requires significant cone crops, and thus MoF did no post-harvest parasitoid work in 2004/05. CFS and INRA staff continued post-harvest work on this objective in Ontario, the United States, and France.

Seed samples from 33 seed lots (11 natural-stand and 22 orchard seed lots) collected in fall 2004 were shipped to the CFS Sault Ste. Marie lab in early 2005. Host species represented are: *Pseudotsuga menziesii*, *Abies amabilis, Larix occidentalis*, *Pinus monticola*, *Pinus ponderosa*, *Tsuga heterophylla*, and *Picea* spp. All seed lots were X-rayed during winter 2005 to determine the presence of insect larvae within seeds. Currently, a proportion of infested seed from all seed lots are being stored at 2° C until spring 2005, when they will be put in an outdoor insectary and checked daily for adult seed chalcid or parasitoid emergence. Half or more of seeds from each infested sample have been shipped to INRA for genetic analysis of emerging specimens.

7.4 Identification of Communication Signals Produced by Male Western Conifer Seed Bugs, *Leptoglossus occidentalis* (SPM 0001)

Robb Bennett (compiled from information submitted by Gerhard Gries)

In the second year of this project, the following objectives were to be addressed under terms of a contribution agreement with Simon Fraser University (SFU):

- Complete identification of the major candidate pheromone component of male western conifer seed bug (WCSB).
- Test in field experiments the attraction of WCSB to airborne auditory communication signals.
- Test in field experiments the attraction of WCSB to substrate-borne vibration signals.

Although some progress was made with acoustic signalling, logistical problems and worker health troubles hampered work on this project in 2004/05. SFU now has a new worker in place to address the project objectives in the 2005/06 season. Until the objectives are met and project review by the Pest Management Technical Advisory Committee indicates satisfactory progress has been made, no further funding will be awarded for this project. A technical manuscript on acoustic signalling in WCSB has been drafted for submission to a scientific journal.

Appendix 1 FGC Seed Planning Unit

SPU Unit (OTIP)	Seed Planning Unit (SPU)	Species	Seed Planning Zone (SPZ)	Elevation Band (metres)		Latitude Band (degrees / minutes)	
		Common name		Min	Max	Min	Max
1	FDC M LOW	Douglas-fir	M	1	700		
2	CW M LOW SOUTH	Western redcedar	M	1	600	4800	5200
3	HW M LOW SOUTH	Western hemlock	M	1	600	4800	5200
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	4800	5200
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	4800	5200
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	4800	5200
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	5200	6000
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 Mtn. 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 b. ssp. trichocarpa	Act
hybrid poplars	Populus spp.	Ax
trembling aspen	Populus tremuloides	At
paper birch	Betula papyrifera	Ep
Garry oak	Quercus garryana	Qg

Appendix 3 Discussions by Tree Species

CONIFERS	ABBREVIATION	PAGE LOCATIONS
Western redcedar	Cw	7, 18, 21, 22, 32, 37
Yellow-cedar	Yc	9, 19, 21, 22, 39-42
Douglas-fir	Fdc	5, 18, 21, 22, 23, 31, 37, 48
Interior Douglas-fir	Fdi	10, 24, 25, 26, 43
Amabilis fir	Ba	22
Western hemlock	Hw	6, 19, 22, 31, 38
Western larch	Lw	16, 24
Lodgepole pine	Pli	12-13, 24, 25, 26, 27-29, 35-37, 44-45, 46-47
Western white pine	Pw	9, 14, 21, 22, 24, 29, 31, 48
Sitka spruce	Ss	5, 19, 45-46
Spruce hybrid (interior spruce/s)	Sx	11-12, 24, 25, 27, 29, 39, 43
Ponderosa pine	Pp	14-15

HARDWOODS		
Hybrid poplars	Ax	
Paper birch	Bp	

PEST		
Caloscypha fulgens		54
Fusarium		54
Sirococcus		54
Dioryctria abietivorella		54, 48-49
Seed chalcids		54-55
Leptoglossus occidentalis		35-37, 55

Appendix 4 Authors and Species Topic

AUTHOR	SPECIES/DISCUSSION	PAGE
Aitken, Sally	Gene Conservation	3-4
Ashley, Valerie	Fdi, Lw, Sx	11-12, 16
Bennett, Robb	Cone and Seed Pests	32, 37, 54-55
Berger, Vicky	Pli	12-13, 14-15
Bird, Keith	Fdc	5
Brown, Patti	Fdc, Hw, Pw, Yc, Cw	21
Carlson, Mike	Pli	12-13, 14-15
Cartwright, Charlie	Hw, Ss	6-7
Cox, Keith	Pw, Sx	14, 15, 29-30
Crowder, Tim	Fdc, Pw, Ba, Hw	21-22
Douglas, Diane	Extension	52-53
Ferguson, Craig	Cw, Yc	7-9
Giampa, Gary	Sx, Lw, Pli	43-45
Graham, Hilary	Pli, Fdi	26-27
Hak, Oldrich	Hw, Yc	38, 39-42
Hooge, Bonnie	Fdi, Sx, Lw	11-12, 16
Hollefreund, Clint	Fdc	5
Hunt, Rich	Pw	9-10
Jaquish, B.	Fdi, Sx, Lw	11-12, 16
King, John	Ss, Sx, Pw	5-6, 9-10
Kolotelo, David	Cones and Pests	54
Lee, Tim	Sx, Pli, Fdi	25
Lohr, Carolyn	Fdc, Hw, Pw	31
McAuley, Leslie	SPAR	2
Mehl, Helga	Sx	39
Murphy, John	Pli	12-13, 14-15
Nicholson, George	Pli, Sx	27
Newton, Craig	Sx, Lw	45-46
Painter, Roger	Program Management/Extension	17-18
Phillips, Giselle	Fdi, Sx, Lw	11-12, 16
Pieper, Greg	Pli, Sx	27
Ponsford, Dave	Ss, Pw	5-6, 9-10
Rudolph, Dan	Pw, Fdc	22-23
Russell, John	Cw, Yc	7-9
Stoehr, Michael	Fdc, Pli, Sx	5
Strong, Ward	Leptoglossus	35-37, 48-49
Van Neijenhuis, Annette	Cw, Fdc, Hw, Ss	18-21
Wagner, Rita	Pli, Sx	27-29
Walsh, Chris	Pli, Sx, Lw, Pw	14-15, 23-24, 46-47
Webber, Joe	Pli	32-34, 46-47
Wigmore, Bevin	Cw	21-22
Woods, Jack	Program Management/SelectSeed	1

Appendix 5 Author Contact List

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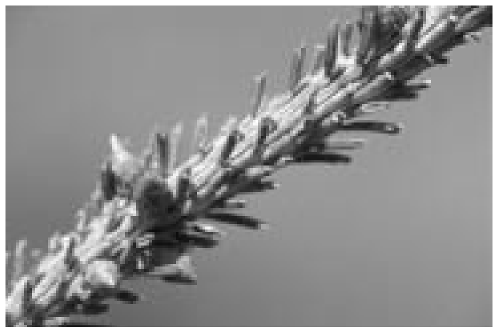
Woods, Jack	SelectSeed	250-748-9579

Back Cover

Grasshopper feeding on spruce shoots reduces the length of all needles equally, giving a brush-cut appearance.

Insect exclusion bag installed over cones of Lodgepole pine for *Leptoglossus* research.

Gall of Western Gall Rust (*Endocronartium harknesii*) on branch of lodgepole pine.



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