Forest Genetics Council of BC Tree Improvement Program

FGC Forest Genetics Council of British Columbia

FOREST SERVICE BRITISH COLUMBIA

Project Report 2001/2002

Front Cover Interpretations

In British Columbia, Interior Douglas-fir and western larch gene resource management programs have been ongoing since 1982 and 1987, respectively. The Interior Douglas-fir tree breeding program focuses on six seed planning zones across the productive forest land base in Interior. More than 1660 wind-pollinated families from the six zones have been planted in 35 progeny tests. Results from these tests have been used for backward selection on the original parents to establish 1.5 generation seed orchards for five zones. The sixth orchard is currently in the development stage. These seed orchards are expected to come into production within three years. Controlled crossing to produce seedlings for second-generation progeny testing is ongoing. In western larch, more than 610 open-pollinated families are in test on fourteen sites in two seed planning zones. Seed orchards are in production and advanced-generation breeding is about 30 percent complete.

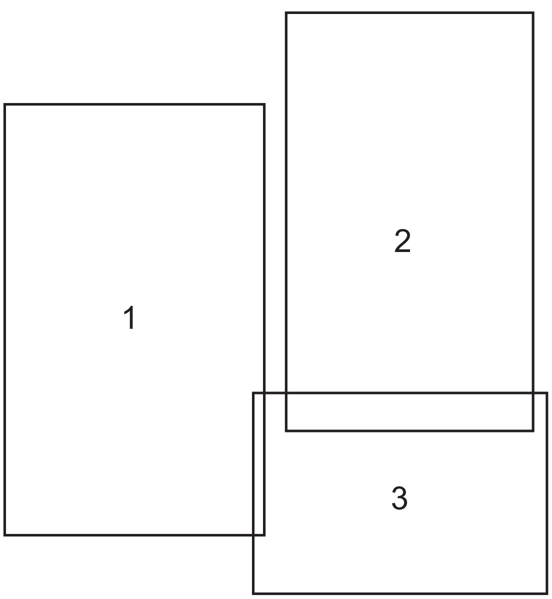


Plate 1. Hybrids of coastal x Interior Douglas-fir. These intraspecific hybrids demonstrated outstanding growth on productive low elevation sites in the BC Interior. After six growing seasons Shuswap Adams hybrids were 15 percent taller, and Cariboo Transition hybrids were 46 percent taller than their respective local sources. Hybrids survival and damage on these sites was minimal.

Plate 2. Western larch seed orchard. The western larch seed orchards at Kalamalka Forestry Centre were planted in spring 1990. The first collectable seed crop was produced in 1999. Today, the majority of the western larch seedlings planted in BC. originate from seed orchards.

Plate 3. Regrafting within western larch orchards is an effective way to improve orchard composition. As progeny test data becomes available, higher value trees are grafted onto existing lower value trees in the orchard.

Forest Genetics Council of BC

Tree Improvement Program

Project Report 2001/2002

Coordinated and compiled by:

Brian Crown,
Island Eyes Images,
and
Roger Painter,
Tree Improvement Branch
British Columbia Ministry of Forests

Acknowledgements

For the past five years the Tree Improvement Program has enjoyed strong financial support from Forest Renewal BC. There is little doubt that this support has provided the resources to put together a vibrant, robust industry. In that time the Forest Genetics Council (FGC) has been reconstituted and has set out an aggressive plan with long term goals for our industry. The FGC has become a model for co-operative organizations and has brought together the efforts of Government, Industry and the intellectual community. From this cooperative approach has come a strong sense of need for a business approach to tree improvement. This has included business plans, budgets with performance indicators and a method for assigning priorities for annual projects to name just a few. With this funding has come the realization that working together in true cooperation has positioned our industry for any future opportunities.

The FGC has developed the tools to ensure that it will continue to provide leadership for tree improvement. Through it's Technical Advisory Committees (TAC's) we've developed a broad based long-term strategic plan that takes into account all aspects of tree improvement while providing mechanisms to measure its progress. This has involved the voluntary help of a large portion of those in the tree improvement industry. Species committees, proposal-review committees, TAC's, and special task forces have all worked co-operatively to ensure that our industry has guidance and direction. Tree Improvement is a long-term program that requires broad support and considerable stable investment.

With the passing of Forest Renewal BC it is important that we recognize the hard work and dedication of Janet Gagne. Janet has been a strong advocate of tree improvement and there is little doubt that she is responsible for much of the continued success we have garnered from within Forest Renewal. She kept the program focussed and ensured that those within her organization were properly aware of the progress our program was making. Thanks once again to the Project Leaders for completing their portions of this report. This publication has proved to be very successful over the years and has been well received by all. My congratulations to you all, I hope that you are proud of this fifth annual report. It's been enjoyable putting it together for you. I would like to acknowledge the work of the editorial review team, Diane Gertzen, Joe Webber, and Ron Planden, for checking our presentations.

The front and back covers of this year's report focus on the work of Barry Jaquish, the Ministry of Forests Breeder for Interior Douglas-fir, Interior Spruce and Western larch. We are pleased to be able to use this publication to showcase his work. Barry has provided an excellent visual presentation of his work.

As you are no doubt aware 2002-2003 will see the initiation of a new funding source - the Forest Investment Program. Because of strong management and good planning the Tree Improvement program is well situated and already recognized under the new funding source. This is indeed good news and I look forward to working with you again on your projects. Hopefully we will be able to produce this report again next year. I would like to take the opportunity to thanks all those who have worked on this program with me in the Operational Tree Improvement and Tree Breeding Programs. They have made the job of administering the program a relatively problem free process. We will continue to work on their behalf in providing the new Forest Investment Program with good sound reporting and accountability while allowing the projects leaders to get on with the work.

To all the Project Leaders I hope 2002/2003 is very successful.

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

Introduction

Dale Draper, and Shane Browne-Clayton, Co-Chairs, Forest Genetics Council of British Columbia

This report marks the fifth and final year of the Forest Renewal B.C. sponsored tree improvement program. Since 1997 FRBC has been a major partner and source of funding for the Forest Genetics Council (FGC) in delivery of provincial tree improvement objectives, including:

- Doubling the genetic gain (genetic worth) of select materials planted from 6% to 12% by year 2007
- Increasing the use of select seed to 75% of total annual provincial sowing requests by year 2007
- Managing a gene conservation program to maintain genetic diversity in commercial tree species, and
- Supporting the long-term seed production capacity needed to meet the priorities of the FGC business plan.

Over this 5 year period of FRBC funding the increase in average genetic worth of planted material rose from 6.5% to 10.1% and the province wide use of select seed rose from 29% to 43%. These enhancements in seed quality and quantity more than double the 1997 estimate of an additional 838 M cu m of volume expected from improved seed to some 1,892 M cu m of added volume from 2001 improved seed use. Volume estimates are at a rotation age of 65 years.

Sincere thanks go to FRBC staff for their work within the tree improvement community over this period. In particular, the FGC wishes to thank Janet Gagne for her dedication to program management and the many contributions she made over this period.

FRBC will officially relinquish its' funding role March 31, 2002 but we are pleased to be able to report that the Forest Investment vote, under the responsibility of the Honourable Michael de Jong, Minister of Forests, will be carrying on in this capacity. The existence of a Tree Improvement envelope within the Forest Investment vote is due to the hard work and lobbying efforts of forest industry, academia and government stakeholders over the last year. In addition to continuation of the FGC and SelectSeed programs through the Tree Improvement envelope, the Forest Investment vote land-base envelope will also recognize a range of tree improvement activities as eligible expenditures for forest industry in 2002/03.

Dale Draper, and Shane Browne-Clayton, Co-Chairs, Forest Genetics Council of British Columbia

In the 2001/02 sowing year the average genetic worth of material requested for reforestation in British Columbia averaged 10.1% (see Figure 1.). This is well on track with projections to the year 2007 targets and represents a considerable increase over last years' figure of 7.8%. Reasons for the increase include speciality seedlot production of high genetic worth material in recognition of its superior performance; a general increase in quality and quantity of seed orchard material; and the assignment of genetic worth values to superior provenance seedlot collections.

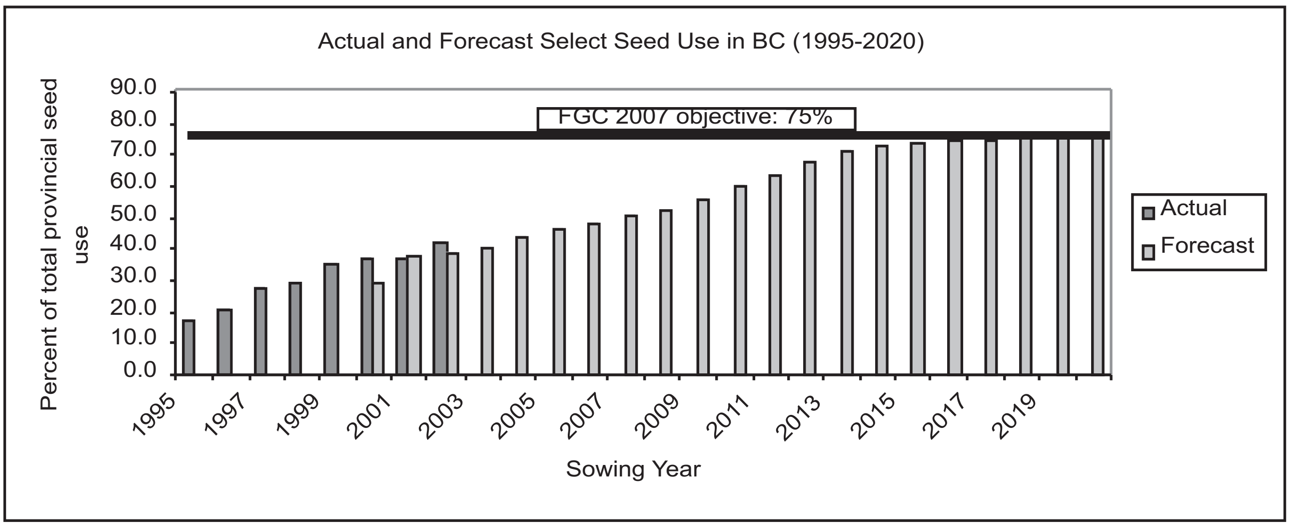


Figure 1.

In this same sowing year (2001/02) the proportion of select seed (gw>0) used across the province also increased to 43% of the provincial sowing program (data from SPAR). This also represents a significant increase over last year and Figure 2 shows the historic use levels and the projections to the year 2007 target.

Dale Draper, and Shane Browne-Clayton, Co-Chairs, Forest Genetics Council of British Columbia

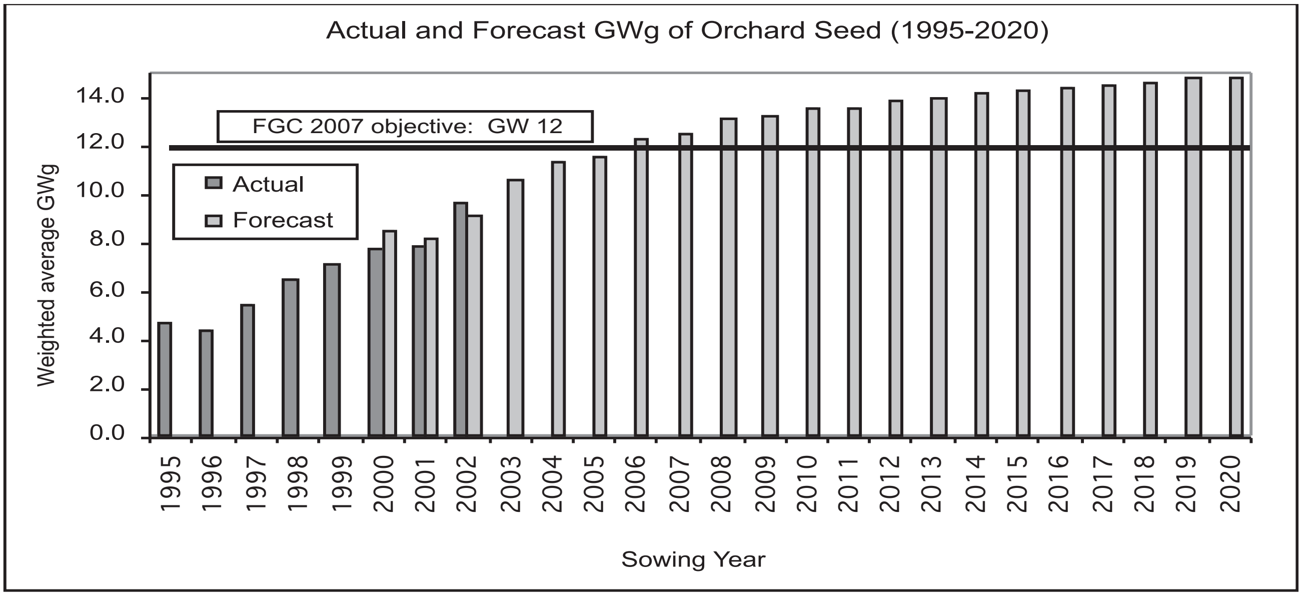


Figure 2.

Once again we note that all materials used in British Columbia's operational reforestation program are derived from selections of wild native trees exhibiting good adaptability and performance traits. These selected parents are tested in conventional breeding and testing programs and are not 'genetically engineered', 'genetically modified' or otherwise artificially produced through modern biotechnology techniques. All seedlots for crown land reforestation in British Columbia are required to meet exacting technical standards before registration and use.

Readers of this annual report will also find program summaries for Gene Conservation, Tree Breeding, the Operational Tree Improvement Program, SelectSeed, Extension and Communications, Seed Information Systems Planning and Administration.

Finally, and with great sadness, we note the recent passing of Dr. Gene Namkoong. Gene played an important role in the education of many of British Columbia's prominent forest geneticists; in the design and implementation of breeding programs and strategies in this province; and in the recent establishment of the Centre for Forest Gene Conservation at the University of British Columbia. Gene was recently recognised by the Forest Genetics Council as their recipient of the 1999 FGC Achievement Award.

Dale Draper, and Shane Browne-Clayton, Co-Chairs, Forest Genetics Council of British Columbia

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:

OTIP Program Administrator
Ministry of Forests
Tree Improvement Branch
PO Box 9518 Stn Prov Govt
Victoria BC, V8W 9C2

Further tree improvement information can be found at our Web sites:

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

Table of Contents

Table of Contents (con't.)

Table of Contents *(con't.)*

Figures

Table of Contents *(con't.)*

Program Overview

1.0 Tree Improvement Program

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, Ministry of Forests (MOF), Canadian Forest Service, and universities.

Forest Renewal B.C. has been a major funding agency for forest gene resource management in British Columbia. Through its Tree Improvement Program (TIP), Forest Renewal invested in forest gene resource management activities that have supported its objectives and are incremental to existing government and industry activities.

The Forest Renewal B.C. TIP was guided by strategic and annual business plans prepared by the FGC.

1.1 The Forest Genetics Council of BC

The Forest Genetics Council of British Columbia (FGC) is a multi-stakeholder group representing the forest industry, Ministry of Forests (MoF), 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.*

1.2 Forest Renewal TIP Subprograms

The Forest Renewal TIP was 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 (Figure 4).

- Gene Conservation
- Tree Breeding
- Operational Tree Improvement Program (OTIP)
- Expansion of Orchard Seed Supply (SelectSeed Ltd.)
- Extension and Communication
- Seed Planning and Information Tools
- Administration.

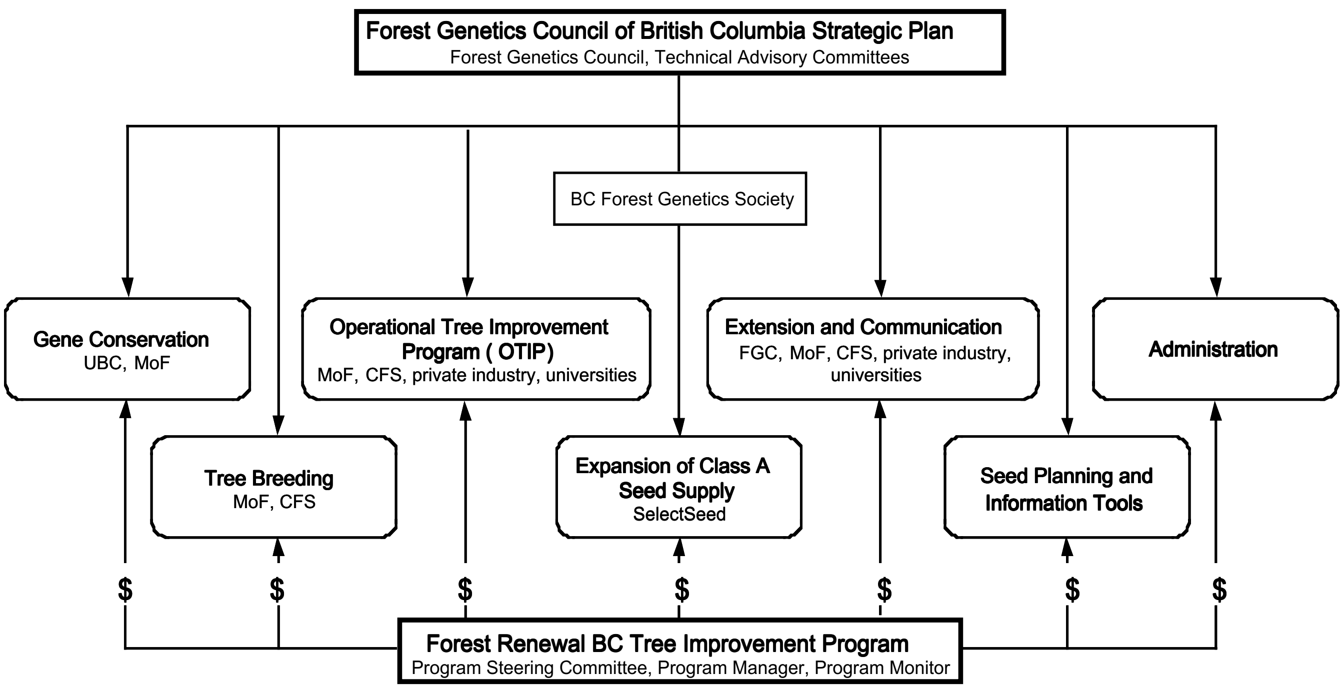


Figure 3. Relationship between FGC Strategic Plan, Forest Renewal B.C. TIP, and participants in various forest gene resource management areas

1.2.1 Gene Conservation Subprogram

Gene conservation activities protect the gene pool needed for species to adapt to future environmental conditions, and to ensure that genetic resources are maintained for future generations. Activities are developed by the Gene Conservation TAC and a newly established Forest Gene Conservation Centre at the University of British Columbia. Technical direction is reviewed through a Scientific Advisory Committee. The Centre has received funding through a Contribution Agreement with Forest Renewal B.C., and will seek funding from other agencies or groups as opportunities arise.

1.2.2 Tree Breeding Subprogram

The Tree Breeding Subprogram focuses on the continued improvement of seed and vegetative materials for reforestation. Tree breeding activities include selecting parents in wild stands, propagation, testing offspring, mating, establishing/maintaining/measuring trials, and technical support. The Subprogram also includes applied genecology to support the information needs of seed planning unit (SPU) programs as described in Species Plans. FGC Interior and Coastal TACs and their associated Species Committees carry out planning for the Tree Breeding Subprogram. The MoF Research Branch manages and carries out Tree Breeding Subprogram activities.

1.2.3 Operational Tree Improvement Program (OTIP)

The objective of the OTIP is to increase the quality and quantity of seed produced from existing forest company and MoF seed orchards. It also provides technical support for orchard production and management, including pest management. OTIP spending is based on Species Plans. Projects are developed through a call-for-proposals process that is based on Species Plans priorities. FGC Review Committees review and rank all proposals on need, technical merit, impact, value, and cost. The MoF Tree Improvement Branch administers the OTIP on behalf of Forest Renewal and the FGC.

1.2.4 Expansion of Orchard Seed Supply Subprogram (SelectSeed Ltd.)

Forest Renewal B.C. has supported seed orchard expansions and the co-operative production of vegetative materials through Select Seed Company Ltd. (SelectSeed), a corporation wholly owned by the B.C. Forest Genetics Society (Figure 1). SelectSeed's primary mandate is to support seed orchard expansions needed to meet FGC objectives. As SelectSeed is controlled by stakeholders and not aligned with any single agency, it also provides program management services to the FGC.

SelectSeed's business plan and investments are based on the long-term and annual business plans prepared by FGC TACs and Species Committees. Management discretion for spending lies with the SelectSeed Board of Directors, and is guided by the terms of the SelectSeed-FRBC Multi-Year Agreement. Orchard development agreements take the form of long-term contracts that provide stability for investment and management. The SelectSeed Business Plan is reviewed and approved annually by the FGC.

1.2.5 Extension and Communication Subprogram

The Extension and Communication Subprogram supports FGC goals and objectives through extension, communication, and education activities. These activities are developed and guided by the FGC Extension Technical Advisory Committee (ETAC), which includes representative groups involved in research, extension, training, and communications. The ETAC prepares an annual activity plan to guide extension and communication activities. The plan forms the basis of an annual call for proposals in conjunction with the OTIP subprogram call. Extension and Communication contracts are administered by the MoF Tree Improvement Branch on behalf of Forest Renewal and the FGC.

1.2.6 Seed Planning and Information Tools Subprogram

The Seed Planning and Information Tools Subprogram supports the development of computer-based information systems that improve user access to information about the availability of select reforestation materials. Two information systems projects are in progress: SPAR Web Conversion, and development of the Species Plan Web Mapping System. These projects are jointly funded by the Ministry of Forests and the Forest Renewal B.C. TIP. Seed Planning and Information Tools activities and budgets are developed by the Seed Information Systems Steering Committee (SISSC), comprised of staff from the MoF Tree Improvement Branch (TIB), MoF systems staff, and the FGC Program Manager. Projects are identified by the Committee, developed by TIB staff and presented to the Forest Genetics Council for approval. This two-year subprogram, which ends in 2002, is administered by the TIB on behalf of Forest Renewal B.C. and the FGC.

1.2.7 Administration Subprogram

The Administration Subprogram has two components. The administrative infrastructure for the Tree Breeding, OTIP, Extension and Communication, and Seed Planning and Information Tools subprograms is provided by the MOF under the FRBC/Ministry of Forests Goals Agreement. Support for the Council's day-to-day business, meetings, communications, and planning activities are provided by the FGC Executive Secretariat, whose services are contracted out through a competitive bidding process.

1.3 TIP Budget

Subprogram budgets are listed in Table 1, which includes only Forest Renewal BC's financial allocations. In-kind, staff and other contributions by industry, Ministry of Forests and university cooperators are not included, but are substantial and necessary inputs for program success. Actual spending may differ somewhat from the information presented here (see table1 below).

Subprogram	Budget	Expenditures
Gene Conservation	$250,000	$250,000
Tree Breeding	$2,450,000	$2,450,000
Operational Tree Improvement Program (OTIP)	$1,400,000	$1,400,000
Expansion of Orchard Seed Supply (SelectSeed Ltd.)	$4,800,000	$1,200,000
Extension and Communication	$190,000	$110,000
Seed Planning and Information Tools	$287,000	$287,000
Administration	$340,000	$340,000
Forest Renewal BC Tree Improvement Program Contribution	$9,655,000	$4,963,804

* Most of this budget was intended for a long-term fund that will support long-term orchard development contracts.

Table 1. Budget summary for Forest Renewal B.C. Tree Improvement Program

- ***Seed planning units-groupings** by species, seed zone, and elevation band-form the basis for tree breeding and seed production planning.*
- ***The Board** is comprised of representatives from the private sector and government, including the industry and government FGC Co-Chairs.*

2.0 The Fifth Year in Review

Roger Painter

This is the last year of our partnership with Forest Renewal B.C.. The Tree Improvement Program has progressed considerably in the last five years in improving the available seed supplies, in both quality and the quantity of the crops that will lead to future generations of healthy stronger forests. This will help meet the growing need for forest products in the future and provide a strong long-term economy. The long-term goals of our industry require a constant commitment to ensure that they will lead to a stable source of economic benefit. This program has provided a steady source of resources to help move the tree improvement industry towards its overall objectives.

The Tree Improvement Program is organized through two key approaches. The first approach has been to divide the Tree Improvement Program into sub-programs to better provide direction for specific areas. Five sub-programs now exist on the operational side of tree improvement. They include Operational Production (OTIP), Tree Breeding, Extension and Communication, Gene Conservation, and Seed Planning and Information Tools. The Forest Genetics Council has four working committees; Coastal and Interior Technical Advisory Committees (CTAC and ITAC), as well as Extension and Communication and Gene Conservation Technical committees. These Committees work to create goals and priorities specific to those areas.

The second approach has been for Council to monitor progress through a performance planning system to ensuring that the overall program goals are met. All projects have a series of specific performance indicators to judge their effectiveness. Species committees (sub-committees of the TAC's) also take on a strong roll in reviewing progress and providing priorities for investment. This has the effect of ensuring that projects are initiated and achieve their objectives. In the current year, a total of 105 proposals in the operational program were reviewed in 2001/2002 for funding. The technical review committees recommended that 92 of the proposals be accepted. The total amount of proposals received was approximately $2.0 million with just over $1.4 millions in proposals being approved.

This operational program is divided into Coastal and Interior regions. The Coast represents a smaller area overall however it's tree improvement activities are more advanced and diverse. The interior programs cover a large proportion of the province and have large seed needs. It received the greater portion of funding this year targeting considerable work in Lodgepole Pine. A sub-committee was formed in the Fall of 1999 to review and make recommendations related to seed-set in Lodgepole Pine orchards in the Okanagan. Seed yields have not been at the level that was originally expected and a number of approaches have been suggested to improve production. This committee reviewed the various approaches, made a series of recommendations, which were incorporated into the Call for Proposals issued for the past two years. Research teams have been working on this problem and have now reported out with their initial results and recommendations to increase seed set. Some follow-up work is being performed in 2002-2003. The breakdown of investment by region for OTIP is as follows:

Number of projects and funding by region		
Interior projects	59	$1,017,748
Coastal projects	33	$468,071
Overall Total	92	$1,485,819

Council has a strong program for developing annual project priorities through annual species committee reviews. Both Tree Breeding and the Operational Tree Improvement Program receive their direction from these reviews. Similarly the Extension and Gene Conservation TAC have developed their own priority review procedures and a steering committee provides oversight for the Seed Planning and Information Tools sub program. Tree Breeding, as a Ministry of Forests responsibility is not part of the original Operational Tree Improvement Program, "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 support is needed in this sub-program and will continue to receive strong levels of funding to ensure that development of new production stock is achieved for the new orchards that are currently in the planning stages. These new orchards will provide seed for the various Seed Planning Zones where production capacity is low and/or where priorities for genetic quality seed are high. It will also help produce stock to replace older less advanced orchards. Work in Tree Breeding has already provided much of the necessary genetic material to establish these new orchards. The development of a long-term investment program through Select Seed Ltd. has produced over 25,000 grafts for new orchard establishment so far.

Although not a specific sub-program, technical support is an integral part of tree improvement in general and continues to be a part of OTIP. This has shown its value particularly in providing answers to the Lodgepole Pine seed-set issue. Operationally focussed investigations allow the tree improvement program to develop better methods for operational delivery of its product while the operational production program continues to expand and enhance existing orchard capacity. A project breakdown by areas of investment follows:

Number of projects area of investment	
Tree Breeding	40
Gene Conservation	8
Operational Production	52
Technical Support	37
Extension and Communication	17
Seed Planning and Information Tools	2

The tree improvement industry represents a broad base of partners. This includes forestry companies, the provincial government, the Canadian Forest Service, universities, private bio-technical companies and individuals. In 2001/2002 Tree Improvement Program involved 48 separate proponents from all parts of the industry. With the current structures that include sub-programs and the focus driven TAC's, the Forest Genetics Council continues to provide the direction necessary for making sound investment and guidance for selecting acceptable proposals. The use of performance planning also helps ensure that approved submissions reflect the direction that the Council has set for meeting its goals. The Council, through its TAC's strives to review and update it's planning documents annual. Seed Planning Units (SPU) (see Appendix 2) are a key element in that planning process and define the intensity of business planning required to successfully manage a diverse provincial program that has a firm direction and purpose.

2.1 Centre for Forest Gene Conservation UBC

Sally Aitken

The Centre for Forest Gene Conservation at the University of British Columbia is now well established and working to meet the needs of the Forest Genetics Council's Gene Conservation Program under the guidance of the Gene Conservation Technical Advisory Committee. In the past year it has become fully staffed, well equipped and started running at full speed. All planned projects have been initiated, and some are completed or nearing completion.

Projects of the CFGC involve collaboration, cooperation and contracts with government agencies, industry and contractors. Extension activities completed to date include a seminar on genetics and certification, a survey and workshop on prioritizing minor species for conservation genetics projects, and the development of an informative web site (http://genetics.forestry.ubc.ca/cfgc). Here we provide a brief summary of progress to date for projects of the CFGC.

Genetic issues in certification.

The role of genetics in several third-party forest product certification programs worldwide was investigated and summarized by Justin Stead (WWF), Graeme Auld (UBC), Gary Bull (UBC) and Sally Aitken. The implications of the results of this survey for forestry in B.C. were evaluated. In general, the policies in place for the management of genetic resources in B.C. exceed those required by certification programs at present. Most references to genetics in the certification programs reviewed are vague and lack specific criteria and measurable indicators.

The report produced by this project was the focus of a half-day seminar at UBC on Jan. 22, 2002, attended by approximately 30 people from government, industry, academia and non-profit organizations. Suggestions and comments made at the seminar from participants and panel members were used to modify the report. The final report will be available from the CFGC by the end of March.

Cataloguing and documenting in situ protection.

In situ gene conservation is the conservation of genetic diversity in wild populations in protected areas and other reserves. Research Associate Andreas Hamann is evaluating *in situ* conservation for all conifer and hardwood tree species in B.C.. As a first step, he estimated the degree of representation of approximately 50 tree species in the province conserved *in situ* using province-wide vegetation cover plot data and GIS layers for biogeoclimatic subzones and protected areas. In this manner, the relative protection of species can be estimated for each ecological unit, assuming representation in vegetation plots, can be extrapolated to subzones. This has been completed for all of the species analyzed. Methodologies are documented in the CFGC website, and the results will be summarized there shortly.

This initial method is not highly accurate as it requires some assumptions about species ranges as well as relationships between percent cover and densities per hectare for extrapolation from vegetation plot data. Andreas Hamann is working with Leslie McAuley, Alvin Yanchuk and other staff from the provincial government to explore other potential GIS databases that would provide a higher degree of accuracy and the ability to estimate population sizes for areas of species' ranges that appear to have marginal or inadequate protection.

Sampling strategies and SPUs

The alternative to gene conservation *in situ* is to capture genetic diversity through *ex situ* sampling. Capturing common alleles can be accomplished with relatively small sample sizes and little thought to sampling strategy, but rare alleles are more difficult to capture and conserve.

We are exploring the efficiency of different sampling strategies for capturing rare alleles by assessing the distribution of genetic diversity, particularly for rare alleles, using Sitka spruce as a model species. Sitka spruce is an interesting model as rare alleles conferring resistance to the white pine shoot tip weevil seem to have unexpected geographic distributions. PhD candidate Washington Gapare obtained most of the necessary samples during the 2001 field season and is in the process of laboratory analysis using molecular markers. DNA extraction of thousands of samples is nearing completion and marker methods are being refined. This project is at approximately the halfway point and should be finished in 2003.

Markers and theory for measuring diversity.

As mentioned above, the project on genetics and certification found a lack of substantive criteria and indicators for monitoring the maintenance of genetic diversity and quality in most third-party certification schemes. The issue of how to assess genetic diversity over time in breeding, deployment and conservation populations remain important. Graduate student Hugh Wellman, under the supervision of Kermit Ritland and Yousry El-Kassaby, has initiated a project in this area and is currently developing an approach.

Whitebark pine genetics and conservation.

Whitebark pine is widely considered the species at most risk in B.C. due to its vulnerability to white pine blister rust. As a result, one of the first priorities of the CFGC was to investigate genetic diversity in this species, and to use the resulting information to develop a gene conservation strategy for whitebark pine.

Jodie Krakowski, an M.Sc. student at UBC, investigated the mating system and genetic diversity in whitebark pine in B.C.. She completed and defended her M.Sc. thesis in December, 2001. The results of this study were very interesting. While whitebark pine has very high levels of genetic diversity, it also has relatively high levels of inbreeding in natural stands (Figure 4). The degree of outcrossing is highly variable among trees within a stand, with some trees producing seed almost exclusively through self-pollination, while others are entirely outcrossing. The wide range in mean outcrossing rates, and the bimodal distribution, are unusual for a conifer. Seed resulting from inbreeding (related matings or self-pollination) may be less likely to produce blister rust resistant trees than outcrossed seed.

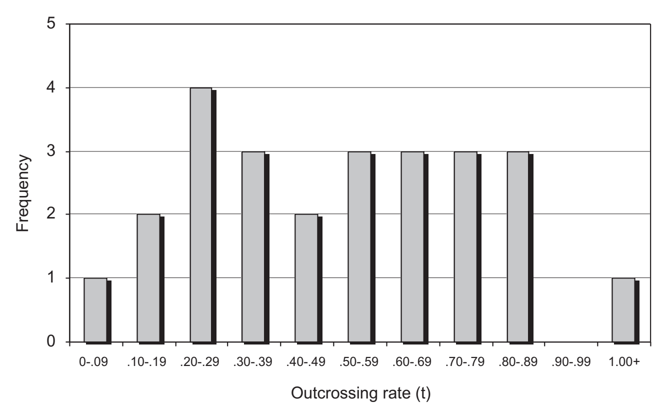


Figure 4. Outcrossing Rates of Individual Whitebark Pine.

The genetic structure in this species within and among stands reflects the role of Clark's nutcrackers in seed dispersal. Indirect evidence suggests that more inbred individuals (less heterozygous) may be less likely to survive white pine blister rust infection. The thesis includes recommendations for conserving whitebark pine. The initial project is being followed up by a genecological study of whitebark pine by PhD student Andy Bower. In addition to assessing geographic patterns of adaptive variation, Andy will be investigating the relationship between heterozygosity and fitness in this threatened species. Seedlots have been collected or obtained from cooperating agencies range wide for this study, and are now being stratified at the Tree Seed Centre.

Genetic structure of minor species.

The objective of this project is to gather information over time, species by species, on the genetic structure, diversity and mating systems of minor tree species in British Columbia. With approximately 50 tree species in the province, but less than a dozen for which any genetic information is available, it is a daunting task to prioritise minor species for genetic research.

We have taken a three-pronged approach to this problem:

1) Soliciting advice from field biologists, foresters and botanists on what species should be prioritised for gene conservation research and why, by widely distributing a survey by email, mail and on the CFGC website;

2) examining the results from the first phase of the project "Cataloguing and documenting protection", to determine what species may currently be underprotected; and

3) summarizing published genetic and ecological literature on these species. Information resulting from these three sources will be combined for a workshop that will bring together experts from different organizations and representing all geographic regions of the province to be held at UBC on March 14th, 2002.

Theoretical Framework document(s).

Gene Namkoong completed a draft theoretical gene conservation strategy for B.C. last spring. This strategy needs to be put into an operational context for the province, and integrated with the results of projects on certification, cataloguing and documenting protection, sampling strategies and SPUs and 1E markers and theory for measuring and monitoring diversity. Sally Aitken, Alvin Yanchuk and Andreas Hamann will continue to work on developing a complete strategy around the core Namkoong report in the 2002-03 fiscal year.

2.2 Tree Breeding

2.2.1 True Fir

Cheng Ying

This has been a busy year for True Fir. Three long-term provenance tests of amabilis fir have been established near Kitimat, Port McNeill and Jordan River. Each test contains 48 provenances and 308 wind-pollinated families from throughout the species' natural range in British Columbia. As a supplement to the B.C. component of provenance sources, we have made additional collections of amabilis fir seeds from seven provenances (70 wind-pollinated families) in Oregon and Washington. The seeds are being stratified for sowing this winter for three additional long-term tests in this fiscal year, aiming at the introduction of the southern provenances. The two series of tests are designed to augment each other, which will supply the growth and yield projection from genetic selection in relation to site productivity along the climate gradient from north to south coast. These tests, thus, constitute the core of the amabilis fir improvement project.

The four short-term tests of amabilis and subapine fir, as described in the 2000/01 annual report, are entering their third season now. We are analysing stem elongation, frost hardiness and data on seed and cone traits for a preliminary assessment of genetic variation. Results indicate substantial variation among provenances and families. For example, one subalpine fir provenance from Nass Valley showed a 50% superiority in total stem elongation over the average of 110 provenances, and 5 out of the 10 families from this particular source ranked in top 10 out of a total of 515 families. This suggests enormous potential to improve growth rate through the selection of superior provenances. However, reliability of selection at a very young age depends on solid database (density information). Intensive data collection will continue to be the focus. (SPU09)

2.2.2 Hemlock Forest Genetics Program

Charlie Cartwright

Considerable progress has been made over the past year in hemlock genetics. More trials were established, more measured, and more analyzed than in any previous year. The general focus has been updating breeding values for most series of tests, making initial advanced generation selections and completing seed transfer trials. Shade tolerance testing moved from the nursery bed stage to field testing, and investigation of possible resistance to dwarf hemlock mistletoe (*Arceuthobium tsugense*) commenced.

The series of first generation trials established in 1981 and 1993 were measured, leading to new breeding values for 101 parent trees. As well, three advanced generation trials were measured. This, in combination with two similar trials measured last year will lead to the selection of approximately 150 advanced generation parents to be grafted this spring.

Breeding was considerably more successful this year than last. A new series of advanced generation diallels was close enough to completion to allow for sowing this spring. (of 75 planned crosses, 60 were completed). Accomplishing this in only two breeding seasons is notable. As well as the new diallel crosses, some work focused on crossing best parents from lower elevation and latitudes with high elevation parent trees from the Mid-Coast and from the Queen Charlotte Islands. It is hoped that some of the already proven parents may be used to transfer gain to higher latitudes and elevations.

In the field, two more advanced generation trials were installed. These are installed five years after the initial trials of this type but feature more families. This material was obtained from the Hemlock Tree Improvement Co-operative (HEMTIC) which has outplanted four more copies of this trial this year, to complement the two we provided them with previously. As well, an elite trial which features only the top 30 parents in HEMTIC was also outplanted. There are four other tests of this material in B.C., but this elite installation features a family block design which should facilitate within-family selection. South of the American border, five tests of this sort were established to complement the one for which we supplied material four years ago. This completes the HEMTIC advanced generation testing. Selections from the older tests will commence this year with deployment to orchards expected about 2008.

Support research to the main program featured ongoing seed transfer testing. Work by the provenance forester Cheng Ying suggests that there is a considerable lag in adaptation in our province, such that optimal sources at some locations can originate hundreds of miles further South (pers comm). To establish best-adapted plants requires widespread trials on which to base seed transfer, and approach optimal growth potential. Tests containing a wide array of natural populations as well as tested families, were outplanted to the Queen Charlotte Islands, Nass/Skeena transition and high elevation North Vancouver Island. This complements other trials deployed last year and two more to go out in 2002. In general, two tests are located in each biogeoclimatic variant of interest, generally attempting to include a mesic site plus a more challenging location. From results, a north Coast hemlock low elevation orchard will be designed and information generated to optimize seed transfer guidelines for the Interior and Transition Zones.

A recent concern has been how to respond to changes in silvicultural systems. Alternative approaches suit hemlock well because of its shade tolerance, but it was unclear how residual stems would affect growth of high gain families. A nursery bed trial has been completed indicating that there is no negative effect of shade at the levels of transmission tested: 17%, 45% and 72%. Although plants grew better in light shade than in the control (unshaded), there was no indication of rank changes between wild stand and improved materials. Changes in morphology were marked for all genotypes, with the plants in the most shaded section being taller but thinner (lower root collar diameters). The nursery bed trial was continued through two growing seasons, and this year a field trial of wildstand materials versus improved families has been outplanted in a Douglas-fir overstory.

Figure 5. Hemlock Nursery Bed Shade Trial

Another problem of uneven aged management is disease. For hemlock, the main concern will be dwarf mistletoe. Since some resistance to this genus has been observed in Interior Douglas-fir, it seemed advisable to screen best hemlock families. To establish protocols for testing, and consider as wide a base of genetic materials as possible, a provenance screening trial was set up in greenhouses at the Canadian Forest Service Pacific Forestry Centre (PFC) in Victoria. Ten provenances represented by five families were potted and infected with 3 seeds each. Hemlock sources were high and low elevation from Mt. Hood, Oregon, Vancouver Island, Nakusp, Prince Rupert, and a low elevation populations from the Charlottes. No results are available to date, but a gene level assay for early detection of infection is being developed in co-operation with Dr. Simon Shamoun of PFC. Later this year progeny from 74 high gain parents will be potted and held for inoculation in the fall of 2002

High Elevation Hemlock

This year has featured more activity in the South Maritime high elevation program than previously. Crossing was limited to seed transfer and gain trial material, but four new tests with 122 poly-crossed parents were deployed and 10-year measurements were completed on 33 others. At this point, data for 135 high elevation parents have been analyzed and the best 32 selected for inclusion in new high elevation orchards. These orchards will carry a gain of about 8 %, but with 10 year old measurements of the 1995 series, and the first measurements of the tests just planted, this should improve to about 12% when the orchard is in production.

Other efforts at high elevation will include adjustment of seed transfer guidelines, and perhaps infusion of higher gain material from low elevation.

2.2.3 Pine Team 2001 Report

Mike Carlson, John Murphy, Vicky Berger & Lynette Ryrie

Lodgepole Pine

Increasing quantity while maintaining quality of second generation pine tree stemwood are the objectives of our current controlled pollination efforts at KFC and RRRS. Our second generation breeding for each of five seed planning zones consists of two breeding subpopulations: one emphasizing volume growth rate and one wood relative density (specific gravity). The best first generation progeny tested parent trees for each trait are grouped and intercrossed in factorial sets to produce 65 second generation test families for each breeding objective. Spring 2001 was the fifth season of second generation breeding. We are finished with the PG and BV breeding sets, about 75% complete with NE, 40% complete with the TO and will start the CP crossing in 2002.

Late spring of 2002 will see the PG second generation family set (~130 families plus controls grown in 2001) planted on three prepared wild sites in the PG seed planning zone. Our regular industry co-operators (Canfor, The Pas, Lakeland, Riverside, West Fraser etc.) again helped us locate and prepare good test sites.

Lodgepole pine seed orchard expansion grafting continued in 2001 with some 14,000 grafts made, which were directed toward 6 orchard expansions. Overall graft 'take' was better than for the year 2000 with about 75% survival (2000 survival was about 64%). We expect to graft approximately the same number of rootstock in 2002 for the six interior seed orchard expansion projects. See figure 6.

Figure 6. Pli Seed Orchard expansion grafts

Following on the work of Dr. Sally John in which Commandra rust susceptibility was evaluated in one of our Bulkley Valley progeny tests (Chowsunket site, planted 1986) we, in co-operation with Dr John and industry co-operators will grow and outplant 60-80 Bulkley Valley seed orchard families along with putatively rust tolerant wild stand seed sources and susceptible control seedlots in 2002/2003. See figure 7.

Figure 7. Commandra stem rust canker at Chowsunket

Western White Pine (Interior)

Our white pine crossing continues at KFC with the objective of accumulating genes controlling different mechanisms of blister rust resistance into individual trees (45 crosses made 2001). Host/pathogen relationship theory predicts longer lasting, more secure host resistance to pathogen attacks when genes for multiple resistance mechanisms are present, ("horizontal resistance") versus when a single resistance gene is present ("vertical resistance"). Our current white pine seed orchards (coast and interior) contain parents that were progeny screened for single resistance mechanisms (with a single gene for each mechanism assumed). Pathologists recognize four or five separate rust resistance mechanisms. Thus, much of the seed coming from our current orchards will contain genes for two mechanisms and therefore result in trees with excellent disease resistance properties. However, for future orchards we would like parents to each have two or more different resistance genes and thus increase the proportion of orchard seed having good horizontal resistance to the rust pathogen.

Seventy wind-pollinated families of white pine from selected "putatively" rust tolerant interior parent trees were rust inoculated at the MOF Skimikin nursery summer 2001. Infection rates will be determined summer 2002. See figure 12. Seventy control-pollinated families from our crossing work will be sown and grown in 2002 for rust inoculation screening in 2003.

Figure 8. Wind pollinated Pw Families ready for blister rust exposure

2.2.4 Western White Pine (Coast)

Charlie Cartwright

The white pine program is emerging from an organizational phase with much time devoted to obtaining materials and data from various contributors and institutions. Results from different testing series are being collated and reviewed. Progress has been considerable this year. Almost 300 controlled crosses were completed in the spring of 2001 at the CanFor Seed Orchard in Sechelt. Some 400 plants were grafted based on selections made with results from disease garden screenings completed by Dr. R. Hunt of the Canadian Forest Service, Pacific Forestry Centre (PFC). Scions were also collected from successful plants in field tests established over a decade ago by Dr. M. Meagher then with PFC.

Support of PFC screening has been ongoing, considerable brushing, re-labelling and map checking has been completed this year; however, field trials of that institution are now the responsibility of the B.C. Forest Service. In addition, four new field trials were established with test materials also going for screening at the disease gardens still operated by the PFC. (SPU 8)

2.2.5 Sitka Spruce

Charlie Cartwright

The Sitka spruce program is at a point of changing focus. Field testing of first generation materials for weevil resistance has culminated in supplying breeding values from three series of open-pollinated trials featuring some 235 parent trees. Clonal tests assembled on provenance program information have yielded data on 325 clones from resistant provenances. Results are being combined into a document that will provide summary information for the program to date. From this point forward emphasis will be on moving gains into seed orchards, and on advanced generation, controlled cross testing, to elucidate the inheritance and mechanisms of weevil resistance.

In preparation for these advances, 77 full-sib crosses were completed this year, and 600 copies of 48 different families were made through grafting at the Forest Service Cowichan Lake Research Station. As well, a test plantation that can function as a breeding orchard was established at the Green Timbers Reforestation Centre.

In the field, maintenance was carried out on eight of the more recent trials, and a similar number will be measured this year. The measurements are on several series. First, growth information will be gathered from an original weevil-screening test near Jordan River. Weevil free height growths have already been obtained for the same genotypes from a site on the Queen Charlotte Islands. By comparing the data to results from the test that has been through considerable weevil pressure, it is possible to identify parents that are not resistant but can be considered weevil-tolerant.

The Maritime low elevation spruce program also includes testing of weevil-susceptible parent trees for deployment to low hazard environments. Trees from the Queen Charlotte Seed Orchard (#142) were tested along with Charlotte families selected by the United Kingdom Forestry Commission several decades ago. The British trees claim a volume lift of some 15% at rotation, and performance in the nursery relative to Seed orchard #142 suggest this is so. Growth data for three sites will have been compiled by year's end. A fog belt site near Tahsis was measured in November 2001, and two further sites on the Queen Charlottes will be measured in March 2002. (SPU 6)

2.2.6 Coast / Interior Transition Spruce

Charlie Cartwright

Spruce is one of the most productive species for the Transition, perhaps due to frost hardiness relative to other conifers. A total of eight trials were established in the previous fiscal year, and this year required maintenance, map checks, and in four cases brushing. These installations will be relevant to pressing questions of seed transfer. To this point southern provenances of Sitka spruce carrying weevil resistance have proven to be hardy in Maritime biogeoclimatic variants of the North Coast, but of questionable durability for even the mildest Transition ground. These tests will hopefully steer the way to well based seed transfer guidelines for genotypes carrying adequate weevil resistance.

Two new tests of transition spruce were deployed in this year. They involved pure Engelmann Spruce from the Cobble Hill orchard, which are necessary to meet high seed needs for high elevation south Interior Coast Transition spruce. To assure balance one test was at 850m elevation, not more than 15km from clearly Maritime ground near Harrison Mills. The other site is at 1100m and a similar distance from clearly Interior zones Northeast of Boston Bar. Initial breeding values for this orchard are still five years off, but at least this proclaims a commitment to tree improvement for areas of lesser priority. (SPU 23)

2.2.7 Coastal Douglas-fir

Michael Stoehr, Norm Pomeroy and Keith Bird

Breeding for the establishment of third generation seed orchards was the highest priority in the spring of 2001. Controlled crosses involving over 100 parents were carried out successfully in greenhouses, the breeding arboretum and clone banks. Enough seed was obtained in the fall to sow eight sublines containing a total of 78 parents. These 78 parents were also "GCA" tested using an "average breeding value" polymix. Sowing will commence in the spring of 2002 with an anticipated planting date in the spring of 2003.

Field work this season included site maintenance of progeny tests and the measurement of the realized gain trials established in 1996. Unfortunately, one of the six realized gain plantation sites burnt down in the Powell River area in an early fire in April 2001. The height and root collar diameter measurements on the other five sites (Campbell River, Spirit Lake north of Campbell River, Lang Bay near Powell River, Roberston Creek near Mesachie Lake, and Norrish near Harrison) were carried out in the fall of 2001. These tests were established at four different planting densities ranging from 625 trees/ha to 3906 trees/ha using three levels of genetic improvement. These were: "Wildstand" controls with an anticipated gain of 0%, "Mid-Gain" families, representing the average of genetic gain expected in second generation seed orchards (roughly 12% genetic gain) and "Top-Crosses", representing the best parents crossed with each other with an anticipated genetic gain of 17% in height growth. The results for fall heights in 2001 are summarized in Figure 13. The average gain of the "Mid-Gain" families over the wildstand was 12%, while the "Top-Crosses" outperformed the controls by an average of 17% over all five sites. Competition effects will be evaluated in detail at a later date.

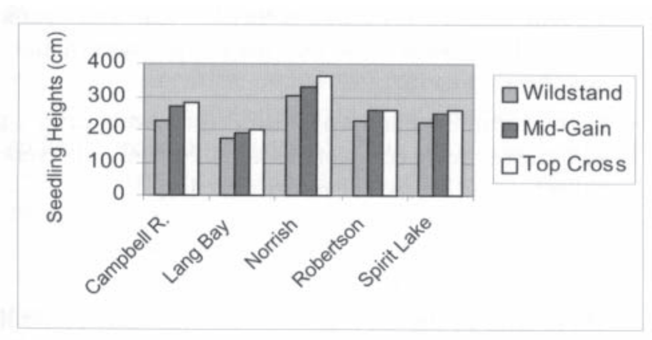


Figure 9. Mean seedling heights for five coastal Douglas-fir sites and three levels of genetic improvement.

Submaritime Douglas-fir (Transition Zone Douglas-fir):

A genecological study on four sub-maritime sites (two in the Pemberton area and two in the Bella Coola area) was established in 1996 to delineate seed transfer zones and to possibly select superior mother trees for orchard establishment. The coastal-interior transition zone is characterized by sharp environmental gradients and local climates that influence growth performance of Douglas-fir characterize transition zone. Heights and mortality were assessed on these four test sites. Included in this test were wind-pollinated transition zone families collected along elevational transects in four major drainages as well as coastal top cross families, open-pollinated families from tested and subsequently selected interior Douglas-fir parents, and interior-coastal hybrids. Five-year heights were measured and are presented in Figure 10. On the best and mildest site (Lilloet River near Pemberton), the coastal top cross families performed very well but were outperformed on the high elevation Railroad site (1100 m) and the harsher Talchako site. Generally, the interior-coastal hybrids performed well. They appear to have maintained their adaptation to harsh conditions combined with the fast growth of the coastal parents. Any strategic decisions may have to be postponed until the seedlings are above the snow line on the harsher sites.

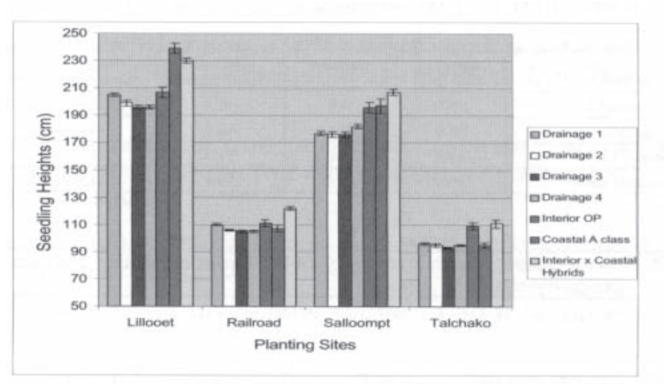


Figure 10. Seedling heights by planting site and source

2.2.8 Interior spruce, Interior Douglas-fir and western larch Tree Breeding: 2000-2001

B. Jaquish, V. Ashley, D. Wallden, G. Phillips and B. Hooge

Interior Spruce

Activities in this reporting period focussed on: 1) second generation breeding, and 2) maintaining and measuring first and second generation progeny tests, provenance tests, and somatic embyogenesis (SE) candidacy tests. Although 2001 was a light flowering year for interior spruce, we completed 77 crosses in the phase II Prince George second generation crossing program. This program, which expands on the phase I program completed by G. Kiss, is designed to combine select parents from the eight smaller populations that comprise the new Prince George seed zone. Forty-nine pollen lots were collected and stored for future breeding.

In the first generation open-pollinated tests, four 3-year-old sites in the Ft. Nelson zone were brushed and measured. Data analysis is complete and results have been used to identify parents for establishing the 1.5 generation Fort Nelson seed orchard at Skimikin (Table 2). Further seed orchard roguing will occur following six and ten-year measurements. Select seedlots from Quebec and the Eastern North America population at Kalamalka generally performed poorly on these cold, northern test sites (Table 3). In the three-year-old Bulkley Valley second generation progeny tests, four sites were brushed and measured. Data analyses are in progress. Three SE candidacy sites near Prince George were brushed and re-labelled.

Site	Survival (%)	Damage (%)	Mean 3-year ht (cm)	Range in family mean 3-year ht (cm)
Cridland Ck	90.0	9.9	46.3	32.2 - 58.1
Inga Lake	91.4	4.7	40.5	30.8 - 49.5
Martin Ck	81.6	9.4	37.9	26.1 - 46.7
Muskeg Lake	90.3	37.6	30.8	21.5 - 39.1

Table 2. Three-year growth summary of Ft. Nelson interior spruce progeny tests by site.

Seed Source	Number of seedlots	Mean 3-year ht (cm)	Survival %	Damage %
Ft Nelson OP	102	40.3	89.6	11.6
Hudson Hope OP	21	39.8	90.4	13.7
Ft Nelson check	7	39.1	89.1	12.2
Alberta OP	40	37.3	88.4	13.5
Quebec *	20	36.3	80.4	37.9
Hudson Hope check	5	36.2	89.9	14.1
ENA *	10	35.6	84.3	29.5
Alberta check	4	34.8	85.7	12.8

Table 3. Three-year growth summary of Ft Nelson interior spruce progeny tests by seed source .

Six-year measurements were completed in the range-wide white spruce field tests at Kalamalka and Skimikin. Preliminary analyses indicate that on these two sites, twenty-three of the top thirty families originated from the Ottawa Valley. These results are consistent with those reported in other range-wide white spruce provenance tests and suggest that these provenances could be very useful in the B.C. program.

Interior Douglas-fir

Eleven test sites in three test series were maintained and measured: Cariboo Transition (CT , age 15, three sites), West Kootenay Low (WKL, age 15, four sites) and East Kootenay (EK, age 10, 4 sites). Data analyses are complete and results from the CT and WKL have been used to rogue seed orchards and guide second generation breeding. Results from the East Kootenay series will be used to establish a new 1.5 generation seed orchard to be established at Kalamalka.

Fifteen-year height measurements were recorded in the Barnes Creek seedling/steckling trial. This planting compares the growth performance of seedlings and stecklings from a common genetic origin. Differences between the seedlings (7.3 m) and stecklings (7.3 m) for 15-year height were non significant. The family rank correlation between the two stock types was highly significant ($r = .82$).

In the second generation controlled crossing program, 214 crosses were completed and 301 pollen lots were collected and stored for future crossing.

Western Larch

Three sites in the six-year-old West Kootenay Series II progeny tests were brushed and measured.

Results are presented in table 4. Parental breeding values were estimated by Best Linear Prediction (BLP) and results were used to rogue the West Kootenay/ Shuswap Adams seed orchard at Kalamalka.

The Series II test population includes 10 open pollinated families from the Tyner Lake marginal population, north of Merritt. These families were all short and ranked in the bottom 10 percent of the test population.

In the second generation crossing program, 149 and 75 crosses were completed in the West Kootenay and East Kootenay populations, respectively. A total of 165 pollen lots were collected and stored for future crossing.

Site	Mean ht (cm)	Range of family mean	Survival %	Damage %	Individual heritability	Family heritability
Cameron Lk	185.2	101 – 247	88.4	3.3	.49 (.07)	.64 (.10)
Miriam Ck	216.7	114 – 297	68.1	3.7	.51 (.07)	.63 (.10)
Sparkle Ck	283.4	148 – 364	77.9	7.4	.59 (.08)	.69 (.10)

Table 4 Six-year growth and heritabilities in West Kootenay Series II western larch genetic tests.

2.3 Operational Tree Improvement Program

2.3.1 The Call for Proposals and Funding Distribution.

Roger Painter

The 2001/2002 Call for Proposals was issued on December 1,2000. Forest Renewal approved overall funding of $4,675,000 for the program of which $1,485,000 was identified by Council for OTIP projects. The Call for Proposals was widely distributed throughout the Forest Industry and included licensees, districts, regions, universities, orchardists, private researchers, contractors and biotechnology firms. Proposals were to be returned by January 15, 2001. As in the past, this program strives to ensure that funding is received by proponents as soon as possible. Procedures are succinct and delays are kept to a minimum. This industry is very dependent on biological timing and it is important to ensure that funding is in place prior to initiation of the field season. A total of 105 projects were received totaling $2,007,491. The Interior and Coastal TAC committees struck review committees to evaluate proposals by the mid-February. Final approval was granted by Council in early March. Funding for Tree Breeding activities and for Seed Planning and Information Tools were also identified and presented for Council approval at the same time. Both Extension and Communication and Gene Conservation Programs also had overall funding approved. However some projects under Extension and Communications were not initiated until later in the year and were a result of a second call for proposals.

2.3.2 Evaluation Criteria

Roger Painter

Evaluation of proposals is done by committees from the Coastal and Interior Technical Advisory Committees of the Forest Genetics Council. Final ranking of proposals is consistent with the investment priorities.

Since the first year evaluation, priorities have been altered to place greater focus on impact and value of the products produced. The committees were asked to rate the proposals according to the three criteria as listed:

Cost Effectiveness	30%
Impact and Value of the Product	50%
Feasibility or Chance of Success	20%

Cost Effectiveness - 30%:

Where innovative approaches were used, a detailed description of the technique was required. Questions to be considered:

- Are the cost per unit or overall costs comparable to the per unit or overall costs of current accepted alternatives?
- Are the budget figures in line with normal acceptable operating costs?
- Is the project financially viable? Can it be done for the amount specified?
- Is the proponent contributing in a meaningful way to the project, in terms of financial and/or manpower resources?

Impact and Value of the Product - 50%:

Evaluation of the products that will be produced, the need for the product, and the impact or value. Questions to be considered:

- Does the product meet an immediate and specific seed need?
- Does the product improve the overall ability of the program, or the ability of the orchard to produce greater amounts of, or better quality, material?
- Does the proponent have the support of a seed user?

Feasibility or Chance for Success - 20%:

Evaluation of the technical feasibility of the proposal based on current practices, knowledge, and available research, and the chances for success.

Questions to be considered:

- Is the proposal technically sound?
- Is it based on current, accepted techniques or sound published research?
- Is the time frame realistic?
- Are the resources requested (and provided) adequate for the project?

  In addition, the reviewers evaluated the capabilities of the proponents to implement the proposal. If the capabilities of the proponents were deemed to be inadequate for meeting the stated goals and objectives, then the proposal was disqualified from further consideration.

Following the review meetings, the results from the two committees were presented to the FGC. The FGC received the recommendations of the Review Committees in early March, ratified their findings and passed them on to FRBC for final approval.

2.3.3 Project Rating

Roger Painter

91 to 100 points: Excellent

- Provides specific opportunities that meet investment priorities and provides improved material in areas that are in specific need.
- Includes, and is targeted to meet, specific seed users' needs.
- Is both cost-effective and involves use of proponents' own resources.
- Is well thought out and technically sound.
- Excellent team capabilities which either includes seed users or evidence of their support.

81 to 90 points: Very Good

- Provides improvements to specific aspects of listed priorities for investment in tree improvement and/or geared to general benefits and long-term goals.
- May not meet specific seed needs in the short term, but clearly enhances orchard capabilities for improving genetic quality and quantity over time.
- Is cost-effective with a technically sound action plan.
- Includes some resources supplied by the proponent and is supported by good, balanced team capabilities.

65 to 80 points: Good

- Provides improvements to general aspects of priorities of tree improvement.
- Will be geared to general benefits and long-term goals.
- Provides for improvements to general production and quality (in relationship to orchard capabilities).
- Is both cost-effective and technically sound with a capable project team.

50 to 64 points: Fair

- Likelihood of funding is very low.
- Lacking some aspects of the key elements of criteria.
- Lacking in terms of meeting priorities and goals for general or specific tree improvement investment (may not be completely suitable for funding).
- Likely requires some changes before being funded.
- Projects may be related to production of seed where seed requirements are adequate, but supply of specific lots may be advantageous, or where low increases in genetic worth are advantageous.

Below 50 points: Poor

- Not recommended for funding.
- Lacking in two or more areas of criteria.
- Poor relationship to overall priorities.
- Poor cost relationship compared to the benefits obtained.
- Poor time lines with doubtful ability to deliver as planned.
- Product does not provide improved benefits to current situations.

The final decision on the funding of projects rests with the FGC and is based on program priorities and the availability of funds.

Orchard Projects

2.3.4 Sechelt Seed Orchards

Patti Brown

Canadian Forest Products Ltd. has increased the amount and genetic worth of the seed it produces from its Sechelt Seed Orchard site with the help of FRBC's OTIP funding program since 1997. Six OTIP funded projects covering 6 coastal species were carried out in the fiscal year 2001/02.

The objective of SPU1101 was to increase the long-term production of high gain yellow-cedar to meet Canfor's annual needs of 300k with a GW of > 12 by 2005. Intensive cultural techniques were applied to the 3,000 donor families with a GW of 6 located at Sechelt. The 3,500 clones with a GW of 10 or greater that were propagated at Cairnpark Nursery in 2000, and the 3,300 two year old donors located at Cairnpark Nursery and Sechelt to maintain juvenility and increase the production capacity. Cuttings for 100,000 plantables with a GW of 6 and 60,000 with a GW of 12 were taken in the winter of 2002.

SPU0201 targeted an increase in the GW of redcedar from Sechelt Seed Orchard by preventing selfing in the 2001 crop using physical barriers and SMP techniques. Second generation grafts were also maintained in holding beds for future orchard capacity of high gain genetic seed. Increasing the amount of seed was also an objective and was achieved by treating the 2001 crop for midge in April and pruning the crop trees post cone collection for future increased yields. The 2001 crop produced 2.195kg, or 438,000 seedlings with no selfing and 6.98kg, 1.4 million seedlings with reduced selfing.

The goal of SPU0801 was to: 1) increase the long term rust resistance value of white pine seed from Orchard #174 by incorporating clones with slow canker growth mechanisms; and 2) increase the short term resistance value by pollinating with MGR pollen from Dorena sources. 450 new ramets with the best slow canker growth trait were potted up and maintained in a holding area. Pruning the existing 700 cone bearing trees increased future production capabilities. 100,000 plantables were produced in 2001 and a potential 150,000 plantables for 2002.

The object of OTIP project SPU0101 was to obtain higher genetic gain from our Douglas-fir orchard #116. 80 trees from parents that performed poorly in progeny tests sites were removed from Orchard #116 in early April prior to pollen shed. Only the bottom 10% of the parents was removed due to site differences in parent rankings. The 50 kg (2,000,000 seedlings) of seed produced this year will be of higher genetic quality than previous crops due to the removal of the poorest parents.

The main objective of SPU0302 was to produce a high gain crop from Orchard #133. 30 ramets were removed prior to pollen shed based on 10-year progeny data results to increase the gains from the SMP crop. Over 6000 bags were applied and insect protected to yield a crop that will produce 1.7 million plantables with a GW of 17. The SMP crop will produce ~3.5 million plantables with a GW of 11. The future production and gain capabilities of Orchard #179 were increased by adding 117 replacement ramets and pruning the existing 200 ramets.

SPU0604 was for growing and culturing 1200 weevil resistant donors at Extension Services. The donors produced an average of 60 stecklings per plant and therefore enough material to provide 70,000 weevil resistant stecklings for outplanting in the spring of 2003.

2.3.5 Kalamalka Seed Orchards

Chris Walsh

Thirteen OTIP projects were approved under the operational production sub-program for 2001/2002 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, 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.

Orchard Composition Activities by Project

Project	Species	SPZ	Orchard	Rouging	Grafts Made	Maintained	Rootstock	Transplants
SPU0401	Sx	NE	305	200		496		19
SPU0502	Sx	NE	306	200		422		10
SPU0701	Pli	NE	307	73	400	34		76
SPU1302	Lw	NE	332	113	145	447	250	21
SPU1401	Sx	PG	209			234		157
SPU1501	Pw	KQ	335			161		247
SPU1604	Pli	TO	310			527		
SPU2501	Sx	EK	304	29		233		33
SPU3201	Pli	EK	340			2296		
SPU3401	Lw	EK	333	226	245	507	150	23
SPU3501	Sx	BV	620			96		9
SPU3701	Fdi	QL	226			54		
SPU4101	Fdi	PG	225		400	844		
Totals				841	1190	6351	400	595

Table 5. Orchard Composition Activies

Figures 11 & 12. Orchard activities at Kalamalka

Project	Species	SPZ	Orchard	Pollen Collected (litres, dry)	Trees Pollinated
SPU0401	Sx	NE	305	4.0	
SPU0502	Sx	NE	306	4.0	
SPU0701	Pli	NE	307	5.0	878
SPU1302	Lw	NE	332	1.5	780
SPU1401	Sx	PG	209	3.0	
SPU1501	Pw	KQ	335	1.0	1667
SPU3401	Lw	EK	333	2.0	1175
SPU3501	Sx	BV	620	2.0	

Table 6. Pollen Management Activities by Project

In addition to collecting, processing and application of pollen, funding also permitted us to purchase blister rust tolerant white pine pollen from the Inland Empire Tree Improvement Co-operative.

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,
- pesticide sprays to control *Leptoglossus*, and
- pesticide sprays to control spittlebugs 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 girdling of orchard trees to induce cone production.

The OTIP funding was instrumental in increasing both the quantity and quality of seed produced. At Kalamalka in 2001, over 114 kg of western larch, lodgepole pine and western white pine spruce seed was produced, equivalent to over 12 million seedlings resulting in Kalamalka seed being used over large areas of the interior of the province.

2.3.6 Increased Volume and Enhanced Quality of Orchard #149 FDC 2001 Seedlot.

Gord Morrow

Six hundred ramets of Orchard #149 were given SMP treatment with pollen mixes from clones with the top breeding values in the orchard to increase seed set and resultant seedlot breeding value. The treatments helped offset the high winds and rain that characterised the 2001 pollination season.

This effort follows the 1999 SPU0105 in which 469 ramets of Orchard #149 were exposed to reproductive bud induction techniques (stem girdling and injections of $GA_{4/7}$). The treatments combined with a favourable cone induction spring in 2000 to produce the orchard's first large crop in 2001.

Harvesting a total of two hundred eighty-four hectolitres required 89.8 worker days (at 3.4 hl per man day). Valued at approximately $538,685 the crop is estimated to produce 6,701,200 seedlings, answering the Ministry needs for reforestation in the Maritime Zone. Twenty-five percent of this result is credited to the SPU0104.

2.3.7 PRT Armstrong – Grandview Seed Orchards

Hilary Graham

FRBC-OTIP 2001 Activities in Three Lodgepole pine Orchards, SPU #'s 0702, 1001, 1002

The PRT Armstrong – Grandview Seed Orchard site includes three Lodgepole pine orchards, which have received FRBC funding for activities to increase the yield and genetic gain of seed produced. Orchards #308 and #311 provide seed for the Thompson-Okanagan (TO) low elevation seed planning unit (SPU), and orchard #313 provides seed for the Nelson (NE) low elevation SPU. Orchard #308 is a provenance-based orchard with an estimated genetic gain of 6%. Orchards #311 and #313 are 1.5 generation orchards each with an estimated genetic gain of about 16%.

In the year 2001, a number of activities were conducted with FRBC funding in these three Lodgepole pine orchards. OTIP projects 0702, 1001, and 1002 covered activities in orchards #313, #311, and #308 respectively. These activities were phenological surveys, pollen monitoring, insect and disease control, crown management, foliar analyses, and supplemental mass pollination or "SMP" (in orchards #311 and #313 only). Each activity is described below.

Phenological Surveys:

Reproductive phenological surveys were performed in all Lodgepole pine orchards to determine the timing and order of seed-cone receptivity among seed orchard's clones inside the orchard pollen flights. The information generated was used to guide pollen management activities, including SMP, to increase seed set.

A long female receptivity period in 2001 allowed for 4 well-timed applications of pollen (SMP). No protandry was observed this season with the shedding of pollen and flower receptivity coinciding well.

In addition to the timing of pollen shed, the amount of pollen produced per tree was assessed and recorded. This data will be used to calculate the genetic worth of seed produced in the orchards in 2002.

Finally, the data collected from the surveys was condensed to provide a clone by clone summary of pollen flight and seed-cone receptivity in each orchard.

Pollen Monitoring:

Pollen monitoring was performed concurrently with the phenological surveys. Just prior to pollen flight, 1-day pollen monitors were installed in all three orchards, at the orchard boundaries, and in the Lodgepole pine holding area on site. At the start of pollen flight, all monitors were equipped with a glass microscope slide covered with a film of Vaseline. These slides collected flying pollen and were replaced daily with a clean slide.

For the duration of pollen flight, pollen slides were changed daily (at the same time of day) and the pollen-coated slides put into storage for counting. At the completion of pollen flight, the last slides were collected and the monitors dismantled.

To assess pollen flight, counts of pollen grains were done on the slides collected and the amount of pollen was determined for each monitor. This data provides information on the amount of pollen within each orchard, going between the orchards, and from the holding area.

Pollen monitoring indicated that there was a substantial pollen supply in orchard #308 and therefore SMP was not conducted in this orchard. However, both orchards #311 and #313 did require SMP as the natural pollen cloud was too small to provide adequate pollination.

Pollen Collection and Supplemental Mass Pollination (SMP):

Young pine orchards typically suffer from a lack of pollen in the early years of production. In both the Pli Thompson-Okanagan low and the Nelson low seed planning units there is a large deficit in the amount of seed produced to meet current needs. Therefore, to increase seed set and production in these young orchards, we conducted SMP in both orchards and collected pollen to use for SMP in 2002. It is expected that SMP will greatly improve seed set by providing pollen in the absence of an adequate natural pollen cloud. During the pollen flight period in 2001 pollen was collected from orchards #311 and #313. Whole pollen buds were manually collected by clone and brought into the laboratory for drying and processing.

Figure 13. Applying pollen, (SMP), to improve seed set

When processing was complete, pollen was tested for moisture content (6-8% target) and put into freezer storage when it achieved target levels. During the storage phase and just prior to reapplication the pollen will be tested for germination. For SMP efforts in 2002, there are 14 litres of pollen in storage.

Orchards #311 and #313 were pollinated (SMP) in 2001 with stored pollen from a 2000 collection (previous FRBC-OTIP project). Surveys were conducted prior to each pollination to indicate the trees with receptive seed-cones. These trees were tagged so that the pollen applicator crew could move quickly from tree to tree and apply the pollen only to receptive seed-cones. Four applications of pollen were made to trees in each orchard during the receptive period.

Crop Management:

Pesticide sprays were applied to control *Leptoglossus* and Pine Needle Cast. Poison baits were set out to control rodents feeding on tree roots, and Pitch moths were removed by hand. Foliar analyses directed the fertilizer program to ensure optimal nutrition.

A small amount of crown pruning was conducted in each orchard to maintain the trees at a manageable height without compromising flower production.

With the early confirmation of the FRBC funding and an inventory of pollen from 2000-2001 FRBC-OTIP work, all projects were completed as planned. For the Pli Thompson Okanagan Low SPU, 13.6 kg of seed was produced in 2001, with the potential for 2.245 million seedlings. In the Pli Nelson Low, 2.3 kg of seed was collected with the potential to produce 380,000 seedlings for this SPU.

The activities conducted in 2001 under FRBC-OTIP ultimately move us closer towards our goal of increasing the amount and quality of A-class seed for the Pli NE low and Pli TO low seed planning units.

2.3.8 Prince George Tree Improvement Station (PGTIS)

Carole Fleetham

SPU 1203, 1802, and 1702 - Activities to increase the quantity and quality of lodgepole pine seed from Orchard 220, Orchard 223 and Orchard 228.

Emphasis was placed on the application of high gain pollen to improve the genetic worth of the seedlots from lodgepole pine seed orchards 220, 223 and 228.

Pollen was also collected from other high gain trees on site for application in future years. Approximately 56 litres of pollen with an average breeding value of 11% is now in storage.

Thirty-five hectolitres of cones (12.3 kg. seed) were harvested from the three orchards in fall, 2001. The seed has a genetic worth of 6%.

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

Trees in all orchards were surveyed for western gall rust and lophodermella needle cast.

SPU 1412 - Management of interior spruce clone banks at the Prince George Tree Improvement Station to ensure availability of scion to replace existing orchard ramets or develop new orchards to boost productivity and gain.

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

In an effort to complete the clone banks, 560 new grafts were made in the spring of 2001. These will be fill-planted in the clone banks in 2003. 650 ramets (grafted in 1999) were transplanted into the clone banks in the summer of 2001 to fill empty positions.

Grafts made in 2000 and held in the holding area till 2002 were weeded, watered, fertilized, pruned and monitored and treated for insects and disease. Similar management activities were carried out in the 12,000 tree clone bank.

2.3.9 Riverside Seed Orchards

George Nicholson

Orchard Quality Quantity Boost in #310 (Sx).

Pollen monitors were used again this spring to assess the pollen flight throughout the orchard. The slides were changed each day and pollen grains counted to provide data on the size and volume of pollen flight.

Pollen was collected and SMP carried during the flowering period.

Ramets that have been rogued from the orchard were replaced with new grafts with higher breeding values. A total of sixty-six ramets were replanted in the orchard.

A pest management program was carried out in orchard 310. Control treatments for *Leptoglossus* were applied several times from May to September. Hand removal of Sequoia pitch moth larvae was done to reduce damage to ramets. (SPU 1601)

Orchard Quality and Quantity in Orchard #303 (Sx).

Pollen buds were collected from a total of twelve out of the top twenty families in the high and low elevation bands. This pollen will be used to conduct controlled crossings for second generation progeny testing. The pollen was extracted, tested and stored at Kalamalka Research station. Due to low pollen production this year the balance of the pollen required with be collected in spring 2002. No cone induction was carried out due to the large number of ramets treated in 2000.

Insect monitoring and treatment regimes were carried out to protect ramet health throughout the orchard. (SPU 2801)

2.3.10 Skimikin Seed Orchards

Keith Cox.

In 2001 work was funded in six of the seed orchards at Skimikin .

The West Kootenay spruce orchards (301 and 302) were surveyed for insects and disease and conelet samples were taken to monitor for the spruce cone maggot. The replacement grafts in the holding area, to be planted in 2002, were maintained. Crop induction was done to 1188 trees using a combination of drought stress and injecting the flowering hormone $GA_{4/7}$. In the late fall a total of 410 trees were rogued from the two orchards using a rubber-tired excavator. The trees, with the roots intact, were skidded to the edges of the orchards and stockpiled. On November 6 they were hauled to the Salmon River to be used for stream-bank restoration. The branch form of these open grown trees is ideally suited to riparian work.

The white pine crop in orchard 609 was sprayed twice for insects. A total of 104 litres of pollen buds were collected in June for SMP work in orchard 335 at Bailey Road. The crop for 2002 is estimated to be 30 to 40 hectolitres.

In spruce orchards 207 and 208, for the Bulkley Valley zone, the holes left from the roguing in the fall of 2000 were levelled and the irrigation lines were put back in place. In August a crop of 10.4 hectolitres was collected with a Genetic Worth of 13.

The on-site research plantations were monitored for insects and disease, baited for rodents, and one young plantation was irrigated. The site where a Douglas-fir plantation had been cut down in 2000 was mulched, stumped, and cultivated to reduce root rot. Also, a small birch plantation was removed and the site was also stumped and cultivated. A Douglas-fir demo plantation was heavily thinned, the thinnings were removed and mulched, and the stumps were dug out with a small rubber-tracked excavator.

SPU 0709

Lodgepole pine pollen was monitored again in 2001 at three sites in the Shuswap to gather base-line data on background pollen levels. This will help determine the suitability of locating lodgepole pine seed orchards in the Shuswap.

The monitors were set up at the same three sites (Skimikin, Tappen, and North Broadview) prior to the pollen flight and the charts were changed weekly.

In 2000, the North Broadview and Tappen pollen levels peaked at between 1 and 1.5 grains per square millimetre per day, while the Skimikin monitor peaked at 3. In 2001 the North Broadview and Tappen pollen levels peaked at 4.4 and 3.1 respectively, while Skimikin was 10. The average daily levels were substantially lower, indicating that while background pollen is present the amount of contamination in a producing seed orchard would be relatively low.

2.3.11 Saanich Seed Orchards

Dan Rudolph

Three projects were carried out at the Ministry of Forests' Saanich site this year.

SPU 0109: Establishment and Monitoring of Regional Pollen Monitors in the Saanich Peninsula.

This project involved the establishment and monitoring of seven-day pollen monitors at various locations around the Saanich Peninsula in order to provide Douglas-fir seed producers in the area with consistent estimates of local pollen contamination. In order to quantify the effects of local pollen contamination on the genetic worth of a given seedlot it is necessary to have an estimate of the amount and timing of the local pollen flight and an estimate of its breeding value. Estimates of the BV's for the local Douglas-fir provenance in Saanich are currently being updated. Estimates of the amount and timing of the local pollen flight are dependent on the monitoring of that flight outside the orchard. This project aimed to provide these estimates so that local Fd seed producers would have a consistent estimate of pollen contamination for all seedlots produced so that estimates of genetic worth from each could be compared critically.

Work Completed:

Five, seven-day monitors were established at various locations throughout the Saanich Peninsula. Pollen flight was monitored from April 2nd through May 13th. Two fields per day per chart were counted and averaged.

Final Results or End product:

Results were forwarded to local orchardists to be used when calculating GW's of seedlots produced.

SPU0804: Repair of Vandalism-Related Damage and Enhancing Seed Production From Rust-Resistant White Pine Seed Orchard #175.

This project is an amalgamation of two SPU08 projects that were carried out in orchard #175 this year. The first part of the project involved the ramet replacement and growing stock management necessary to repair the damage caused to the orchard by vandals in the Spring of 2000. The second part of the project was a continuation of a project initiated in 1999 and involved both the collection of the crop produced by supplemental mass pollination in the Spring of 2000 and the continued use of SMP to enhance seed yields in the crop to be produced in 2002.

Work Completed:

For the part of the project aimed at replacing vandalised trees, scion collection and ramet re-grafting are to be carried out during the fourth quarter.

For the part of the project aimed at enhancing seed yields the following work was done;

- Male and female phenology surveys were conducted on 219 ramets in the orchard six times during the Spring pollination period.
- Pollen was collected from 46 ramets.
- 8.1 litres of pollen was extracted, moisture contents were calculated and all lots were vacuum-sealed in preparation for storage, if needed.
- Pollen was re-applied to receptive flowers on 214 orchard ramets. Each ramet was pollinated at least three times at two day intervals.
- 8,198 cones, or 22.0 hectolitres, were collected from the orchard.

Final Results or End product:

Seed yields from the 2001 SMP treatment will be calculated following collection later in 2002. The 2000 SMP treatment yielded a crop of 11.772 kilograms or approximately 530,000 seeds. This represented a yield of approximately 65 seeds per cone.

SPU 1901: Graft Maintenance of Saanich Fdc Holding Area.

Replacement stock for the genetic upgrading and eventual replacement of Sub-Maritime zone seed orchard #120 has been established in a holding area at the Saanich site for a number of years. The objective of this project was to provide proper maintenance of this stock in order to ensure healthy and vigorous trees for the planned outplanting in the Fall of 2002.

Work Completed:

1,950 three to six year old ramets were maintained throughout the year by pruning rootstock branches, fertilization, irrigation, graft maintenance, identity maintenance, mulching, controlling weed competition, conducting mortality and vigour surveys, mapping and removing cones from smaller ramets to lessen stress.

Final Results or End Product:

1,950 ramets of 115 clones were maintained in a healthy and vigorous condition.

2.3.12 Mount Newton Seed Orchard.

Tim Crowder.

Mount Newton seed orchard owned and operated by Timberwest carried out three projects under the Operational Tree Improvement Program of Forest Renewal B.C..

Funds were applied only for the portion of the projects that would apply directly to public lands, as projects on a private land base are not eligible for FRBC funding.

SPU 0205: Western redcedar Orchard #140 crop Enhancement and Upgrading

One hundred and twenty-four large orchard trees were sprayed with a solution of growth hormones at two different times in an effort to promote the development of both male and female reproductive structures. Spring surveys of the reproductive buds indicate that we were successful in inducing both male and females and a seed crop capable of producing approximately 5 million trees with a genetic gain of + 6% volume at harvest should be available in 2002.

In an effort to reduce the time taken for establishment of a new and improved orchard 2,650 2 year old grafted trees were planted in a holding bed. These were maintained by fertilizing, pruning, tagging and irrigating them in order that we have a vigorous healthy trees ready for cone production, available for planting into orchard positions as soon as results progeny tests are available

SPU 0901: Maintenance of Abies amabilis Orchard #129

Abies amabilis is the ninth most important species in B.C. in terms of trees replanted and value of the logs harvested, and in the early 1980's an effort was undertaken to start an improvement program for this species. Orchard #129 was one of three planted and is currently the only one surviving undisturbed. Poor flowering and a difficulty to overcome plagiotrophic (branch like) growth has discouraged any further development in a breeding program.

Orchard # 129 has been funded by FRBC for the last 4 years in order that research staff, universities and other interested parties have a set of trees with clonal identities to work on to try and determine methods that will help improve this important species.

Two litres of pollen were collected extracted and re-applied to the emerging flower crop and 2230 trees were treated to control balsam wooly adelgid attack.

The orchard was maintained in a healthy and vigorous state by irrigating, fertilizing, pruning and controlling grass and weeds.

SPU 1109: Yellow-cedar Donor Hedge Upgrading

The yellow cedar donor hedge at Mt Newton produces enough cutting material to set 350,000 cuttings with a genetic value of +10% gain in volume. The main portion is used in the Weyerhaeuser Canada program with any surplus made available to other operators.

The breeding program of the Ministry of Forests has identified clones with significantly higher genetic values so a portion of the donor hedge was removed and replaced with improved clones. This raises the overall genetic value of the donor material to 14%.

It is critical to have material from donors that produce roots rapidly in order to achieve a satisfactory tree within one year in the nursery. To evaluate this a rooting test of 35 cuttings from each of 25% of the donors, in the hedge was set up and the speed and quality of rooting was assessed. Donors with poor rooting were removed from the hedge. A further 25% will be tested next year.

2.3.13 Vernon Seed Orchard Company

Tim Lee

Vernon Seed Orchard Company (VSOC) operations are located on 195 acres to the southwest of Vernon. All orchards established over the 13-year history are managed for the production of Class A seed from the eight 1.5 generation orchards. OTIP funding enables VSOC to manage each orchard for maximum seed production for each SPU.

SPU 1403 & 1404

Prince George - Spruce #211 - During ITAC 2000, orchard #211 was identified for the potential of becoming the weevil resistant seed orchard for this SPU. Since #214 covers the bulk of the seed needs for the SPU, the value of #211 weevil resistant seed production became a realizable option for this orchard. The demand for weevil resistant seed is established, as some spruce areas are unable to overcome the attacks of this pest. Funding for roguing is required as parents are identified as being weevil susceptible in the progeny trials and test blocks. 858 Susceptible ramets were removed to allow the initial seed production to be rated as a weevil resistant seedlot. Further roguing will take place in 2002 as more information becomes available. Monitoring of insects found that mites were a problem and spraying was required in July for control.

Prince George –Spruce #214 -Pollen monitoring, picking and processing from both the top 12 breeding value parents and the top 12 weevil resistant parents for future use was completed. Stored pollen is an important element in managing orchards. In years of poor male flowering such as the case in 1999, the stored pollen ensured the seed set for 275 kg of production in that year. No control cross weevil seed production was undertaken, as the flowering was minimal in 2001. Monitoring of insects was a part of the management activities in 2001.

SPU 1202, 1701 & 1801

Prince George Low - Pine #222 Orchard planting effort and re-establishment of 1575 ramets was completed.

Bulkley Valley - Pine #219 –Orchard planting effort of 787 ramets was completed.

Central Plateau – Pine #218 Orchard planting effort of 517 ramets was completed.

Activities in the pine orchards included:

The final planting ensures production targets are achievable in the future. Pollen work continues to be a large part of managing young pine orchards. Pollen monitoring, picking and processing were required for SMP applications during this production year. Stored pollen picked late the previous year was applied to the early flowers in 2001, as this aids in the diversity of each seedlot, as early and late parents each year normally are not able to cross. Data was collected and added to all previous data for a better understanding of the reproductive cycle each parents follows. SMP applications in the PG and BV orchards in 2000 enhanced the cone harvest of 14 hectolitres in the PG and 52.2 hectolitres in the BV. European Pine Shoot Moth continued to be a concern that involved monitoring population and spray timing to lower the damaging effect that this pest has created in the past. The contractor used pheromone traps to monitor the emergence throughout the adult life cycle. With our efforts in 2000, the Shoot Moth population was found to be only 25 to 30% of what was present before. Further effort in 2002 will help to develop the permanent control strategy for seed orchards. A full report of the European Pine Shoot Moth work by done Tia Heeley and Rene Alfaro in the interior can be found in section 2.3.22 of this publication.

SPU 3702, 4102 and 4301

Prince George - Fir #225 -Orchard is the youngest of the VSOC established fir orchards. Some planting of blank positions occurred in 2001. Pollen, for future use was monitored and collected. Few female flowers were present for the start of seed production for this SPU. Insect monitoring and spraying was required for the control of aphids and sawfly.

Quesnel Lake- Douglas-fir #226 and Cariboo Transition Douglas-fir #231: Ramets are growing to a mature size that will support a good crop when the production cycle next appears. Pollen production did increase in 2001. Monitoring, picking and extracting pollen was completed as needed this year. SMP was utilized to ensure pollen reached the flowering families and a cone crop was harvested for extraction. A small amount of seed was extracted for the initial production for this SPU. All stored pollen will be available for future use. Insect monitoring and spraying were required for the control of aphids and sawfly. The observation of a cone worm at harvest gives warning that a cone worm spray will be required for fir production.

2.3.14 Western Forest Products Limited – Saanich Forestry Centre Annette van Niejenhuis

In 2001, Western Forest Products produced high quality seed and stecklings for coastal British Columbia from licensed orchards at the Saanich Forestry Centre in Saanichton and at Lost Lake in Victoria. Orchard development and management to capture the potential gain identified in breeding programs continued. The primary objective of the management of these orchards is to provide seed to Company Operations from the North Coast to the south end of Vancouver Island. Surplus seed is declared and sold through the Seed Planning and Registry system (SPAR). The Company manages 10 seed orchards and a hedge orchard at the Saanich Forestry Centre to supply A-Class stock in six of the ranked Seed Planning Units.

Crops were managed and harvested from five orchards in 2001. Two western redcedar orchards, one western hemlock orchard, and two coastal Douglas-fir orchards yielded seed for more than 21.3 million plantables. Other mature licensed orchards were not managed due to large seed inventories on hand from past crops, or low reproductive potential in the year.

Four seedlots were harvested from the two coastal Douglas-fir orchards at Saanich Forestry Centre. These included a custom high elevation lot of 9.2 hl, a custom high GW lot of 5.5 hl, a bulk lot of 53.5 hl from Fdc 166, and a bulk lot of 6.4 hl from Fdc 169. Fdc 166 had a heavy crop. Cooling efforts in this orchard were successful, and outside pollen rates were low and generally out of synch with the orchard receptivity period.

Figure 14. Overhead cooling effectively delaying Fdc bud development

Supplemental mass pollination, funded in part by Forest Renewal B.C. through the Forest Genetics Council's Operational Tree Improvement Program (OTIP 0107) was used to further offset the deleterious effects of local pollen, which has a very poor GW compared with the orchard average of 10. The projected yield from these crops is 1.1 million plantables for planting in the Maritime zone to elevations of 700 m, with the custom high elevation lot extending to 845 m, and to latitudes up to 52°.

Orchard management of the Douglas-fir orchards continued with the assistance of funds from OTIP 0107. This included graft union scoring, foliar nutrient analysis and nutrient amelioration, and crown management pruning.

Four western redcedar seedlots were harvested from the Lost Lake orchards in 2001. These included a custom high elevation lot from Cw 155 (2.2 hl), a custom high elevation lot from Cw 128 (6.8 hl), a special collection of upper crown cones in Cw 128 (58.3 hl), and a bulk collection of lower crown cones in Cw 128 (40 hl).

Figure 15. Clayton Chu loads the final portion of Cw crop

DNA test results completed for the 1999 crop indicate that significantly higher outcrossing rates are delivered in the upper crown and through the efforts of supplemental mass pollination. Forest Renewal B.C. (OTIP 0206) funded the supplemental mass pollination. Reports from the Seed Centre confirm excellent seed yields and germination on the 2001 crop; thus, these lots will produce more than 20 million plantables for the low elevation Maritime zone.

Enhanced orchard management and ramet replacement efforts were supported by OTIP 0206 funds. These included potting and maintenance of parents in test, foliar nutrient analysis and fertilization, and pest management. Additional grafting will occur in this final quarter of the year.

The first crop was harvested from Hw 170 at the Saanich Forestry Centre in 2001. Supplemental mass pollination was applied to this light crop. The 1.4 hl of cones harvested are projected to yield 0.2 million plantables with a Genetic Worth of 15. Seed from this crop is suitable for Maritime sites on Vancouver Island to elevations of 600 m.

Figure 16. Cw pollen extraction

Figure 17. Samantha Mellings harvests Hw cones

Orchard Hw 170 still requires extra maintenance resulting from the 1999 vandalism event. OTIP 0304 funds supported activities including pest management, repotting of replacement stock in the holding bed, and nutrient analysis and fertilization.

Development of the weevil resistant Sitka spruce orchard continued with financial support from Forest Renewal B.C. (OTIP 0601).

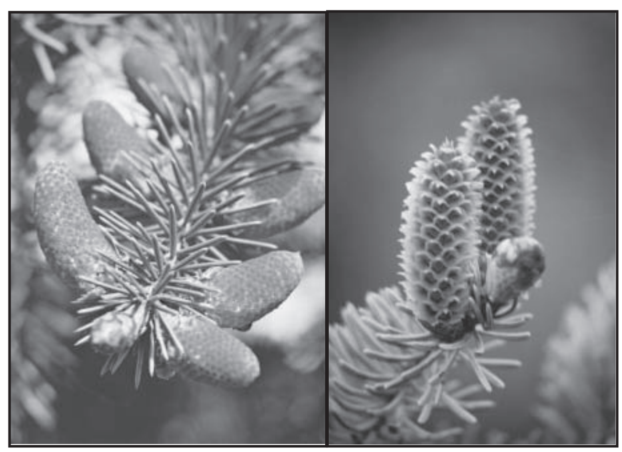


Figure 18. Left: Ss males Right: Ss females

This included maintaining the orchard and holding bed stock, monitoring pest populations, and fertilizing the orchard stock as per the findings of the nutrient analysis. The donor stock production effort was successful with delivery of material for an estimated

70,000 stecklings for the 2003 operational planting program from 2,200 highly weevil-resistant donor plants.

Maximizing the gain that can be delivered to operational planting programs in yellow cypress is rapidly moving forward. OTIP 1104 funds provided support for enhanced hedge orchard management, including fertilization, pruning, and pest management. These techniques increase the yield and quality of stock to the regeneration program. More than 60 percent of the cuttings delivered to the nurseries for the 2003 operational planting has a genetic worth of 10 or greater.

Figure 19. Jeanie Sam replacing ramets in the high gain Cy hedge orchard at SFC

Technical Support

2.3.15 Cone and Seed Pest Management: Interior Operations

Robb Bennett

During 2001/02 the Interior Seed Pest Management Biologist (Dr. Ward Strong) continued to provide the exceptional extension, research, and training services for which he is noted. During this period he provided the following services to the Interior cone and seed production community and others:

- 156 seed orchard site visits, pest surveys and identification, and damage predictions and assessments.
- 39 written pest survey reports to orchard managers and other seed production personnel
- 21 other pest identification events to Ministry of Forests personnel and others
- 8 extension education presentations to secondary school, college anduniversity students
- 5 professional presentations to seed orchard groups and professional societies
- Numerous "tail-gate" type extension presentations to operational seed production personnel.
- 7 in-house seed pest management research projects initiated, continued, or completed.
- Collaboration with university, research institution, and other personnel in 5 other research projects.

(SPU 0405)

The following publications resulted from these activities:

Bates, S. L. and W. B. Strong. 2002. Abortion and seed set in lodgepole and western white pine conelets following feeding by *Leptoglossus occidentalis* (Heteroptera: Coreidae). The Canadian Entomologist (submitted).

Strong, W. B., S. L. Bates, and M. U. Stoehr. 2001. Feeding by *L. occidentalis* (Hemiptera: Coreidae) reduces seed set in lodgepole pine (Pinaceae). The Canadian Entomologist **133:** 857-865.

Strong, W. B. 2001. Cone and Seed Pest Research in Canada. in: W.J.A. Volney, J.R. Spence, and E.M. Lefebvre, eds. Proceedings of the North American Forest Insect Work Conference, May 14-18 2001, Edmonton, AB, Canada. Information Report NOR-X-381, Natural Resources Canada, p. 108.

Strong, W. B. 2001. Cone and Seed Pest Research in Canada: 2001. Tree Seed Working Group News Bulletin No. 33, May 2001. Canadian Tree Improvement Association, Natural Resources Canada, Fredericton, NB Canada.

2.3.16 Estimating Selfing Rate in a Lodgepole Pine Seed Orchard After Mixing of Orchard Pollen Cloud by a Low-Flying Helicopter

Michael Stoehr and Helga Mehl

Background:

Seed set in lodgepole pine orchards in the in Okanagan Valley have been historically very low, resulting in a shortage of genetically improved seed. Several theories have been proposed as to why seed production is so low. One of them is the possibly low number of pollen grains in the micropyle of receptive ovules. To remedy this potential short coming, the seed orchard staff at Vernon Seed Orchard Company (VSOC) hired low-flying helicopters in the spring of 2001 to mix and disturb the pollen cloud in the orchard to enhance pollination success. Preliminary examinations showed that the number of pollen grains in the micropyles was increased by this treatment. However, it was not known if selfing was also increased by this treatment. Therefore, the purpose of this study is to use molecular markers to examine the selfing rate in selected clones of this orchard.

Prior to selecting candidate clones for evaluating selfing, the orchard must be genotyped using chloroplast DNA markers. These markers are ideal for this situation as they are inherited through the male parent (pollen) and can be detected in the embryo of a seed. Therefore, if the DNA marker in the embryo matches the DNA marker in the parent tree, then a selfing event can be inferred. However, for this method to work, only clones with unique genotypes among all orchard clones can be used.

Activity:

Vegetative buds were collected from 61 clones of VSOC orchard #219 in the spring of 2001 after the orchard was subjected to the low-flying helicopter treatment. Total DNA was extracted from the fresh bud tissue. DNA samples were amplified using five sets of primer pairs in five separate PCR reactions. The five genetic markers generated were used to genotype each orchard clone. The results of this genotyping are shown in Table 7.

			Primer Pair			# of Clones
Clones	1	2	3	4	5	per Genotype
1739	a	d	d	b	b	1
1745	b	c	c	b	b	1
445	b	c	d	b	b	1
501 1775	c	a	d	b	b	2
483	c	b	d	a	b	1
346 406 472 502	c	b	d	b	b	4
224 422 1742	c	c	c	b	b	3
327 1773 1809	c	c	(c or d)	b	b	3
299	c	c	d	a	b	1
236 392 428 488 491 499 1630 1666 1741 1770 1795	c	c	d	b	b	11
1811	c	c	d	b	x	1
1616	c	c	d	b	x	1
291	c	d	(c or d)	b	b	1
250	c	d	d	b	(a or b)	1
284 375 1730	c	d	d	b	b	3
1629	d	c	d	b	(a or b)	1
1820	d	c	d	b	b	1
495	d	d	a	b	(a or b)	1
233 479	d	d	a	b	b	2
1618	d	d	a	b	a	1
275 430 431 1732 1799	d	d	b	b	a	5
1740	d	d	b	b	(a or b)	1
258 480	d	d	b	b	x	2
1733 1822	d	d	b	b	b	2
1772	d	d	b	c	a	1
385 484 1779 1791	d	d	c	b	a	4
402	d	d	d	b	a	1
266 276	d	e	a	b	a	2
478	d	e	b	b	a	1
223	c	c	x	b	b	1
Totals						61

Candidate clones for the evaluation of selfing will be 1739, 1745, 445, 483, 299, 1820, 1618, 1772, 402 and 478.

Table 7. Genotyping of genetic markers

With this information, open-pollinated seed will be collected from these clones and selfing rate assessed in 30 filled seed per clone. SPU 0410

2.3.17 Enhancing Seed Production in the North Okanagan Lodgepole Pine Seed Orchards

Joe Webber

Our approach to improving seed yields in north Okanagan lodgepole pine seed orchards is cultural. It is our hypothesis that if pollen supply is not limiting and *Leptoglossus* is controlled, then improved seed yields can be obtained. It is our contention that the current drip irrigation system used by many orchard managers limits the volume of root development, which in turn is not sufficient to support the large crown mass. During hot dry weather, either the volume of roots available or the amount of water supplied (or both) cannot meet the tree's demand when temperatures rise and humidity drops. This can be particularly important when the high temperature and low humidity coincides with sensitive stages of reproductive development.

To test this hypothesis, we installed a larger irrigation system (more water distributed over a greater area) and an overhead mist system in two north Okanagan lodgepole pine seed orchards: Ministry of Forests, Kalamalka Seed Orchard 307, and PRT Seed Orchard 308. Our objective with the overhead mist system was to cool crowns during very hot weather in an attempt to alleviate high water stress conditions during sensitive stages of reproductive development.

Irrigation began before orchard receptivity and continued through to early August. Our overhead misting system was activated when the mid-crown temperature exceeded 24ºC. Tree crown was wetted for 10 minutes (2000) and 5 minutes (2001) and then the misting system was shut off for 40 minutes to allow for evaporative cooling to occur. Misting treatments began at the end of orchard receptivity (end of May) and continued through to early August.

Our cultural systems (mist only) did significantly improve seed yields at KAL in 2000. We also observed increases of first-year cone mass and seed weight (KAL only). We did not see any effect on second-year cone mass.

For both the pollination (May) and fertilization/early embryo development (June), 2001 was an exceptionally cool, damp year. Seed yields from both orchards were among the highest (average of 25 filled seed per cone) for any north Okanagan lodgepole pine seed orchard. Table 8 and 9 show the mean seed yields for total seed per cone (TSPC), filled seed per cone, and seed weight for each of the four treatment blocks at KAL and PRT, for cones pollinated (SMP) in 2000 and insect bagged in April 2001.

	SMP-2000 Bagged-2001		
	TSPC	FSPC	Seed Wt (mg)
Treatment			
Control	39.4 (3.2)	29.2 (2.8)	3.79 (0.16)
Irrigation/Mist	41.1 (2.5)	29.7 (2.0)	4.41 (0.19)
Irrigation	43.6 (3.3)	31.3 (3.3)	4.90 (0.22)
Mist	42.4 (3.5)	29.2 (3.2)	3.98 (0.15)

Table 8. Seed Yields at KAL for 2001

	PRT Seed Yields		
	2001		
	SMP-2000/Bagged-2001		OP-2000
	FSPC	Seed Wt. (mg)	noBag-2001
Treatment			
Control	29.6	4.13	9.0
Irrigation/Mist	21.5	4.31	11.5
Irrigation	21.7	3.74	6.2
Mist	26.5	4.38	15.0

Table 9. Seed yields at PRT for 2001

No cultural treatment effects were observed but we did see significant differences in seed yields from open pollinated, unprotected and protected (insect bagged) cones. Table 9 shows the comparison of seed yields from three sets of cones at KAL. In 2000, we applied SMP to a sub set of cones and then insect bagged these cones in April 2001. We then compared the seed yields from these cones to open pollinated cones that were either insect bagged or not.

Table 10 shows a summary of KAL-2001 seed yields (FSPC) comparing SMP-pollinated, wind (open)-pollinated versus for insect bagged and non-bagged cones. This indicates

that *Leptoglossus* control is effective but seed losses still occur. Open pollinated cones that were not bagged for insects had about 7 fewer filled seeds per cone compared to the insect protected open pollinated cones. Comparing open pollinated to SMP cones suggest that open pollinated cones may not have been completely pollinated. Since the SMP cones were virtually hand pollinated, it is not likely we would consider a broad scale use of SMP. However, we may have to reconsider the threshold value of *Leptoglossus* incidence used to initiate control measures.

	Filled Seed per Cone KAL-2001		
	SMP-Bagged	OP-Bagged	OP-No Bag
Treatment			
Control	29.2	25.2	18.8
Irrigation/Mist	29.7	26.8	19.5
Irrigation	31.3	23.7	18.5
Mist	29.2	26.9	21.5
Mean	**29.9**	**25.7**	**19.6**

Table 10. Seed yield comparisons for SMP, OP-bagged and OP- no bag.

We also monitored orchard pollen supply (pollen cloud density) and quality (*in vitro* viability assays) as well as seed cone receptivity and pollen shed (synchrony). Irrigation and misting treatment effects on cone mass, cone numbers, cone yields and tree vigour were measured. Pollen supply (quality and quantity) was not limiting at either orchard in either year. In fact, we observed some of the highest pollen cloud density values ever recorded in any conifer seed orchard. Synchrony between seed cone receptivity and pollen shed was also good.

Finally, we recorded first- and second-year cone numbers for each block in each year. Table 11 and 12 show the counts for first- and second-year cones for KAL and PRT, respectively. We did not see any effect on treatments on either first year cone numbers. This is important because we were concerned that irrigation and or misting could have a detrimental effect on cone differentiation leading to fewer cones the following year.

Lodgepole Pine Cone Counts Kalamalka Seed Orchard 307						
	2000				2001	
	Pollen Bud Clusters	First Year Conelets	Second Year Cones	%First Year Retention	Pollen Bud Clusters	First Year Conelets
Treatment						
Control	37.6	17.1	7.9	90.8	46.7	16.7
Irrigation/Mist	34.1	13.6	8.2	93.9	34.7	17.2
Irrigation	35.6	12.9	7.1	94.2	35.9	15.2
Mist	30.7	13.8	5.2	93.7	32.7	13.1
Mean	**34.5**	**14.4**	**7.1**	**93.2**	**37.5**	**15.6**

Table 11. Cone bud surveys for study years 2000 and 2001 at KAL

Lodgepole Pine Cone Counts PRT Seed Orchard 308						
	2000				2001	
	Pollen Bud Clusters	First Year Conelets	Second Year Cones	%First Year Retention	Pollen Bud Clusters	First Year Conelets
Treatment						
Control	22.9	5.0	7.1	90.8	32.2	8.1
Irrigation/Mist	21.0	7.7	6.1	91.0	30.7	11.8
Irrigation	31.0	7.4	7.2	85.4	36.5	12.4
Mist	25.1	6.0	6.3	90.2	32.9	8.4
Mean	**25.0**	**6.5**	**6.7**	**89.4**	**33.1**	**10.2**

Table 12. Cone bud surveys for study years 2000 and 2001 at PRT.

Future Work:

Controlling *Leptoglossus* may be the single most important management activity for lodgepole pine seed orchards in the north Okanagan. We still must wait for a very hot pollination spring to test cultural effects on pollination, in particular, pollen uptake. As well we must confirm the beneficial effects of overhead misting (crown cooling) on fertilization and early embryo development. In general, our studies do confirm that good seed yields are possible in these orchards when mild environmental conditions occur. The next question to ask is what effect will our cultural treatments have during moderate and extreme environmental conditions? (SPU0711)

2.3.18 Technical Support to Increase Seedset in Southern Interior Pli Orchards

Gary Giampa for Joe Webber

Background :

During the 2001 field season Kalamalka staff continued to assist Joe Webber's Research Branch team with their "Enhancing seed production in North Okanagan Pli seed orchards" project. Dr. Webber's team used Kalamalka orchard 307 and PRT orchard 308 for their studies. Kalamalka staff were available to provide labour and assist with technical tasks as required. It was not possible for Dr. Webber's team to be on site at all times during the field season as they are based out of Victoria. For this reason it was important that a technically proficient group of local workers were available to monitor the project and take care of routine maintenance as well as unexpected incidents.

Activities :

During the 2001 field season Kalamalka staff were active at both Kalamalka and Grandview sites. We assisted the Research Branch team with a variety of duties including :

- Setting up, maintaining and repairing the irrigation system.
- Selecting and flagging branches on individual trial trees.
- Observing and recording pollen flight data, flower receptivity.
- Collecting and applying pollen.
- Installing and removing isolation bags. Installing insect bags.
- Monitoring and controlling pitch moth on trial trees.
- Executing various phenological surveys.
- Collecting samples

Kalamalka staff members are prepared to continue assisting with this project during the 2003 field season. (SPU 0705)

2.3.19 Sequoia Pitch Moth Mating Disruption

Ward B. Strong

Introduction

Synanthedon sequoiae, the Sequoia pitch moth (Fig 24), is novel in having a name with all the vowels present in a row.

Figure 20. *Synanthedon sequoiae* adult male.

The larvae attack the boles of lodgepole pine trees in seed orchards, breeding orchards, and clone banks, tunnelling the cambium and creating pitch masses (Fig. 25).

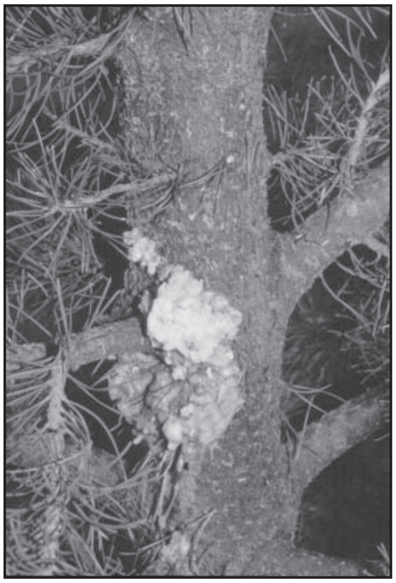


Figure 21. Pitch mass on lodgepole pine stem.

This weakens the tree, creates sites for *Dioryctria* attack, and possibly causes breakage. Currently, control relies on sending crews through orchards to dig larvae out of pitch masses with screwdrivers, which does not stop tree damage, is very labour intensive (required up to 3 times per season), and is an unpleasant job for field staff. The incidence of pitch moth attacks has been rising over the past few years, requiring increased expense for manual control.

Control of pitch moths through mating disruption (the use of synthetic sex pheromones to prevent mate-finding) would be a simple and environmentally friendly method of preventing tree damage, thus helping ensure that FGC goals for seed production are met in an economical way. Sex pheromone, which attracts males to females, is distributed at high densities throughout an area, which theoretically can make it difficult for males to find females, thereby preventing mating. This experiment was conducted to determine whether mating disruption could be used to control *S. sequoiae* in a lodgepole pine orchard setting.

Methods

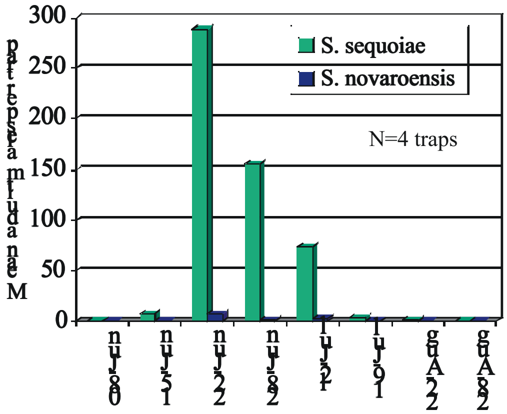
In 1999, 2000, and 2001, traps baited with synthetic pheromone were placed at the Kalamalka Forestry Center and other points throughout the North Okanagan. These were checked weekly and trap catches tallied. In 2000, a mating disruption trial was conducted at Kalamalka, described in an OTIP Report for Project 0707 in 2000. In 2001, this trial was repeated.

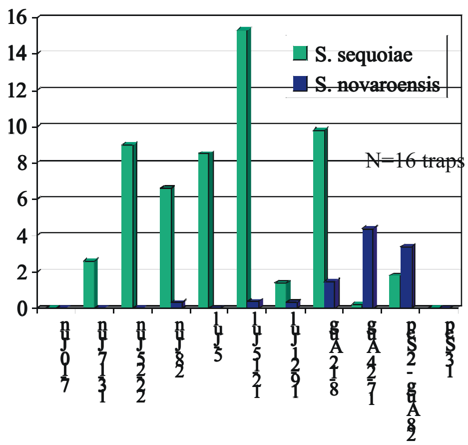
Two Pli orchards at the research centre at Kalamalka were used, blocks 8 and 10, each about 1/2 ha in size. Four pheromone traps were hung in each orchard to monitor for first flight and for the success of mating disruption: if male moths can't find the traps, they probably can't find the females either, and disruption is assumed to be successful. Traps were checked weekly from 1 June until 20 July. On June 15 (after first detection of *S. sequoiae* flight), two release devices (a small rubber septum injected with synthetic pheromone) were placed in each of the 750 trees in Block 10, for a total of ca. 0.6 g/ha pheromone. Nearby block 8, with a similar number of trees, was left untreated as a control.

All old pitch masses were dug out of all stems, up to about 2m, in both orchards on July 20-23, enabling the detection of new pitch masses resulting from attacks in 2001. Fifty randomly selected trees were inspected for new pitch masses on September 17. New pitch masses were excavated and larvae were identified microscopically.

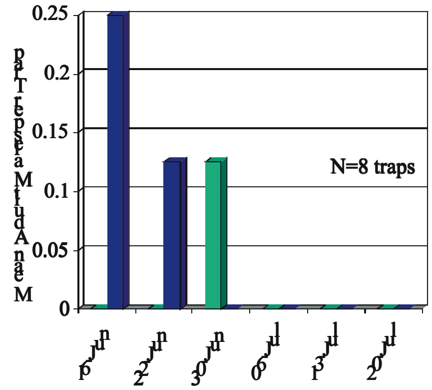
Results

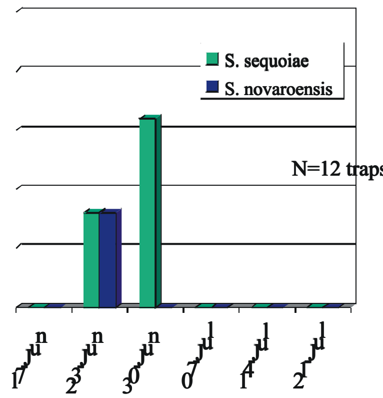
Trap catches started in mid-June and continued through August in 1999, reaching 283 males/trap in the Kalamalka traps, and 14 in the rest of the Okanagan (Fig 26). By comparison, populations were vanishingly small in 2000, with a maximum of 0.25 males per trap (Fig 27). For this reason, the success of mating disruption could not be determined in 2000. In 2001, populations were intermediate, reaching 3.8 per trap (Fig 30).





Figures 22 & 23. Trap catch comparisons





Figures 24. & 25. Pheromone trap catches in 2000.
A. Kalamalka; B. Other North Okanagan sites.

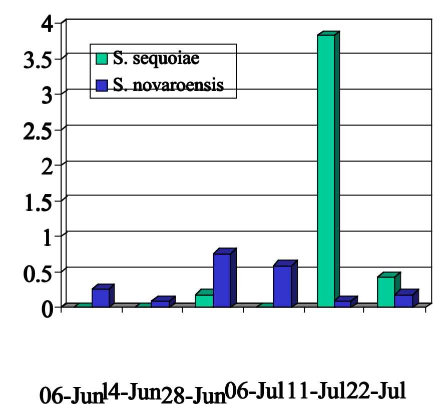


Figure 26. Pheromone trap catches in 2001 at other North Okanagan sites.

In the mating disruption plots of 2001, the first trap catches were on June 14 (Fig 27). . Treatment plot had two release devices attached to each tree. Disruption devices were hung on trees the next day. The flight peaked on June 22 and lasted until July 13. Dramatically more were caught in the treatment plot than the control plot. Since this is an unreplicated study, statistical analysis is not possible. The trap catches suggest that mating disruption was unsuccessful. However, the large amount of pheromone emanating from the treatment plot may have attracted males from surrounding areas. It is possible that they were able to find the traps but not female moths, in which case high trap catches would have masked successful disruption.

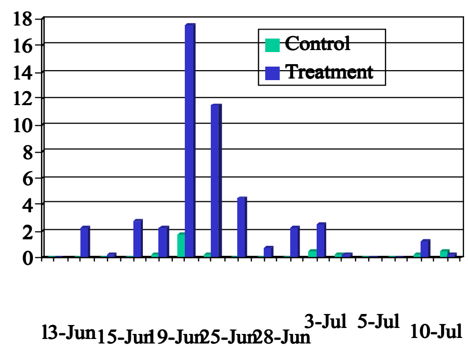


Figure 27. Pheromone trapping results in mating disruption plots, 2001.

The larval samples in September dealt with this question. If mating disruption were successful, few larvae would be found in September. Instead, there were an average of about one larva per 3 trees (Fig. 32), a high density by any standard. Many more were found in the treatment than the control plots. Abundant larvae in treatment plot indicate no mating disruption occurred.

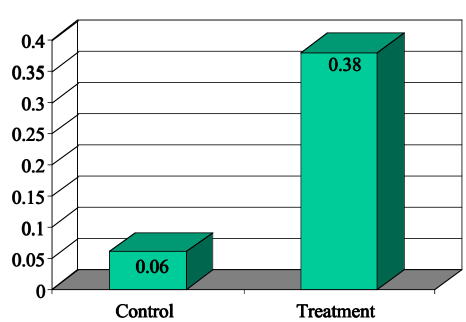


Figure 28. New larvae per tree in mating disruption trial, 2001.

Thus, mating disruption was unsuccessful. The higher trap catches in the treatment plot, and the more abundant larvae, may have been due to a higher population in Block 10 to start with. The pheromone may also have attracted additional males from outside the block, though this would not have resulted in more larvae, since females would not have been attracted to that block.

The lack of success may have been due to a high density of moths in the treated block, the small plot size, immigration of mated females from outside the treatment block, or an incomplete pheromone blend, allowing males to find females despite large amounts of synthetic pheromone. This illustrates the complexity of designing a mating disruption system. Determining the exact problem, and correcting it, would require an amount of resources disproportionate to the problem. (SPU 0707)

2.3.20 Install Microclimate Weather Stations at All North Okanagan Seed Orchard Sites Supporting Pli Orchards, and Future Pli Orchard Sites.

Gary Giampa

Background :

The Pli Seedset Task Group recommended installation of a microclimate weather station at each North Okanagan seed orchard site. It has become fairly obvious that weather conditions play a large part in orchard performance. Climate factors into significant orchard events such as pollen shed, flower receptivity, seed production and general health and vigour of the trees. It was felt that accurately recording weather data and comparing climate to seed yield would help resolve some of the Pli seed set issues. Once orchard managers determine how weather affects seed set the orchard environment could be manipulated to approximate optimal climatic conditions.

Outline of Project :

It was determined that temperature and relative humidity were the weather components we were most interested in tracking. After investigating the different units available we decided to purchase HOBO Pro RH / Temp microclimate weather stations. Theses units are reliable, economical and easy to use. Information is stored and can be downloaded to create a historical data base that can be shared between sites.

Results

The weather stations have been installed and are recording data at all six North Okanagan seed orchard sites. The information generated will provide managers with another tool to assist them in operating the orchards in the most efficient manner. (SPU 0713)

2.3.21 Causes of Low Seed Production and Methods of Increasing Seed and Cone Production in Lodgepole Pine Seed Orchards

John Owens.

Introduction

The current Pli planting requirements from the existing nine seed orchards are 72 million seedlings per year. With a sowing factor of 1.3, there is a present need for 94 million seeds per year. The current supply of Class A seed is much lower than this. In order to meet the needs for 2007, it has been estimated that up to 60,000 additional ramets are required. Seed set varies among seed orchards. At Prince George 20 seeds per cone or more are commonly obtained, whereas at KSO before 2000, the average was commonly less than 10 seeds per cone. The purpose of the 2000-2001 project was to determine why seed production per cone was high at PGSO (about 40% of potential) and low at KSO (about 10% of potential) and from this information develop seed orchard management practices for KSO that would increase the seed per cone thus reducing the need for as many new ramets as was predicted at that time

In 2000 and 2001 three main studies were designed to look at seed/cone and cones/tree production at the PGSO where high seed/cone but low cone/tree are commonly obtained, at KSO where low seed/cone but high cone/tree are generally obtained and an intermediate location at PRT Armstrong. Wherever possible, the same clones were compared using the same trials at each site. Comparisons were most important between KSO and PGSO because most clones used were the same at both orchards and because KSO trees had been severely crown-pruned to 1-2m high several years earlier but the trees at PGSO were not crown-pruned. There have been several studies of the effect of crown-pruning on seed-cone and pollen production of several species including Pli but no studies on seed/ cone (See M. Stoehr et al. 1995, New Forests, 10:133-143).

The two main hypotheses to be tested over the 3 year study were that: (1) Severe crown-pruning of young Pli causes high levels of self-pollination that results in low seed set/cone; and, (2) The hot dry weather often experienced before and during pollination at KSO adversely affects the pollination-drop mechanism in Pli resulting in lower seed set.

The work done in 2001-2002 was primarily to complete the sampling and data collection and developmental studies from the previous year's experiments plus set up a misting trial at KSO and pollen distribution trials at KSO and PGSO..

Our approach is both developmental and experimental. The advantage of the developmental approach is that we evaluate the results of experiments at several stages through out cone and seed development to determine when and how cone and seed loss occur. These times are: (1) Immediately after pollination to determine pollination success as measured by the amount of pollen entering the cone (pollen-on); (2) Soon after pollination, after pollen has been taken into the ovule (pollen-in); (3) In mid- summer to determine cone survival; (4) The following spring to determine cone survival after winter dormancy; (5) In June and July, one year after pollination, to determine fertilization success and embryo development; and,(6) At cone maturity to determine cone survival and seed set as a portion of seed potential.

Objectives

Because pines have a two-year reproductive cycle, the results from the spring 2000 pollinations could not be fully known until cone and seed analysis in the fall of 2001. Therefore, the main objectives for 2001-2002 were to complete the collections and studies begun in 2000. These objectives were to:

- Complete the collections and cone analysis to determine the effects of pollination at different times and the causes of cone and seed loss at different times from experiments done in 2000 using the same clones at KSO, PGSO and PRT Armstrong. Cone counts were made in April to determine cone loss over winter and in the fall to determine final cone survival and seed set by seed categories.
- Determine the importance and the time of cone and seed loss as a result of self-, cross- and open-pollination using the same clones at KSO and PGSO.
- Set up an operational misting trial at KSO to

increase the amount of water in the air at KSO to about the level at PGSO and determine the effects of this treatment on pollination drop formation, pollination success, cone survival and seed set.

- Set up operational pollen distribution trails at KSO and PGSO.

Activities

- Cones from all of the pollination treatments made in 2000 were counted in the fall of 2000 and spring and fall of 2001. All remaining treated cones were collected at cone maturity in the fall 2001 to determine final cone survival, seed potential, seed efficiency, proportion of all categories of seed produced (filled, rudimentary, aborted and insect damaged), pollination success (pollen-on and pollen-in) and cone survival to determine the times and causes of seed and cone loss for the two-year reproductive cycle.
- Cones that were self-, cross- and open- pollinated on the same clones at KSO and PGSO in 2000 were sampled during 2000 and after winter dormancy in April 2001 and once or twice a week in June at fertilization and during embryo development through July to determine the sequence of embryo development and the times and methods of embryo, megagametophyte and seed abortion. Cones were dissected then ovules further dissected and fixed for light and electron microscopy as in 2000. Developing ovules and seeds were sectioned and stained then studied to determine the causes of ovule, embryo and seed abnormalities and abortions. All remaining cones were collected at maturity and the final cone survival, seed potential, seed efficiency and proportion of all categories of seed produced was determined.
- With the cooperation of the KSO staff, a misting trial was set up in a section of the orchard in 2001. Four adjacent rows consisting of 10 trees per row were selected and an inexpensive PVC misting system was placed in each tree in the four rows. Four misting heads were placed in the four quadrants in the top of each tree to insure that the entire crown was misted. Trials in 2000 demonstrated that, because of wind direction, one or two misting heads per tree were not enough. Misting was done in the morning from 0700 to 1100, before pollen began to be shed, in order to increase the water in the air to about the amount determined to be present at PGSO. A similar four rows (40 trees) served as controls and received no misting. The temperature and humidity were recorded at two locations in the misted and two in the unmisted areas then later downloaded onto a computer. Cones were sampled during the pollination period to determine the frequency, size and duration of pollination drop formation before and after misting. Results from 2000 indicated that misting, although inadequate that year, increased the number of pollination drops observed per cone. Trees in both plots were left for open pollination. During the pollination period, cones were sampled daily to determine the pollination success (pollen-on the micropylar arms). After the pollination period, cones were sampled from trees in both plots to determine in a different way the pollination success (pollen taken into the ovules). Cone survival was determined soon after pollination was completed and in the fall 2001.
- At KSO and PGSO a portion of the orchards had existing pollen vigorously blown around everyday during pollination using tractor-pulled blowers.
- In 2002-2003 cone survival will be measured after winter dormancy and at cone maturity and samples of mature cones will be dissected and analyzed for seed potential, seed efficiency and proportion of filled, empty, rudimentary, insect damaged and empty seeds.

Results

Filled seed and empty seed: The average number of filled, empty, flat and insect damaged seed in mature lodgepole pine cones analyzed by seed extraction and the cutting test for cones pollinated in 2000 and maturing in 2001 for four seed orchards is shown in Table 13.

Orchard	Filled Seed	Empty Seed	Flat Seed	Insect-damaged Seed
KSO	28.3	10,8	0.8	0.2
PRT	24.1	10.0	1.3	0.1
VSOC	17.6	4.7	3.0	0.3
PGSO	21.7	6.3	0.2	0.3

Table 13. Seed categories from Pli pollination.

The highest filled seed per cone occurred at KSO, followed by PRT, PGSO and VSOC. The averages for these same categories of seed at KSO and PGSO over the past few years, for which I have records obtained in the same manner as 2001 are shown in Table 14.

Orchard/year	Filled Seed	Empty Seed	Flat Seed	Insect-damaged Seed
KSO/ 1997	8	23	1.0	2.0
KSO/1999	12	12	1.0	3.0
PGSO/1999	25	8	0.2	0.5
KSO/2000	15	9	0.5	1.0
PGSO/2000	27	6	0.2	0.0
KSO/2001	28	11	0.8	0.2
PGSO/2001	22	6	0.2	0.3

Table 14. Seed categories from Pli pollinations over four years.

The filled seed per cone has increased and the empty seed decreased since 1997 at KSO. From these data I suggest that KSO no longer has a problem with low filled seed per cone.

Selfing Experiments:

The results, as shown in Table 15, indicate that in both clones used at both orchards, selfed cones produced only 5-16% filled seeds and about 50% empty seeds with 34-42% aborting due to lack of pollination or pre-zygotic factors. In both clones at both orchards, cross-pollinated cones produced 36-60% filled seed, 1-15% empty seeds with 32-50% of seeds aborting due to lack of pollination or other pre-zygotic factors. In both clones in both orchards, wind-pollinated cones produced 37-60% filled seeds, 19-30% empty seed with 17-44% of seeds aborting due to lack of pollination or other pre-zygotic factors. The anatomical studies show that there was no difference in development in pollinated ovules, whether self-, cross- or open-pollinated, until the early- to mid-embryo stages in late June to early July, one year after pollination, at which time the embryos aborted and the megagametophyte aborted and shriveled leaving a rounded normal-looking seed but containing only the degenerated megagametophyte. These are the empty seeds in our cone analyses.

Pli Clone	Pollination treatment	Site	Average percentage of each seed type per cone			
			Filled Seed	Empty Seed	Ovule abortion due to lack of pollination	Pre-zygotic abortion
1538	Self	Kalamalka	16.4	49.7	33.9	0
		Prince George	5.3	40.6	52	2.1
	Cross	Kalamalka	60.2	7.3	32.1	0.4
		Prince George	36.0	6.5	57	0.5
	Wind	Kalamalka	47.3	29.3	23	0.4
		Prince George	37.3	18.6	44.1	0
1536	Self	Kalamalka	4.8	53.4	41.8	0
		Prince George *	-	-	-	-
	Cross	Kalamalka	48.6	1.2	50.2	0
		Prince George	42.8	14.6	41.5	1.1
	Wind	Kalamalka	53.9	29.1	17.0	0
		Prince George	60.0	20.0	18.0	2.0

** There is no data for this site as all treated cones were collected for embedment or aborted during the overwintering period.*

Table 15. Pollination treatment, seed type and cause of abortion.

These results support those by other researchers working on several species of conifers and indicate that selfing results in a high proportion of empty seed as we have seen in past years at KSO. Self pollen does not adversely affect cone or ovule development in the first year but only manifests itself during embryo development in June or July of the second year. This late-acting form of self incompatibility, called selfinviability, is found in all conifers thus far studied in a similar manner thus far and in many hardwood species (teak, *Acacia, Pterocarpus* and many fruit trees). It is a primitive form of self-incompatibility and not usually found in herbaceous species in which most research is done. Our results at KSO and PGSO indicate that very high levels of selfing at KSO in past years, due to the extreme crown-pruning has resulted in the low filled seed at that orchard and that the problem has largely solved itself as the trees have grown out of this condition.

Severe crown-pruning of young trees results in complete intermingling of pollen cones and seed cones on the same branches, much more than in unpruned Pli trees at PGSO. A high level of selfing does not cause cone abortion or seed abortion in the year of pollination but selfing results in ovule and/or seed abortion early in the second year (about June when fertilization occurs) causing high numbers of normal appearing (large, rounded with a well developed seed coat) but empty seed. Similar appearing empty seed can result from *Leptoglossus* feeding and this would occur at about the same time as abortion due to selfing.

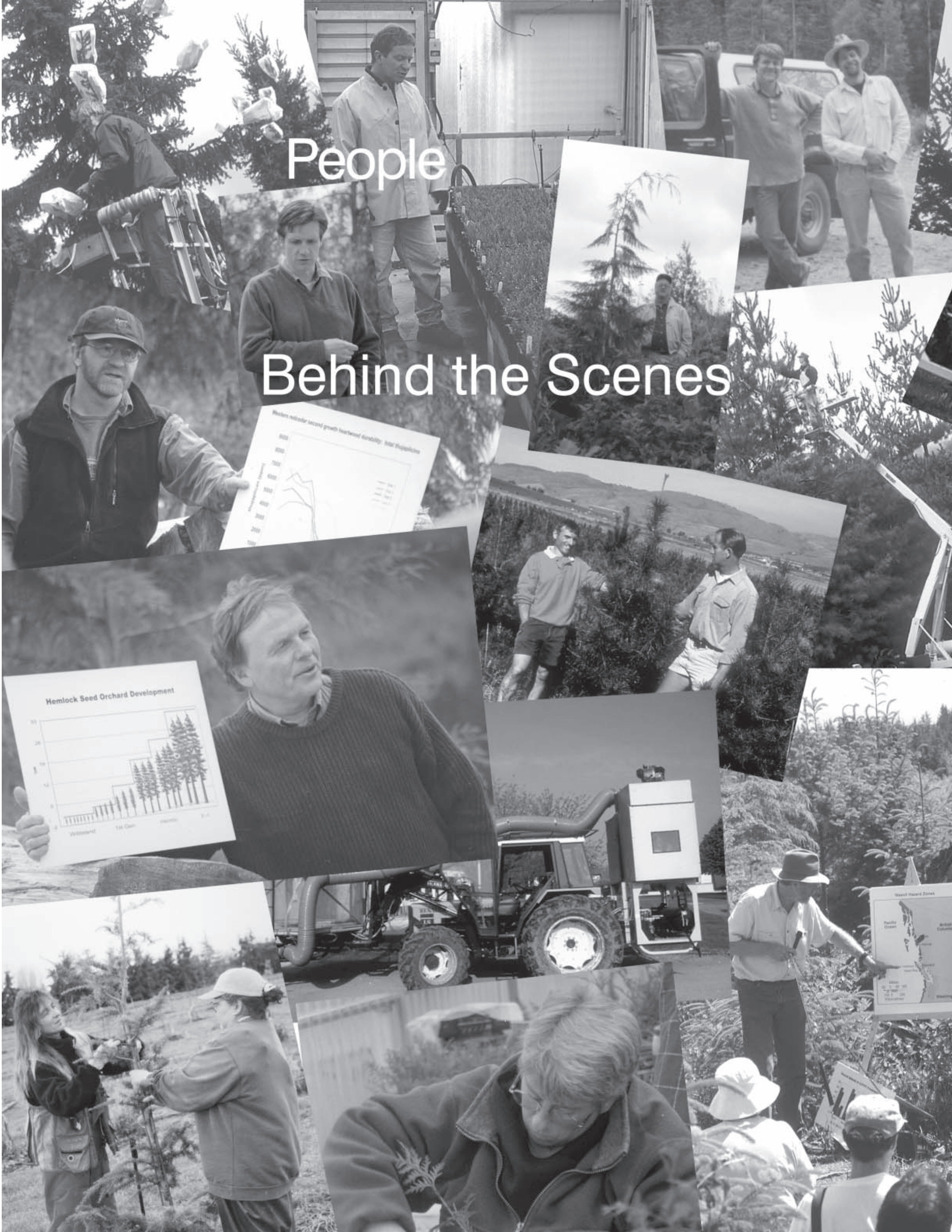
Other results from the 2000-2001 and 2001-2002 studies:

Receptivity stages have been described and illustrated and seed set resulting from pollinations at each stage was determined. Stages 3, 4 and 5 are all receptive and give fair to good seed set but stage 4 is the optimal stage for control pollinations. *Protandry* was not a problem at KSO, PRT or PGSO in the spring of 2000 or 2001. In the past this has been a problem at KSO, and will recur when the spring weather is hot and dry, but this was not the case in 2000 and 2001. *Cone survival* or cone drop soon after pollination in pine results from too few ovules being pollinated. Developmental studies and measures of fertilization success showed that in Pli about 80% of the ovules in a cone have to be pollinated by self- or cross-pollen or the cone aborts and drops within about two weeks of pollination. At PGSO cone survival was low in 2000 when pollen abundance was also low, but higher in 2001 when pollen abundance was similar to that at KSO. Seed production per tree involves more than just cones initiated and filled seed per cone. KSO had abundant pollen and high cone survival (about 80%), whereas PGSO had less abundant pollen in 2000 and lower cone survival (about 50%). Increasing pollination success at PGSO by SMP or simply blowing existing pollen around in the orchard may overcome the low cone survival at PGSO. The latter was tried in 2001. *Pollination drops* produced by the ovule (usually at stage 5 or 6) are required to take pollen into the ovules in pines. The developmental studies show that pollination drops are abundant and large at PGSO where morning temperatures are low, humidity high and there are frequent rains but drops are infrequently observed and small at KSO where morning temperature are high, humidity low and there are infrequent rains. This difference will be more extreme in hot dry springs at KSO. Misting treatments were set up at KSO in 2001 and misting for four hours (0700-1100) increased the humidity to the level found at PGSO in the morning and also increased the size and abundance of pollination drops compared to cones on unmisted ramets of the same clones.

Summary:

The steady increase in filled seed per cone and the high number of cones per tree at KSO, indicate that in years when the spring is cool and relatively wet, seed set per ramet will exceed the goal of 15 seeds per cone and 150 cones per tree. Information since my 1997 studies at KSO suggest that the major cause of low seed production was high levels of selfing and this resulted from severe crown-pruning of the trees that caused complete intermingling of seed cones and pollen cones on the trees. The trees have grown out of this form in the past few years and there is now 1-2 m of erect crown bearing mostly seed cones above the original pruning level. Empty seed occurs as a result of embryo and megagametophyte abortion soon after fertilization. However, this is the same time that *Leptoglossus* sucks the contents from seeds so both result in similar appearing empty seeds. *Leptoglossus* populations have decreased at KSO in recent years but this does not appear to account for the decrease in empty seeds and increase in filled seed. Seed production is also controlled by initial cone number and cone survival. About 80% of the ovules in Pli cones must be pollinated or the cone aborts soon after pollination. This is a major problem at PGSO but not at KSO or PRT where there is abundant pollen. Simply blowing the pollen around the orchard using tractor-pulled blowers or a helicopter every day during pollination should increase both cone retention and filled seed production. Sprinkling in the morning before and during the pollination period in hot dry springs at KSO will reduce protandry and increase humidity, thus pollination drop size, frequency and the pollination success.(SPU 1003)

People Behind the Scenes



Working to Bring Tree Improvement Into the New Millennium

2.3.22 Life History and Parasitism of *Rhyacionia buoliana* (Lepidoptera: Olethreuidae) in a Central British Columbia Seed Orchard

Tia Heeley and René Alfaro

The European pine shoot moth, *Rhyacionia buoliana*, is an important shoot boring pest of two and three needle pines. Since its' introduction to British Columbia in 1925, *R. buoliana* was considered unimportant as it attacked mainly ornamentals. However, recently the shoot moth has been discovered in a lodgepole pine seed orchard in the interior of British Columbia, where it has created a substantial economic impact. The current seed needs for the Thompson Okanagan is 6.3 million seedlings. The Vernon Seed Orchard Company estimated that in 2000 the seed orchard lost almost 300,000 seedlings due to *R. buoliana* damage. Increased infestations in B.C. seed orchards could be an indicator of growing populations in natural or reforested lodgepole pine stands in the interior. In natural stands, the shoot moth could cause economic loss due to reduced growth, and deformities, such as crooks and forks. By understanding the biology, distribution, and natural enemies of the shoot moth it will be possible to prepare a pest management plan which include; locating and treating the source of the infestation, encouragement of natural enemies. As well as accurate timing for chemical control to maximise effectiveness and minimize negative effects on the environment.

Life-cycle

Literature indicates that the shoot moth has six larval instars. Although we did not sample the first two instars, comparison with the measurements by Pointing (1963) also indicated the presence of six larval instars in the interior and coast of B.C..

Rhyacionia buoliana have one generation per year. Females lay yellowish, disc shaped eggs on the shoots of pine in June or July, which hatch approximately two weeks later. First instar larvae, yellowish in colour, construct a tunnel-like web, coated with resin and debris between the needle base and the twig of the current years growth, and feed upon the needles within this sheath. In the fall, third instar larvae, which are now a deeper brown, migrate to new buds where they feed before over-wintering (Fig. 33).

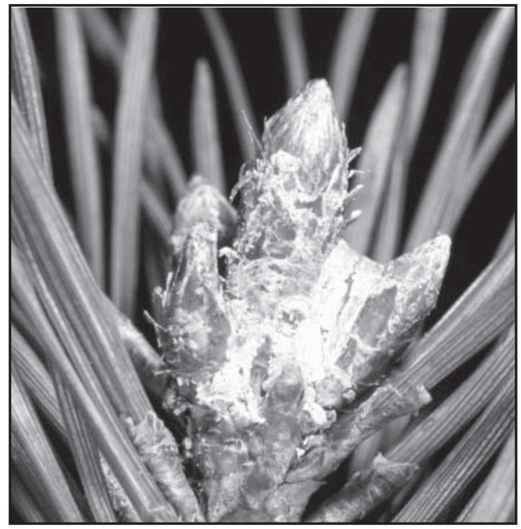


Figure 29. European pine shoot moth third and fourth instar damage.

Figure 30. European pine shoot moth fifth and sixth instar damage on a lodgepole pine.

In the spring, the larvae migrate to the upper whorls to feed in elongating shoots where they complete their development before pupating (Fig. 34). During the early instars damage caused by *Rhyacionia buoliana* is hard to detect on buds and thus could go undetected until the V or VI instar, when chemical control efforts may not be as effective. The pupal stage lasts approximately two weeks, then the adults emerge and begin mating within 24 hours. Adults have light reddish orange forewings with moulted silver lines and grey forewings (Fig 35).

Figure 31. Adult shoot moth resting on an infested lodgepole pine shoot.

Wingspan of the adult shoot moth is approximately 19 mm. Based on trap catches in the Vernon Forest District, in 2000 and 2001 pupation occurred during the middle of May, and moth flight began after 155 Julian days.

Daily minimum and maximum temperatures from Environment Canada were entered into a sine wave program compiled by Raworth to determine degree-day accumulation above a 5°C threshold from January 1 to August 31, 2000 and 2001.

In 2000 it took *R. buoliana* 897 degree-days to reach peak flight, and 819 degree-days in 2001. The 78 difference in degree-day accumulation between 2000 and 2001 is not large when compared to the amount of degree-days that can accumulate in one week. Reasons for this difference may be the change in climate from year to year, as well as the accuracy of the temperature readers. Table 16 indicates the number of degree-days needed to achieve various percent emergence levels according to adult male *R. buoliana* pheromone trap catches (January 1st to August 31st with a 5°C threshold) at the Vernon Seed Orchard. To obtain an accurate figure which best represents the degree-day accumulation of *R. buoliana* in the interior, several years of weather and emergence data would have to be collected and the mean calculated.

Percent Emergence	Julian Date	Degree-Day
2000		
10	174	642
20	181	745
50	195	922
90	195	922
2001		
10	157	476
20	172	619
50	179	695
90	193	927

Table 16. *R. buoliana* emergence, Julian date and Degree-day accumulation for the Vernon Seed Orchard.

Distribution

Pheromone traps were placed in high-density pine areas throughout the Vernon Forest District at varying elevations, concentrated mainly in the Vernon and Kelowna area. Of the 134 traps placed within the district, 86 were hung at the Vernon Seed Orchard which was thought to be the epicenter of the shoot moth infestation. The Vernon Seed Orchard consists of over 10,000 trees of superior strain lodgepole pine, *Pinus contorta* var. *latifolia*, representing pines from three areas of British Columbia: Bulkley Valley, Willow Bowron and Central Plateau. Numbers of adult moths caught in traps were highest in urban areas, while high elevation trap catches were sparse. This is due to the high density of ornamentals in the urban area and low winter temperatures in the high elevation sites. *R. buoliana* is a freeze-susceptible insect and therefore freezing temperatures of –22°C or more are fatal.

Parasitism

The dominant parasitoid present at the Vernon Seed Orchard is *Orgilus obscurator*, which attacks first instar larvae of *R. buoliana*. In addition parasitiods, *Exeristes comstockii*, *Itoplectis evetriae*, *Phyllobaenus subfasciatus*, were present. In 2001 there were a higher number of *Exeristes comstokii* present than the previous year. Currently the parasitism level at the seed orchard is only 22 percent, while in 2000 it was 23 percent, which is not substantial enough to have a significant impact on moth populations at the seed orchard. Syme (1995) suggested that the enhancement of plantation environments, such as planting wild carrot, *Daucus carota*, as a nectar source, will promote the presence, as well as the longevity and fecundity of *O. obscurator*. (SPU 1006)

2.3.23 Development and Implementation of an Integrated Pest Management Program for the Western Conifer Seed Bug, *Leptoglossus occidentalis*, in Lodgepole Pine.

Sarah Bates, John Borden, Allison Kermode, Ward Strong, Chris Walsh and Robb Bennett

The overall objective of this project was to lay the groundwork for the implementation of an integrated pest management program for *Leptoglossus occidentalis*. Specifically, this involved the following: 1) development of a monitoring system; 2) completion of a partial life table for the seed bug to refine developing damage prediction formulae; 3) assessment of seed bug impact on first year conelets; 4) evaluation of non-host volatiles as a seed bug deterrent, and 5) testing attractiveness of male-specific compounds to improve trap catches.

Monitoring L. occidentalis.

Yellow panel traps were set up in six lodgepole pine seed orchards in early May 2001 at a density of one trap per 100 ramets. Orchards were then surveyed to determine seed bug densities. Despite the low number of insects caught (0.15-0.8 bugs per trap), there was a significant relationship between the numbers of bugs caught and the actual density of seed bugs in the orchard . Figure 36 shows the comparison between the number of *L. occidentalis* adults found on the trees and caught in yellow panel traps in six North Okanagon lodgepole pine orchards in 2001

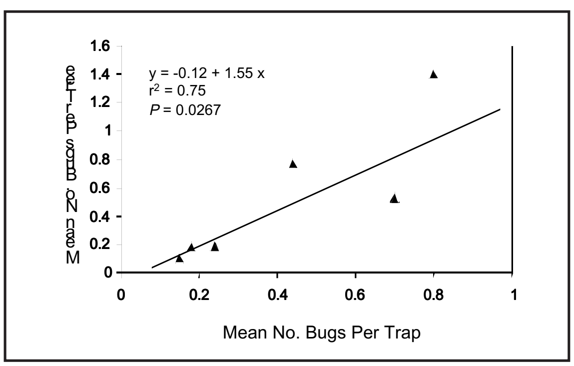


Figure 32. Number of *L. occidentalis* adults found on trees and caught in yellow panel traps.

Completion of Partial Life Table.

Nymph survival was assessed in one unsprayed seed orchard. Egg masses of known size were placed on individual trees, which were then sampled by beating, at one of four stages of nymph development. Egg parasitism was also evaluated by placing egg masses throughout the orchard, collecting unhatched eggs and rearing out the parasitoids. Because of cool weather in late July, only a few nymphs were recovered during the third and fourth sampling periods. Complete life table data are therefore based on both 2000 and 2001 data (Table 17). Life table data have now been used to refine damage prediction formulae for estimating seed loss at harvest based on the initial density of seed bugs.

Age Class or Time Interval	% Survival (± SE)	Stage(s) Counted	No. of Replicates
egg	61.1 ± 13.2	N1	(10)
egg - 1 wk	41.4 ± 9.1	N1, N2	(10)
egg - 2 wk	23.2 ± 11.5	N2, N3	(11)
egg - 3 wk	29.8 ± 6.9	N3, N4, N5	(14)
egg - 4 wk	19.0 ± 6.8	N4, N5	(5)
N5 - adult (caged)	79.4 ± 5.1	Adults	(21)
Total Survival from egg to adult = 9.2%			

Table 17. Cumulative survival of *L.occidentalis* eggs in lodgepole pine

Evaluation of Non-host Volatiles as Seed Bug Deterrent.

Conophthorin and a general non-host volatile blend were evaluated for their ability to protect individual trees from seed bug feeding. Trees were baited with either conophthorin or a blend of (E)-ocimene, guiacol, nonanal, p-dimethoxybenzene and decanal in July. Unbaited trees served as controls. The number of bugs visible on each tree was recorded on 6 August. No difference was observed in the number of bugs on baited trees and control trees.

Testing Attractiveness of Male-Specific Volatiles.

We are continuing our collaboration with chemists Dr. Harold Pierce and Ms. Regine Gries at S.F.U. to isolate and/or synthesize four male-specific volatiles produced by *L. occidentalis*. Unfortunately, difficulties in identifying and synthesizing all of these compounds prevented us from conducting field tests in 2001.

However, a small trapping experiment was conducted in late June using Z9:14OAc, a lepidopteran sex pheromone that elicits a strong antennal response in *L. occidentalis.* Only a small number of bugs (six) were successfully trapped, but five of these were found in baited traps. Z9:14OAc is a component of several lepidopteran sex pheromones, including a number of *Dioryctria spp*. It is possible that *L. occidentalis* may use the pheromone of these cone moths as a cue in host location. Demonstration of *L. occidentalis* attraction to this compound in additional field tests may warrant its use as a bait in monitoring traps (in lieu of the obscure male volatiles) to further improve trap efficacy.

Completion of Impact Assessment on 1st-Year Conelets.

No abortion was observed in conelets exposed to *L. occidentalis* nymphs or adults. However, seed set in conelets exposed to nymphs was reduced by 75% when no alternative food source (i.e. second year cones) was available. Nymphs experienced high mortality (95%) and appear unable to survive on conelets alone. Seed set in conelets exposed to adults was unaffected.

Conclusion.

Leptoglossus occidentalis populations were successfully correlated to trap catches early in the season. Together with data on nymph survival and refined damage prediction formulae, the traps may form the basis of an effective monitoring program for seed bugs in lodgepole pine seed orchards. Although we were unable to identify an effective seed bug deterrent, the monitoring program should allow informed spray decisions to be made when necessary. We will continue our efforts to validate the trapping correlation in a second year of field testing, and to identify potential baits that may increase trap efficacy. (SPU 1007)

2.3.24 Prince George Tree Improvement Station

Carole Fleetham

SPU 1703 - Determination of the efficacy and contribution of supplemental mass pollination (SMP) on seed produced in lodgepole pine seed orchard 228.

Supplemental mass pollination is recognized as an operational tool to improve seed production and genetic gain within seed orchards of some species of conifers. To determine the efficacy of SMP in lodgepole pine seed orchards, pollen with unique DNA markers was applied to select trees in Orchard 228 in the spring of 2000. However, cool and wet weather prevented the application of pollen as outlined in SPU 0708 and resulted in the collection of insufficient seed for analysis. The trial was successfully repeated in 2001 following the procedures identified in SPU 1703.

2.3.25 Development of Vegetative Propagation Techniques for Western Redcedar

Bevin Wigmore and John Russell

Background:

Controlled crossing of elite families of western redcedar could eliminate selfing in the orchards, but it is an expensive process. Bulking-up of control-crossed seed through rooted cuttings could mitigate the costs. However, protocols for vegetative propagation of western redcedar are lacking.

Objective:

The objective of this project is to develop techniques for the production of hedge plants and rooted cuttings of western redcedar.

Results:

In this third and final year of the project (SPU0204), nursery trials were completed, experimental hedges were transplanted at Mt Newton Seed Orchard for potential operational use, and an extension note is being prepared.

In one trial, cuttings taken from existing serially-propagated hedges showed that rooting percentages of over 95% are obtainable from field-based hedges up to at least 12 years old. Cuttings from original hedges rooted as well as those from re-propagated hedges. Data on the quality of the rooted cuttings has not yet been analyzed.

Another trial examined cultural methods for growing one- and two-year-old containerized hedges, to maximize number of good quality cuttings. A large number of cuttings can be obtained quickly using greenhouse grown potted hedges. Specific results from the pruning and environmental experiments will be presented in the extension note.

In all rooting experiments, the cuttings initiated roots with a high degree of success. The final plant quality, however, was variable. Some crops had a recovery rate of 90%, while others were as low as 50%. Cutting size proved to be an important factor, with larger (10-12 cm) cuttings producing a far better plug than small (6 cm) cuttings. The soft, dark green cuttings with flattened stems, found around the base of the hedge plant, and produced particularly poor plugs. By selecting large, robust cuttings, a high recovery rate can be expected. (SPU0204)

2.3.26 Western Redcedar Pollen Management.

Joe Webber

The conditions under which we can successfully collect and store western redcedar pollen are still not completely defined. Seed yield results from pollen collected in 1999, stored one year, and used for the pollination tests in 2000 were poor. Year 2000 was a poor pollination year (fresh pollen yields were also low) and heavy abortion occurred. We could not determine if the quality of the pollen collected in 1999 was poor, if our storage conditions were poor, or if the maternal environment of year 2000 pollination trial was poor. For 2001, we decided to focus on pollen collection conditions and determine if our operational collection techniques were appropriate.

The following table summaries the seed yield results for this trial. The typical operational procedure for extracting western red cedar pollen is to process branchlets of cedar in closed pollination bags (high humidity) under cool conditions (17ºC). Extraction continues for about 24-36 hours, and then the shed pollen is vacuum collected from the bag (inside vac). We also compared the same procedure without vacuum extraction (inside novac) and outside extraction (on cone racks) with no vacuum extraction (outside). The last three treatments included self-pollination and two self-by-outcross pollen comparisons (50/50 mix).

Western Redcedar Pollination Trial WFP 2001 (LLSO)

	TSPC	FSPC	sTSPC	sFSPC	n
inside novac	4.74456	2.40475	0.56125	0.38168	24
inside vac	5.78171	2.53543	0.60507	0.45008	25
outside	6.35857	3.45952	0.55513	0.44828	30
Self	5.35333	1.82667	0.61925	0.32613	20
Out1	4.70351	1.39415	0.53455	0.30512	19
Out2	4.80683	1.69006	0.49335	0.25038	23

TSPC	Total Seed per Cone
FSPC	Filled Seed per Cone
s	Standard Error
n	Sample Size

Table 18. Cw Pollination trial results

Seed potential in western redcedar is about 16 (i.e., potential ovules). However, between 50-75% of these ovules either abort or never produce seed because of poor pollination or insect damage. It is likely these ratios will vary by orchard site and year but on average and for operational planning we can only expect between 3-5 filled seed per cone for western red cedar.

The results shown in the above table indicates we are within this seed yield range for pollen extracted under external environments (outside). Extracting pollen in an inside environment may be somewhat detrimental to pollen quality but vacuum collection has no apparent ill effect. We do not know if the temperature (17ºC) of the inside extracting room is too high compared to outside temperature. We did monitor both temperature and humidity inside and outside and these data are currently being analysed.

Based on this information, we recommend that western red cedar pollen be extracted under ambient outside conditions (within the cone shed). Our extraction conditions for outside also include pollination bags, so we would continue to recommend using extraction conditions of higher humidity. (SPU207)

2.3.27 Improving Genetic Quality and Operational Efficiency of Seed Production in Western Redcedar Seed Orchards.

Oldrich Hak

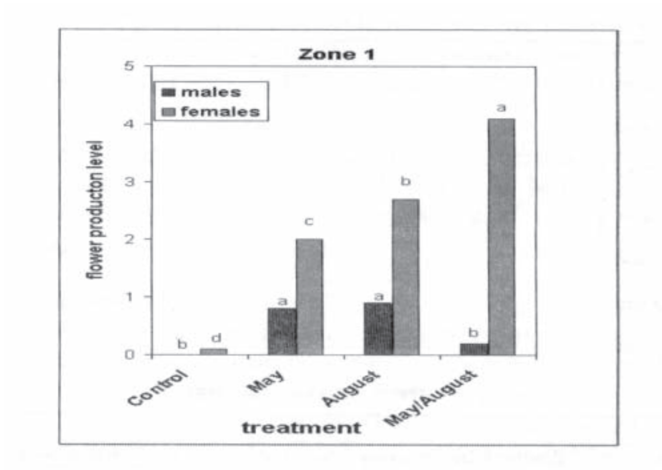
During the first two years of this project three cone induction trials were established to improve genetic quality and operational efficiency of seed production in western redcedar seed orchards.

Specific questions included:

- What is the most favorable time period for operational efficiency of cone induction ?
- Can we calibrate GA treatments to increase female to male ratio in vigorous regions of the tree and thus reduce selfing and improve genetic gain ?
- When in late summer does the effectiveness of GA_3 cease ?
- What is the effect of GA_3 induction timing on cone and seed quality ?

Assessments were done on vigorous branches and each branch was divided into 2 sections or zones: Zone 1 was the inner half of the vigorous branch and Zone 2 was the outer half of the vigorous branch.

The results in Figure 37 show that late GA_3 induction treatments, i.e. August and May & August, were effective for significantly higher female flower production in both zones of the vigorous branch, i.e. Zone 1 and Zone 2.



* treatments with different letters indicate significance at p=0.05 according to Duncan's Multiple Range test

Figure 33. Effect of GA_3 timing on western redcedar flower production.

The male production between May and August was not significantly different in Zone 1, and the production in May and August was lower. Zone 2 did not produce any males. Similarly, late GA_3 treatments were effective for higher female to male ratio. It appears that the higher ratio is not the result of decreased male production as was hoped for but it is the result of substantial increase of female production.

The results also show that the effectiveness of GA_3 treatments significantly decreased in the 3rd week in August (4th treatment) and there was not significant difference between the first three treatments (i.e. last week in July, first and second week in August).

There was not significant difference in male production between any of the six treatments.

Figure 38 illustrates the relationship between GA_3 timing, flower production, and shoot increment.

It shows that treatments after the second week in August are associated with the decrease in shoot increments and lower cone production

It has been noted that the later August treatments, (i.e. after the second week), started to produce abnormal flowers, (i.e. very small size), still developing at a time of female receptivity in the orchard. Cones were collected in the fall and the effect on cone size, number of filled seed, and seed quality is being assessed and will be completed in spring 2002. (SPU 0208)

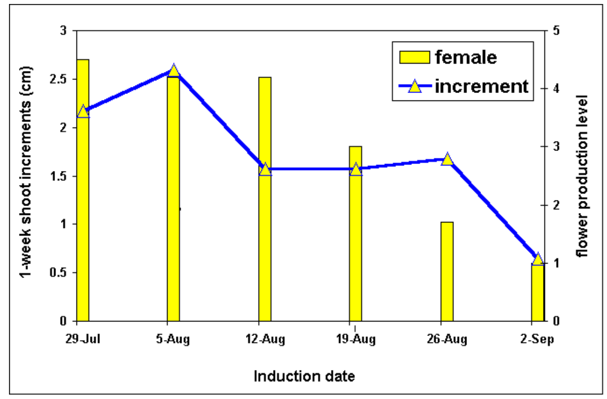


Figure 34. Relationship between GA_3 timing, flower production, and shoot increments

2.3.28 Controlling Selfing Rates in Natural and Seed Orchard Populations of Western Redcedar

Kermit Ritland, Yousry El-Kassaby, Don Pigott and Annette Van Niejenhuis

Previous studies based upon the analysis of genetic markers have demonstrated considerable selfing in Cw seed orchards, but the inferred levels vary tremendously (from 10 to 60% selfing) among these studies. To document possible factors responsible for selfing, so that their levels can be better controlled, in the current year (2001) we assayed the Mt. Newton orchard for selfing rates in three canopy positions (upper crown, inside of lower crown, and outside lower crown). Because Cw is effectively monomorphic for isozyme markers, in preparation for this work we have developed a set of highly polymorphic microsatellite primer-pairs for Cw. In the current study, we assayed four microsatellite loci and 500 progeny. We obtained the following estimates of outcrossing and correlated matings (standard errors in parentheses):

	Upper crown	Lower crown in	Lower crown out
Multilocus tm	0.764 (0.061)	0.760 (0.059)	0.643 (0.075)
Singlelocus ts	0.677 (0.065)	0.613 (0.061)	0.552 (0.066)
Difference tm-ts	0.088 (0.028)	0.148 (0.031)	0.090 (0.029)
Correlation of t	0.272 (0.104)	0.384 (0.080)	0.356 (0.087)
Correlation of p	0.584 (0.088)	0.701 (0.080)	0.682 (0.103)

Table 19. Cw Outcrossing estimates

(The correlation of t is that for outcrossing between members of the same family; the correlation of p is the probability that two outcrossed members of the same family share the same father).

First of all, these results show that significant levels of selfing, on the order of 20-30%, are present in this orchard. Second, the upper crown tended to have a higher outcrossing rate, but this was not statistically significant. Paradoxically, the outside of the lower crown appeared to have a lower outcrossing rate than the inside of the lower crown, but again the standard errors place this trend in question. Certainly there is not the opposite tendency.

Interestingly, the correlation of t estimate shows that selfing rates vary significantly among trees. It would be useful to identify correlates of such variation. The correlation of 'p' estimate (the probability that two siblings share the same father) was quite high, indicating significant levels of outcrossing to neighbors and that pollen clouds are quite localized. Given John Russell's studies that demonstrate inbreeding depression in Cw, controlling selfing rates in Cw seed orchards is of paramount importance.

Other Cw orchard operators are encouraged to contact KR (email kermit.ritland@ubc.ca) regarding studies of self-pollination in their own systems. (SPU0209)

2.3.29 Improvements of Marker-Based Estimation of Seedlot Quality

Kermit Ritland

Current approaches for using genetic markers to evaluate the genetic efficiency of seed orchard practices are hampered by the need for rather detailed sampling, involving the collection of progeny arrays and the assay of potential contributors of background pollen. I am investigating methods for estimating genetic efficiency based upon "bulk" sample of seed (seed randomly collected without knowledge of family), with the long-term objective that seedlots can be routinely and efficiently rated by the information provided by these methods, especially in Cw orchards, where considerable inbreeding is often present.

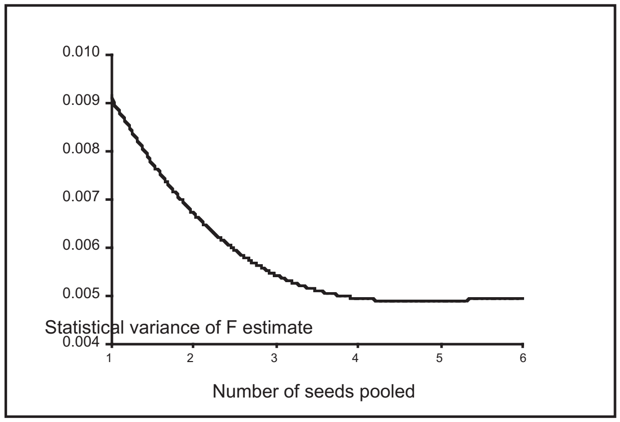


Figure 35. Estimated statistical variance of F for Cw orchards

The three elements of genetic efficiency are: selfing rates, pollen contamination and paternal imbalance. If the parents are assumed outbred, then bulk assays for genotypic frequencies readily reveal the percentage of selfing as $s=2F$, where the inbreeding coefficient $F=1-H_o/H_e$ for H_o and H_e the observed and expected heterozygsity, respectively. If one has highly polymorphic markers, one can further improve the statistical precision of this estimate by "pooling" samples, e.g., assaying several individuals as one sample. In any such pool, more than two alleles will usually be observed, and a mixture model for alternative allelic configurations is invoked (Ritland, in prep.). Consider one example of the improvement of efficiency — a 24-allele microsatellite locus where the true F is 0.20. The statistical variance of the estimate of F across different pool sizes (always 20 pools in total), as determined by simulated data, is shown in the figure. It is most efficient to pool 5 or 6 seeds; also no increase of statistical bias was evident. Alternatively, a multilocus model for a mixture of outcross and selfed zygotes can be fit to the bulk (but unpooled) genotypic data. We are using this approach to characterize apparent selfing rates in natural populations of cedar, utilizing bulk collections from a range-wide survey (O'Connell and Ritland, in prep).

To characterize the other two components of efficiency, pollen contamination and paternal imbalance, the orchard must first be genotyped. Then, pollen contamination and paternal imbalance is jointly inferred via deviations of seedlot gene frequencies from the expected orchard parent frequencies. As well, pooling of samples can improve power, particularly for the detection of rare immigrant alleles. These models are currently in development. Operators or researchers interested in these methods are encouraged to contact KR (email kermit.ritland@ubc.ca). (SPU 0210)

2.3.30 Induction of Western Redcedar (Cw) in Natural Stands to Reduce Inbreeding and Improve Genetic Quality.

Michael Peterson

Background:

No breeding program or Cw seed orchards for the submaritime and maritime areas above 700 m elevation exists in B.C. at present. This is despite a current annual demand of 1 million and 700,000 seedlings for the 27 Cw, SM all, 200–1000m and 33 Cw, M, high 600+ m SPU's respectively. Natural crops in these SPU's have been infrequent with selfing rates of up to 70% occurring, causing up to a 10% volume loss at rotation. In the absence of an elaborate tree breeding or seed orchard program, developing low-cost seed production areas could result in 10% volume gain for 1.7 million seedlings annually by minimizing selfing.

Observations within another project, (OTIP 07-C) where GA_3 was applied to western red cedar trees near Port McNeill in 1999, indicated a significant response in the production of male and female strobili.

Project Description/Overview:

Cone inductions are being carried out on Cw trees in plantations where surrounding natural stands provide pollen to produce a seed supply with minimal selfing to deliver a modest genetic gain with up to a 5-10% gain in volume growth at rotation. Inductions are being carried out in two seed planning units where no current breeding programs exists.

Objectives:

- To increase seed production on Cw trees using GA_3 in plantations within two seed planning units where seed orchards are not going to meet the seed needs.
- To minimize selfing by locating plantations of cone-bearing age where a good source of background (natural) unrelated pollen is available.

Activities:

Candidate plantations for cone induction with good sources of background pollen were selected in each of the two SPU's: 27, Cw, SM all, in the Tsitika watershed and 33, Cw, M high at Rutherford Creek near Whistler where current annual seedling requirements are 1 and 0.7 million seedlings respectively.

During the spring of 2000, approximately 50 Cw trees in each of the two plantations were marked, and size and age recorded. GA_3 was applied to each tree at both locations three times at a rate of 0.2 g of Activol per tree. In October, all treated trees were evaluated for treatment efficacy compared to untreated controls. The number of induced male and female strobili were recorded and a rating of low, medium, or heavy was applied to each tree. In most cases the rating was heavy, indicating a good response.

Spring (February – March) 2001, phenological observations were made to monitor cone abortion rates and synchronicity with the natural stand pollen.

Cones were collected during October, 2001 from upper and lower crowns at two areas, A and B at the Rutherford Creek site and from the Tsitika River site. Seed extraction and testing for germination and viability was dropped from the deliverables this year. The cone and seed yields from the upper and lower crowns at each site are shown in the following table.

Rutherford Area "A"	Lower	6.0 Cone sacks	1.50 Hl	0.835 Kg seed	.557 Kg/Hl
	Upper	4.5 Cone sacks	1.06 Hl	0.682 Kg seed	.643 Kg/Hl
Rutherford Area "B"	Lower	4.0 Cone sacks	1.0 Hl	0.525 Kg seed	.525 Kg/Hl
Tsitika River	Lower	6.5 Cone sacks	1.63 Hl	0.692 Kg seed	.424 Kg/Hl

Table 20. Seed yields for Cw

Seed yields in kilograms of seed per hectoliter of cones were highest at the Rutherford Creek site. Evaluation of selfing will be conducted through DNA analysis.

Final Results or End Product:

The project will develop a seed source that minimizes selfing and has a 5-10% gain in volume at rotation over control lots, in areas where there is a high annual seedling demand (1.7 million) but no tree improvement activities are in place. Companies or agencies currently planting Cw in the Submaritime and Maritime seed planning zones at higher elevation will benefit directly from the increased production of seed from trees where selfing has been minimized. (SPU 2701)

2.3.31 Yellow-Cedar Seed Orchard Cone Induction and Seed Production.

Don Pigott & Mike Peterson

SPU 1105 Description/Overview

This project involves the induction of cones using GA_3 foliar spray applications for the purpose of producing more yellow-cedar seed for both end users and the breeding program.

Objectives

- To increase seed production in Weyerhaeuser Company's Seed Orchard #137, located at two sites, and the MOF Cowichan Lake Research Station (CLRS) cone bank through GA_3 cone induction.
- To determine the effects of orchard elevation and local climate on reproductive bud initiation and cone abortion rates in order to enable increases in the production of viable seed to be obtained.

Progress Report

In 1996 a part of Weyerhaeuser Company's Seed Orchard #137 (yellow-cedar) was moved from Yellow Point to Rheinhart Lake in an attempt to remedy the absence of satisfactory seed production at the original site.

In April 1998 the Rheinhart Lake Seed Orchard was assessed for presence of one-year-old and two-year-old cones as well as pollen and female flowers for the current year. Survival and vigor of the original plantings and the replacements was also recorded. Based on those assessments, the clones to be treated with GA_3 in 1998 were also chosen. The 21 clones chosen were represented at Rheinhart Lake, at the original orchard site at Yellow Point, and in the clone banks at Mesachie Lake.

Weather stations were set up to record temperature and rainfall at Yellow Point and at Rheinhart Lake. Weather data was already being collected at Mesachie Lake. GA_3 was applied as a foliar spray to two ramets of the 21 clones at each of the three sites. The rate of application was approximately 0.2 grams of Activol per tree, depending on tree size. Each site was treated three times, starting in late June and at approximately 10-day intervals. Twenty-four wildings (natural regeneration) were also treated at the Rheinhart Lake site. Sixteen trees were treated three times, four were treated twice, and ten were treated once.

In order to spray the trees quickly and efficiently, a 12-volt pump was mounted on a plastic tote bin. A cigarette lighter adapter plugged into the truck supplied the power. One hundred and twenty-five feet of garden hose and a simple spray nozzle were used for the application. In August visual inspections indicated no phytotoxicity and all trees appeared to be healthy. In late September all ramets treated were evaluated to estimate the approximate number of male and female strobili produced. In the spring, reproductive phenology and cone abortion rate will be assessed. In general, a significant response to the GA_3 applications was observed at both Mesachie Lake and Rheinhart Lake. At Yellow Point a heavy crop of both male and female flowers occurred on both the treated and untreated trees.

Perhaps the most interesting response was at Rheinhart Lake on the wildings. All of the wildings treated developed reproductive buds while untreated trees had few or no male or female buds.

In 1999 access to the Rheinhart Lake site was not possible until June 3 and at that time there was still more than one metre of snow. Total snow accumulations that winter were in excess of nine metres. Significant branch damage of the many larger ramets was due to the unusually heavy snow press. Damage was sometimes substantial on naturals and planted trees of other species adjacent to the site.

In June and July of 1999, trees of the same 20 clones that were treated with GA_3 at Rheinhart Lake, Yellow Point, and Mesachie Lake were assessed for number of cones. The number of cones was counted on 3 branches per tree (60cm per branch). Cones initiated prior to the induction treatments were also tabulated.

In November those cones initiated prior to treatment were collected at Yellow Point and Rheinhart Lake. There was an abundance of cones at Rheinhart Lake, probably induced by the stress of their relocation to the site from Yellow Point. There were not enough cones to collect at Mesachie Lake.

In November the seed from the collected cones was extracted and cleaned. Preliminary observations indicated a much higher filled seed per cone content at Rheinhart Lake than at Yellow Point. Significantly more cones were induced at Yellow Point Seed Orchard than at either of the other two.

In June and July of 2000 the same 21 clones that were treated at the three sites in 1998 were again sprayed with GA_3 at the Rheinhart Lake and Mesachie Lake sites. The Yellow Point site had been sold and were not treated.

In the fall of 2000 the treated ramets of the 21 clones were assessed for both male and female flowers. The response was less significant than the 1998 application, indicating a need for more studies on timing and rates of application.

In 2001 the work on this project consisted of maintenance of only the Rheinhart Lake site. This included fertilization and monitoring the crop induced in 2000. That induction was far less successful than the one done in 1998; it is unlikely that collecting the crop in 2002 will prove useful.

Although not funded this year, the cone crops induced in 1999 at the two Port McNeill sites were collected and the seed has been processed. One site was a natural stand while the other was a clonal trial established by Western Forest Products. At the clonal trial, where two ramets of each of 20 clones were induced, a good crop of cones resulted, but not one cone was produced on the untreated ramets of the same clones.

This project has shown us that we are able to induce cone crops and produce viable seed on yellow-cedar seedlings, grafts, and rooted cuttings in the more Maritime regions of Vancouver Island. This has not been the case in the orchards at low elevation on the East Coast of Vancouver Island.

2.3.32 Development of Pollen Management Guidelines for Yellow-Cedar.

Oldrich Hak

The success of any seed production program, breeding or operational, depends largely on the quality of pollen. Yellow-cedar pollen matures at different times, depending on environmental conditions. Low elevation pollen, which completes its development in the fall, may be more fertile at that time than later in the spring. Pollen deterioration over time may be the main reason for low quality of pollen and for the failure of low elevation seed orchards to produce viable seed. High elevation pollen, on the other hand, may be more viable in the spring since it completes its development at that time.

The purpose of this project is to evaluate the quality of fresh, fully developed pollen collected from two distinct climate environments, i.e. low and high elevation. A multi-faceted approach (respiration, conductivity, and control pollination) is being used to assess pollen quality at both environments. In order to establish a good measure of pollen lot's potential fertility, the assessment of pollen quality should be based not only on its viability but also on its health condition (i.e. the level of vigour). This can be done by scoring pollen vigour levels based on the length of pollen tube during pollen germination testing.

The results show that the quality of fully developed pollen, collected in the fall from the two low elevation orchards, is superior (i.e. higher viability and higher vigour) to pollen collected in the spring from the same orchards (Tables 21 & 22).

Spring 2001 (shedding time) Averages based on 10 clones			
Location	% Viability	% Vigour level	
		A	B
Yellow Point	33	11	22
Mt. Newton	30	5	25

A = high vigour (pollen tube length = 3 or > than 3x the diameter of hydrated pollen grain)

B = moderate vigour (pollen tube length > than 1x diameter but < than 3x the diameter of hydrated pollen grain.

Table 21. Yc Pollen Quality at Low Elevation - Spring

Fall 2001 (fresh, fully developed pollen)Averages based on 10 clones					
	% Cond.	Resp.	% Viability	% Vigour level	
Location:			(A+B)	A	B
Yellow Point	48.56	5.98	73	57	16
Mt. Newton	62	4.5	71	54	17

Table 22. Yc Pollen Quality at Low Elevation - Fall

Pollen collected from two high elevation natural stands in the spring has much higher quality when compared to the other collections described above (Table 23).

Control pollinations in a natural stand at high elevation, using fresh high elevation pollen, will be done in the spring 2002.

Spring 2001 (shedding time)Averages based on 10 clones					
	% Cond.	Resp.	% Viability	%Vigour level	
Location:			(A+B)	A	B
Pemberton	27.34	14.2	88	60	28
Mt. Washington	26.4	11.9	89	54	35

Table 23. Yc Pollen Quality at High Elevation

When comparing the assessments of the three distinct pollen collections, the high elevation collections in the spring produced the highest pollen quality, while the low elevation collections in the fall resulted in moderate pollen quality, and the low elevation collections in the spring had the poorest pollen quality (viability and vigour). The quality of low elevation pollen collected in the spring was much lower than of pollen collected in the fall from the same orchards. This suggests that the fully developed pollen in the fall may be subjected to various levels of deterioration before pollination in the spring. Such pollen may be considered non-viable and unsuitable for pollination. It is possible that this is the main reason for the failure of low elevation orchards to produce viable seed. (SPU 1106)

2.3.33 Improving Seed Production in Yellow Cedar Seed and Breeding Orchards.

Oldrich Hak

Plans call for the establishment of new breeding orchards in the near future to rejuvenate clonal material in hedge orchards. Situating these orchards at low elevation is questionable since previous orchards, planted at low elevations on Vancouver Island, have failed to produce viable seed. The hypothesis is that poor fertility of pollen produced at low elevation seed orchards may be the main reason for this failure. If this proves to be true, yellow-cedar pollen could be produced at high elevation, stored, and used for pollinations at low elevation or high elevation orchards. Pollen and seed production at high elevations are sporadic. Techniques to enhance male and female cone production have been developed for low elevation orchards only.

The first objective of this project is to test if there is a significant deterioration of pollen quality in low elevation seed orchards, when compared to high elevation natural stands. The second objective is to refine hormonal cone induction treatments for high elevation yellow-cedar that would provide the most effective response for male and female cone production. Assessments of pollen development and deterioration over time are still ongoing and the final spring assessments will be completed in the Spring of 2002.

Assessments are done at 6-week intervals, based on pollen developmental stages and pollen viability. Assessments at high elevation were interrupted when the temperature reached freezing point in the fall and will resume in the spring. Initial results indicate that male buds at low elevation orchard were initiated in mid-summer, about one month earlier than at high elevation, and finished their development in September. Pollen maturation is more variable at high elevation and it enters winter dormancy at various levels of development.

The establishment of the cone induction treatment trials was completed at two high elevation locations. Assessment of male and female cone production, data compilation and analyses, and report will be done during the late spring 2002.

Pollen developmental stages at high elevation in the fall were compared between natural and GA_3 induced male cones (Table 24).

Type of Induction	Time of Induction	Development Stage
NATURAL	?	4.5
GA_3	JUNE	2.5
GA_3	JULY	1.0
GA_3	AUGUST	0.0

Table 24. Developmental Stages of Male Yc Cones at High Elevation in the Fall.

There was a notable difference between the two inductions. The development of GA_3 induced male cones was much slower than the development of naturally induced male cones. This delayed development of GA_3 induced cones was even more striking with later treatments in July and August. Indications are that the timing of cone induction treatments, which started 1 month after pollen shed, may have been too late. The effect of delayed pollen development on pollen viability during pollination in the spring is unknown and will be tested. (SPU 1107)

2.3.34 Conservation and Management of Grand fir.

Don Pigott

Grand fir is an important part of reforestation programs in coastal British Columbia at lower elevations. It is a fast growing species; provenance testing showed that 20-year height of the most productive seed sources reached 18m at fertile sites, indicating a potential rotation of 40-45 years at many coastal sites. Grand fir is also very tolerant of flooding and fluctuating water tables. The species has an important role in wood production and ecology.

In the year 2000, approximately 138,000 grand fir were planted in B.C.. Less than 2000 of these trees were planted in the Nelson region; the remainder was planted in the Vancouver Forest Region. Minor amounts have also been planted in the Prince Rupert Region, with notable performance from inland sources east of Hope.

Seed demands will likely increase as logging of low elevation second growth stands on the East Coast of Vancouver Island, the Sunshine Coast, and the Lower Mainland accelerates. Seed production in the one grand fir orchard, after 14 years, has been dismal, similar to the experience in other *Abies* orchards. Considering the demand, further investment in seed orchards is unwarranted, and future seed needs must be met through collection from productive natural stands identified according to provenance testing results.

Many of the best grand fir stands on the East Coast of Vancouver Island, including several recognized B+ stands, have been eliminated or are threatened by urbanization and logging. Conservation measures are necessary to secure long-term access to a seed supply for grand fir.

The range of grand fir in the Interior of B.C. is limited to lower elevations in the Arrow Lakes and Kootenay Lake region in southern B.C.. Little information is available on the status concerning gene conservation and seed supply potential, however generally the stands are small isolated pockets, which are vulnerable to both human activity and natural disturbance.

In 2001-2002, many of grand fir stands remaining on the East Coast of Vancouver Island, and the adjacent mainland as far east as Hope, were visited and assessed for suitability for gene conservation and long term seed supply. This information is currently being compiled and evaluated in order to present recommendations for a long-term strategy to the Abies Committee. In 2002-2003, it is proposed to set aside areas, which have been identified as superior provenances for seed production, and secure access to areas previously unavailable, for research and possibly operational seed production.

Initially, we were concerned about the negative impact of logging and urban development on the stands and trees, particularly on the East Coast of Vancouver Island. However, one of the more positive findings of this survey was that the species is better represented in a network of provincial, federal, and municipal or regional parks than was originally thought. Although technically this will probably satisfy the needs for gene conservation, these areas are currently not accessible for operational, or even research seed collections in most cases.

There are a few stands on Crown land and private forestland in the vicinity of currently known superior provenances, where there is the potential to manage the species to satisfy our objectives. This will be done in concert with the analysis of the most recent provenance trial assessments and a review of the current material in ex situ. (SPU 3601)

2.3.35 Douglas-fir Cone Gall Midge Pheromone Monitoring and "Attract & Kill" Control

Robb Bennett

Background:

Douglas-fir cone gall midge (DFCGM), *Contarinia oregonensis*, is the most serious pest of Douglas-fir seed production in the Pacific Northwest. Adults lay eggs at cone scale bases during pollination. Developing larvae feed in scales, reducing seed counts and extractability. In B.C., DFCGM is monitored by time-consuming conelet dissections and egg counts. Control is effected through use of highly toxic systemic insecticides to kill young larvae. "Bennettin" is a synthetic copy of the female DFCGM sex pheromone and is being developed for use as a novel and simple-to-use monitoring and control tool. Bennettin-baited insect traps can be used to pinpoint first flight of DFCGM in the spring and to assess population levels and predict damage. "Attract & Kill" methodology (paste formulation of Bennettin plus minute quantities of synthetic pyrethroid insecticide) may provide control of DFCGM by killing males and reducing mating and egg production.

Pheromone-based monitoring of DFCGM:

The objective of this study was to 1) confirm that Bennettin is suitable for pheromone-based monitoring of DFCGM and 2) improve usefulness of the methodology by "tightening" insect/damage correlation and reducing non-target insect trap catch (by-catch). Modified Delta traps were used in 2001 field season to correlate trap catches of males with 1) numbers of egg-infested scales in conelets and 2) numbers of gall-damaged scales in mature cones. Modified Delta traps were compared with Wing traps (used in earlier work) to determine whether the amount of by-catch could be reduced.

In direct comparison, the modified Delta traps captured significantly fewer flies that are very easily confused with DFCGM than the Wing traps. Eliminating these flies from trap catches greatly improves the usefulness of the Bennettin-based monitoring program for orchard technicians.

Mean numbers of DFCGM males captured throughout 4-7 ha seed orchard blocks in 20 Bennettin-baited Delta traps showed significant positive relationships with mean numbers of both egg-infested scales in conelets and galled scales in cones. Relationships were much stronger when percentages of crop trees (trees with at least 5 conelets visible) were incorporated into the analysis or when only seed orchards with >50% crop trees were included.

In B.C., insecticide applications against DFCGM in seed orchards are recommended when an average of 2.6 or more scales per conelet are egg-infested (value based on 10% insect damage tolerance level and 85% insecticide efficiency). In orchards with >50% crop trees, an average of 0.6-1.5 DFCGM per Delta trap predicts 2.6 egg-infested scales per conelet. Alternatively, an average of 1.1-2.3 DFCGM per Delta trap predicts 0.9 galled scales per half cone, equivalent to 2.6 egg-infested scales per conelet.

In the USA, for control of DFCGM, Douglas-fir seed orchard technicians rely upon pinpointing the date of first flight of DFCGM in the spring. Because many very similar appearing insects are flying at that time, Bennettin-baited traps are the only accurate and reliable tools for the job.

In conclusion, our data show that crop damage by DFCGM can be predicted by catches of male midges in Bennettin-baited Delta traps. These trap catches, together with estimated seed crop values and the history of DFCGM damage, should help orchard managers decide when control of DFCGM is warranted. Further work is needed to improve the correlation between trap catches of male DFCGM and subsequent damage.

Pheromone-Based "Attract-&-Kill" Control of DFCGM:

Efficacy of "Attract & Kill" was assessed by comparing numbers of trap-captured males, egg-infested young scales, and galled mature scales within pairs of treatment and control blocks. Treatment trees each received six droplets of Last Call™ (0.1% Bennettin + 6% permethrin) on the lower part of the tree (from ground level to ca. 2.5 m above ground). DFCGM numbers in each block were monitored with Bennettin-baited Delta traps

Numbers of male DFCGM were significantly reduced in the treatment blocks, indicating there was a strong effect on male DFCGM due to Last Call™ application. However, in all but one orchard treatment, numbers of egg-infested and subsequently galled scales were not significantly lowered. Results were insufficient to conclude that "Attract & Kill" methodology has any effect on female DFCGM reproductive success and damage to Douglas-fir seed crops.

As tested, "Attract & Kill" formulation is not sufficiently effective on its own to reduce damage caused by DFCGM. Alternative placement and/or numbers of Last Call™ droplets should be tested, particularly in those orchards that are isolated from Douglas-fir forests. Moreover, improved knowledge of the basic biology of DFCGM, including understanding of stimuli affecting selection of egg-laying sites by female DFCGM, and "Attract & Kill" formulations of those stimuli, may be required to render the "Attract & Kill" tactic effective for control of DFCGM populations. (SPU 0102)

2.3.36 Estimation of Propensity to Self in Elite Seed Orchard Clones of Western Hemlock

Oldrich Hak

Previous studies have shown that the propensity of western hemlock orchard clones to self-pollinate shows strong family effects. This factor is particularly important in clonal row orchard designs. Once the problem clones are identified, managers can avoid planting ramets of these clones adjacent to each other, or employ some form of pollen management (i.e. SMP), or collect from these trees in years where no remedies could be undertaken. Minimizing selfing in orchard seed will assure that the growth potential of high-gain lots is not compromised by inbreeding.

In this project, the propensity to self was estimated for 32 high breeding value orchard clones. Controlled crossings were done at the Cowichan Lake Research Station and in collaboration with the Sechelt Seed Orchard at Canfor and the Lost Lake Seed Orchard at Western Forest Products. Two selfed and two out-crossed isolations were done on each of the high breeding value parents. A poly-mix for out-crossings was formulated using an equal amount of pollen collected from six unrelated lower breeding value families. Seed from selfed and out-crossed cones was extracted, the number of empty and filled seed is being counted, and the percent of filled seed for each isolation bag will be determined. (SPU 0309)

2.3.37 Western Hemlock Seedling/Cutting Field Comparison – Age 5 Measurements

Bevin Wigmore, Patti Brown, and Charlie Cartwright

This project (SPU0311) compares the five-year heights of hemlock cuttings and seedlings from elite full-sib families, planted at four field sites.

Methods:

One year old seedlings and rooted cuttings were planted out in spring 1998 at five field sites. One site was later abandoned because of elk damage. The seedlings and cuttings were from seven elite full-sib families from the B.C., Washington, and Oregon breeding programs. Woods' run seedlings were also planted out for comparison.

Height and root-collar diameter were measured at the time of planting, and there were no significant differences between cuttings and seedlings at that time. By age three, seedlings were taller and had larger diameter than cuttings, but the difference was only significant at one site. Diameters were not measured at age five, because the trees were too large for root-collar diameter measurements, and yet frequently too small for dbh.

Results:

The overall mean heights for elite seedlings, elite cuttings, and standard seedlings were 2.52m, 2.42m and 2.22m respectively. Elite seedlings were taller than elite cuttings at each individual site as well as overall, but the differences were not statistically significant (Figure 40).

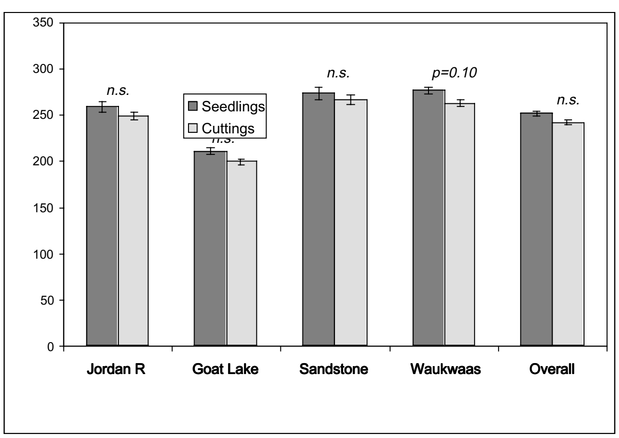


Figure 36. Five year height for elite seedlings and rooted cuttings of Cw at four test sites (+/- s.e.)

Standard seedling data were not used in the statistical comparisons of cuttings vs. seedlings. Family effect was marginally significant ($p=0.06$) as was the family by site interaction; however, there was no significant interaction between stock type and family. There was no difference between cutting and seedling in survival, or in form characteristics such as forking.

In another study comparing hemlock cuttings and seedlings from operational seedlots and grown at three different commercial nurseries, there are strong interactions between nursery and stock type, and between seedlot and stock type.

While the five-year measurement was intended to be the last one for this trial, the ambiguous findings indicate another measurement at age seven or older is warranted. (SPU 0311)

2.3.38 Productivity of Sitka Spruce with Resistance to White Pine Weevil

René Alfaro, Robert McDonald and Michelle Meier

A computer system, named SWAT, or Spruce Weevil Attack, was developed to estimate the impacts of the white pine weevil, *Pissodes strobi*, on productivity of Sitka spruce, *Picea sitchensis*. Working interactively with the Tree and Stand Simulator (TASS) of the B.C. Ministry of Forests, the system simulates weevil outbreaks in plantations and provides data on attack rates and volume losses due to repeated weevil damage, under various weevil hazard scenarios and plantation designs.

Figure 37. Sitka spruce tree topkilled by the spruce (or white pine) weevil.

The program incorporates the population dynamics of the insect, including selection of trees for oviposition, emergence of adults and dispersal. Two mechanisms of genetic resistance to weevil are incorporated, repellency to oviposition and toxicity to eggs and larvae. (SPU 0409)

2.3.39 Operational Crown Management in an Interior Spruce "High Density" Seed Orchard and Two Western Larch Orchards.

Gary Giampa

Background

The objectives of this program are 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 cone production.

Outline of Project

Based on analysis of past results it was decided to streamline treatments into fewer, more practical applications. For 2001 there were only three treatments applied to trees in the western larch orchards and four treatments applied in the micro orchard. The trellises in the larch orchards were eliminated altogether as they seemed to offer no advantages and impeded access within the orchards. Crop surveys were conducted to help evaluate the effectiveness of the different treatments. *Please note that the results shown reflect the year 2000 pruning regime. Cone and pollen surveys were conducted in the spring before any treatments were applied. Analysis of our survey results confirmed our decision to streamline the treatments.*

Crown Management in the Western Larch Orchards

Trtmt. #	Description	Prune Leader?	Prune Branches?	Train?
1	Height control, necessary training	To 4m. height	To 4m. or if extending into rows	If extending +1.5 m. into rows
2	Moderate pruning	50% new growth, control @ 4m. height	No more than 25% to maintain hedge effect	If extending +1.5 m. into rows
3	Severe pruning	75% new growth, control @ 4m. height	No more than 25% to maintain hedge effect	If extending +1.5 m. into rows
4	Complete pruning	100% new growth, control @ 4m. height	If extending +1.5 m. into rows	None
5	Severe crown top	To 3m. if exceeding 5m. tall	If extending +1.5 m. into rows	If extending +1.5 m. into rows
C	Control	None	None	None
T	Trellised rows	To 4m. height	To 4m. or if extending into rows	If extending +1.5 m. into rows

Table 25 Treatments Applied to Ramets in Two Western Larch Seed Orchards 2001

Trtmt. #	Description	Prune Leader?	Prune Branches?	Train?
1	Control	None	None	None
2	Operational Style Pruning	To 3m. if exceeding 5m. tall	If extending +1.5 m. into rows	If extending +1.5 m. into rows
3	Height Control and Moderate Pruning	To 4m. height	No more than 25% to maintain hedge effect	If extending +1.5 m. into rows

Table 26. Revised Treatments Applied to Ramets in Two Western Larch Seed Orchards 2002

Results

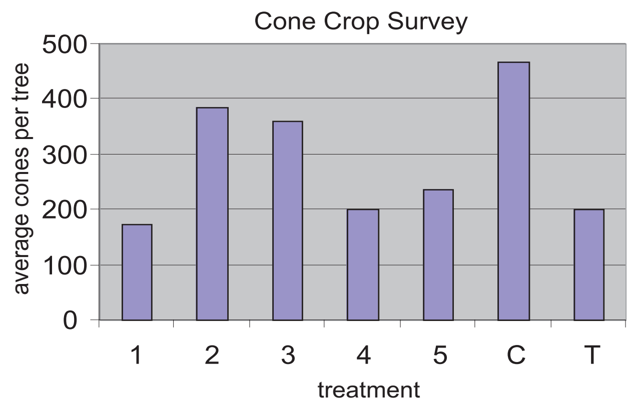
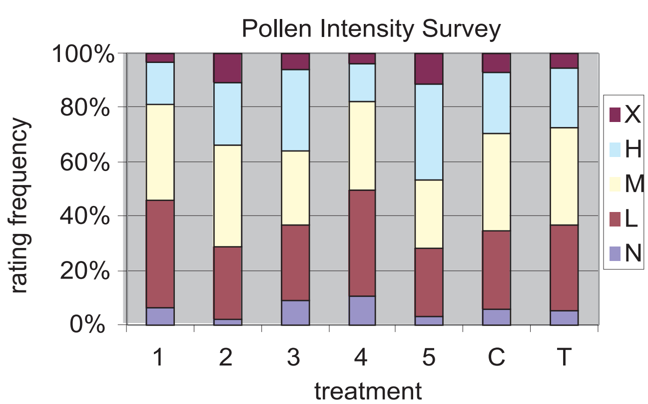


Figure 38 Cone crop relative to treatment.

This graph indicates that the control treatment produces the most cones, followed by treatments 2 (moderate pruning), 3 (severe pruning) and 5 (severe topping). We have combined the most promising treatments (2 and 3) into a less labour intensive treatment consisting of moderate pruning and height control. A modified version of treatment 5 is also being tested (operational style pruning). The treatments showing poor potential were eliminated.



It appears that treatments 2,3 and 5 promote pollen production as well as cone production.

Figure 39. Pollen intensity relative to treatment.

Our decision to streamline treatments was based mainly on survey results but we had to consider practical realities. Some of the treatments were too labour intensive and expensive to be applied on an operational basis. The control treatment, for example, produced lots of flowers but the crop was impossible to manage.

Crown Management in the Spruce Micro Orchard

Four different treatments were applied to ramets in our interior spruce micro orchard. Each treatment was repeated in free-standing and trellised rows.

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	Along trellis, or to other branches
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

Table 27. Revised Treatments Applied to Ramets in the Interior Spruce Micro Orchard 2002

Results

Unfortunately none of the Spruce orchards at Kalamalka produced a crop this year. This makes it impossible to evaluate our crown management techniques in the Micro Orchard.

Conclusion

We will continue to test our refined crown management techniques during the 2002 field season. If a good cone crop is produced in 2002 we will be able to generate sufficient data to allow us to recommend the most effective crown management techniques for these types of orchards. (SPU 1301)

2.3.40 Seven-Year Field Performance of Six Spruce Seed Orchard and Wild Seedlots Grown at Seven Nurseries.

Christopher Hawkins

This trial was initiated in 1994 as part of the larger seed orchard seed project, which the Silviculture Branch of the B.C. Forest Service began in 1993. An orchard and a natural stand seedlot, from each of the Prince George, Shuswap Adams and East Kootenay seed planning zones, were grown at seven nurseries in 1994. The nurseries were Surrey, Reid Collins, Mountain View, Skimikin, Woodmere, Northwood, and Red Rock Research. Stock was summer planted in 1994 and spring planted in 1995 at two sites, one in the ICH (Skimikin) and the other in the SBS (Prince George). See fifth year report in 1999-2000 OTIP report.

Five-year heights were determined in the fall of 1999 at both sites. The stocking at Skimikin was reduced from about 6500 to 3200 saplings after measurement. Seven-year heights were determined in the fall of 2001 at both sites. The stocking at Prince George was reduced following the seven-year measurements. Growth data were analyzed using a fixed affects ANOVA with main sources being plant date, nursery, source and seed planning zone and site. Survival data were analyzed with a Pearson Chi-square test.

After seven years, there are still significant differences in growth between sites – the mean height, regardless of nursery, was 135.9 cm at Skimikin and 123.5 cm at Prince George (Table 28). The best seven-year growth (147 cm) occurred at Skimikin and the poorest growth (99 cm) occurred at Prince George. There were 24 and 32 cm differences in seventh year heights between the best and poorest nurseries at Skimikin (SK) and Prince George (PG) respectively and nursery rankings were different by site. Seventh year survival, however, was better at Prince George (63.7%) than at Skimikin (60.8%); nursery again played a significant role. At year seven, seed planning zone and timing of planting significantly influenced survival at both Skimikin and Prince George. For seventh year height growth, timing of planting was significant at Prince George, but not at Skimikin.

	Nursery 1		Nursery 2		Nursery 3		Nursery 4		Nursery 5		Nursery 6		Nursery 7	
	Mean Height(cm)		Mean Height(cm)		Mean Height(cm)		Mean Height(cm)		Mean Height(cm)		Mean Height(cm)		Mean Height(cm)	
Age	5	7	5	7	5	7	5	7	5	7	5	7	5	7
Site														
SK	98	147	86	135	88	134	82	123	89	133	91	137	91	139
PG	78	127	75	124	61	99	78	131	79	126	77	124	79	131
	Survival (%)		Survival (%)		Survival (%)		Survival (%)		Survival (%)		Survival (%)		Survival (%)	
Age	5	7	5	7	5	7	5	7	5	7	5	7	5	7
Site														
SK		56.7		52.7		55.6		66.1		65.7		69.2		63.2
PG		65.3		56.9		49.4		51.4		63.0		75.4		75.9

Table 28. Mean height after five and seven years and seventh year survival by site, for each nursery.

There were significant differences in growth by seed planning zone at Prince George; however, these differences were minimal at Skimikin (Figure 44).

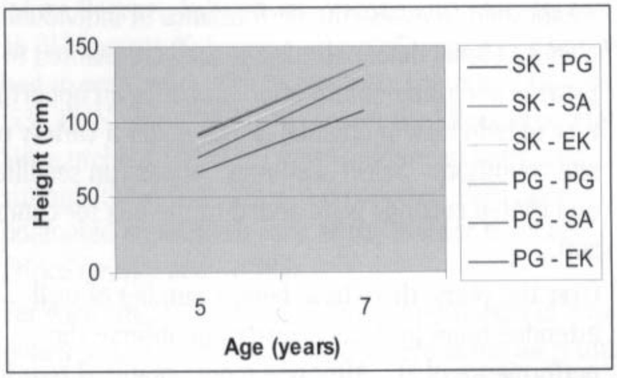


Figure 40. Mean height at age five and seven by growing site and seed planning zone.

At year seven, the difference in growth between orchard and wild sources was significant at Skimikin; with orchard sources outperforming wild sources (Figure 45), however, in contrast and contrary to what would have been expected, this difference was minimal at Prince George. Additionally, the difference in growth between orchard and wild sources appears to be increasing at Skimikin.

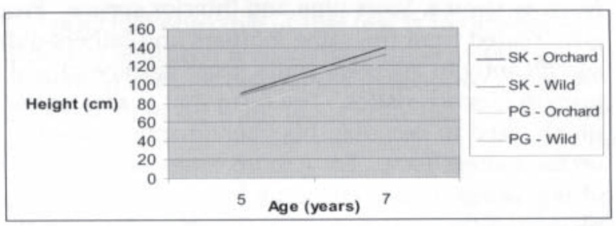


Figure 41. Mean height at age five and seven by growing site and seed source

In conclusion, height growth was affected by a number of factors which varied by site; nursery and source being the key factors at Skimikin, while nursery, time of plant and seed planning zone were the key factors at Prince George. Survival too, was influenced by a number of different factors including seed planning zone, source, nursery and time of plant at Prince George and seed planning zone, nursery and time of plant at Skimikin. Seven years after planting nursery origin still significantly influences spruce growth and survival at both sites and there are interactions between nursery and site. The lack of difference between orchard and wild stock is puzzling, but it may in part be due to having two of the sources (EK and SA) very much off site. Ten-year measurements in 2004 may clarify some of the posed questions. (SPU 0403)

2.3.41 Operational Test Of IPM Plan For Management Of Interior Spruce Cone Rust.

Robb Bennett.

Interior spruce cone rust, caused by the fungus *Chrysomyxa pirolata*, is the most important disease of spruce cones in B.C.. When left unchecked, the disease may ruin up to 60% of cones in interior spruce seed orchards and natural stands. Seeds from diseased cones have very low viability and germinants are often abnormal. The fungus has a complex life cycle involving four kinds of spores and an alternate host (wintergreens and single delight — species of *Pyrola* and *Moneses*). Basidiospores released by the alternate host infect spruce cones and are the most important part of the life cycle to be considered in management strategies for this disease.

Management of interior spruce cone rust at susceptible seed orchard sites currently consists of an annual calendar fungicidal spray. No operational monitoring or damage prediction protocols exist. Additionally, the currently registered fungicide for control of this disease is not "user-friendly" and is in danger of losing its registration through failure to comply with provincial Forestry Pest Management Plan regulations. To resolve these issues, B.C. Ministry of Forests has been working with AFS Limited to develop an effective, integrated approach to management of interior spruce cone rust.

Previous work by AFS Limited 1) produced a climatologically-based model to predict likelihood and periods of basidiospore production and 2) determined environmental and cone phenological conditions necessary for spore germination on spruce cones. The objective of the current project was to begin testing the predictive model operationally using current environmental data. This Integrated Pest Management Plan should reduce the usage of, and dependence upon, fungicides for controlling interior spruce cone rust in spruce orchards.

From April 1, 2001 onwards, growing degree-days data were obtained from Environment Canada weather observations near the test seed orchards. In early April, ambient air temperature, relative humidity and rainfall sensors were placed near infected *Pyrola* plants adjacent to the test orchards and connected to a datalogger. Temperature and vapour pressure deficit was used to predict airborne spore densities in the seed orchards daily. Cone phenology, number of days cones remained receptive, and incidence of disease were recorded on selected orchard trees. Selected trees were assigned to one of three treatments:

- standard operational fungicide sprays applied,
- no operational fungicide sprays applied, or
- fungicide sprays applied based on a recommendation for application when 50% of the cones remained receptive for more than3 days.

The incidence of infected cones in each of the trial treatments was assessed in late July 2001. Initial analysis of results indicates that cones sprayed on basis of model-based recommendation had the lowest incidence of cone rust (0.17%). Standard operationally treated cones had twice the incidence of cone rust (0.35%). Untreated cones had the highest levels of cone rust (1.0%). Incidence of cone rust in 2001 at the test orchards was generally low and the results still need to be subjected to statistical analysis. However, the 2001 results show excellent potential for the full development and delivery of an effective IPM plan for the management of interior spruce cone rust in seed orchards based on environmental monitoring.

(SPU 0406)

2.3.42 Development of Spruce Somatic Seedling Demonstration Sites in the Central Interior.

Don Summers

In 2001/02, 9 clonal block demonstration sites (1997 planting) in the Prince George Region were measured for 5-year height growth. That data is being incorporated into a summary data set for all sites over the term of the project (1995 - 2003). Next year, measurements from the remaining 12 sites (1998 planting) will complete all 5 year height measurements. A final report will be produced in the winter of 2003.

The Prince George clonal block project includes a total of 33 sites; each planted with several blocks of woods-run or select seedlings, rooted cuttings, or somatic seedlings (SE). These plantations cover representative areas throughout the Prince George (PG Low), Prince George Nelson (PGN) and Bulkley Valley/Prince George (BVP) interior spruce planning units. The SE blocks are meant to complement the detailed SE Candidacy Trials established through the MOF Research Branch and FGC OTIP program.

This trial began in the early 1990's, with the start of commercial somatic seedling production (through B.C. Research, now CellFor, and various partners). The product was largely untested under operational conditions, so experimental Candidacy Tests were established to assess the performance of individual SE clones. Clonal demonstration plots were planted to provide additional information and offer an opportunity to help view individual clones under a variety of site conditions. Select seedlings, woods-run seedlings, and rooted cuttings were added to the mix for comparison.

Over the years, there have been a number of well-attended tours for local foresters to observe the performance of SE. After one more organised tour in 2002, maps and data will be made available for self-guided tours through co-operating licensees and Districts. (SPU1406)

2.3.43 The Effect of Seed Orchard Environment on Progeny Performance of Interior Spruce.

Joe Webber

Introduction

The concept that environment can have an effect on progeny performance has been demonstrated in Norway spruce, Scots pine and interior spruce. Progeny created from the same mothers and fathers differ significantly in adaptive traits (frost hardiness) and growth characteristics. The term that is most commonly used to describe this phenomenon is seed orchard aftereffects. For a more complete description of this phenomenon including literature references, please see the 2001 summary report on file with the OTIP Co-ordinator, Roger Painter, B.C. Ministry of Forests, Tree Improvement Branch.

Seed Orchard Aftereffects

In order to determine the magnitude of aftereffects in interior spruce, we created single parent crosses on 20 mothers using 20 unrelated fathers from two sources (i.e., north on north and south on north for PG and south on south and north on south for Vernon). The design was not a complete 20 x 20 factorial but rather an incomplete factorial with pollen parents nested within mothers, which were nested within sets. A set comprised of five groups of 4 pollen parents applied to each of 4 female parents. The design is more fully described in the 2001 summary report available from the OTIP Co-ordinator, Roger Painter.

The two orchard sites being compared are Vernon and Prince George. In 1996, the Vernon (50º 14´N by 119º 16´W) crosses (Kalamalka arboreta) were made but we had to wait until 1999 to complete the Prince George (53º 45´N´ by 122º 41´N) crosses (Red Rock arboreta). Since orchard site (KAL) was confounded with seed storage (three years), we also collected 1999 open pollinated cones from each of the mother trees at Prince George and Vernon.

For each site, five sets of 16 crosses with each of two pollen sources (north and south) were made for a total of 160 family lots per site. The total for both sites is 80 specific female x male crosses each comprised of four north x south combinations (i.e., north x north, south x south, north x south and south x north) for a potential total of 320 families plus OP's. However, since only 18 of the original 20 clones used at KAL flowered at Prince George, only 144 crosses were made (72 north female x north pollen and 72 north female x south pollen) plus their corresponding OP's. The overall total number of families generated was 340. Since some of the crosses were lost (mostly at PG) we ended up having a total of 324 families for sowing.

Plantation Design

The principal objective of this test is to determine the fitness of southern seed orchard progeny on northern plantation sites. If differences in adaptive traits are detected, then we want to separate out both location and parent effects (female and male). We selected two northern sites (PGTIS and a recent cut block near Wanas Creek). Each site consisted of 5 blocks and 20 main plots per block (comprised of one male and four females), four female/male sources (i.e., north-south combinations) per cross and 6 tree row plots for each female/male combination. The following table is an example for one of the four males in Set 1 (Male 21):

M21															
F48				F123				F132				F142			
N/N	S/S	N/S	S/N	N/N	S/S	N/S	S/N	N/N	S/S	N/S	S/N	N/N	S/S	N/S	S/N
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6

N/N	north mother x north father
N/S	north mother x south father
S/S	south mother x south father
S/N	south mother x north father

Table 29. Cross combinations for one of four males

For each specific cross, we used a six-seedling row plot. Thus, a main plot (20 per site) consisted of 96 seedlings plus their corresponding OP crosses from each site (also 6 tree row plots). For each site we used five blocks. Thus, there are a total of 30 seedlings per cross to be planted in each of the two sites. Randomization within each planting site was first by main plots, then by mothers within each main plot and finally female/male source combinations within each female/male cross. OP families were also randomly assigned to each block. The complete planting designation for each of the two sites and five blocks is shown in the 2001 summary report.

Planting

Two sites were selected in the fall of 2000; one at the Prince George Tree Improvement Centre and the other about 40 km east of Prince George at the junction of Highway 16 and the Wansa Creek Forestry Road (between the Willow River and Purden Lake). R. White Woods Inc. was contracted for layout, planting, mapping and measuring each site. Planting was completed by the first week of June 2001. A total of 10,800 trees were planted at both sites (9600 from crosses and 1200 from OP). This also includes in-fill surrounds where less than 30 trees per cross per site were available. Spacing within each plantation was 1m within rows and 2m between rows. Planting of each 6 row tree plot was such that every second tree could be taken out to thin the plantation by 50 % if necessary.

Effect of Temperature during Reproductive Development

We have a growing body of evidence to suggest that temperature during reproductive development may explain aftereffects. We are testing a series of experiments by applying different temperature regimes during various stages of reproductive development. In the first test, we applied two temperatures (12ºC and 24ºC) during post pollination to early embryo development. We term this test GamSel (gametophytic selection) and found that progeny from the cool environment have constantly been more frost hardy in both early fall and late spring tests. We have also shown that temperature effects applied during pollen meiosis had no effect on progeny performance.

This series of tests has been expanded to study temperature effects applied to early seed cone development (FemCon) including meiosis, post pollination reproductive stages, and the late stage of embryo maturation (EmCon). For FemCon and EmCon, single pollen parent crosses on 6 clones were treated to three levels of heat (22ºC, 18ºC and 12ºC) during two stages of reproductive development. For FemCon, treatments began prior to seed-cone bud swell (pre-meiosis) and extended to early embryo development. From past experiments, we knew early embryo development began around 50 days after pollination for the warm treatments and about 60 days for the cool.

The second set of treatments (EmCon) was done on the same 6 clones but a different set of ramets. The same single pollen lot was used and heat treatments began about the time of fertilization and continued through to the end of embryo maturation. Heat treatments began about 40 days after seed-cone bud-swell (about 30 days after pollination) and continued until cone maturation. This was about 60 days for the heat treatment and about 85 days for the cool treatment.

For both FemCon and EmCon, 18 seed lots each were made for a total of 36. These lots were also grown at Skimikin and lifted at the same time as the aftereffects seedlings and are now in cold storage.

The 36 families for FemCon and EmCon were also grown and lifted with the aftereffect seedlings. We will use two plantation sites for this test as well, Skimikin and Prince George. The planting design will use 2 tree row plots (15 row plots in total) for each of the 36 crosses. These row plots will be randomly assigned to each planting site at a spacing of 1m x 1m. Again, the planting design was first established on paper and then the seedlings lifted and boxed according to the plantation design.

Activities Completed in 2001.

All aftereffects and temperature effects seedlings were planted, mapped and measured (nursery height growth for 2000). We also installed meteorological stations at each of the two after-effects sites. This completes the installation phase of this project. This material can now be used to determine the extent of seed orchard aftereffects and the role of maternal and paternal effects (if present) on altering adaptive traits. We also have material to determine if aftereffects are affected by temperature during reproductive development. (SPU 1407)

2.3.44 Early Root Egress and Five Year Height Growth of Summer and Spring Planted Wild, Seed Orchard, Full Sib and Open Pollinated Spruce Seed Sources.

Christopher Hawkins

Concerns expressed in the early 1990's by silviculture foresters about the spruce seed orchard program resulted in the initiation of the "Seed Orchard Seed Project" by Research Branch (BCFS) in 1993. Early project objectives were to demonstrate similarities and differences among wild seedlots, seed orchard seedlots and seed orchard families at the nursery and after planting. Seedlings from many sources (wild seedlots, seed orchard seedlots, full sib families and open pollinated families) were planted and excavated after the first winter (summer plant stock) and after the second winter (summer and spring plant stock from the same nursery year with different treatments) to determine how well above ground growth at 5 years was correlated to early below ground growth.

Roots were excavated and dried from all sources (wild, seed orchard, full sib) for the summer plant of 1993 in spring of 1994. This was repeated in the spring of 1995 for summer 1993 and spring 1994 plantings. Similar excavations were done for summer 1994 and spring 1995 (open pollinated rather than full sib). Five year height measurements were done for all plant date–seed source combinations. The results presented here look at those seedlings excavated in 1995 (planted summer 1993 and spring 1994).

Planting Date

Seedlings planted in the spring of 1994 were taller at the time of excavation than those planted in the summer of 1993 (Figure 46). In all figures below the Y-axis values were omitted since units and scales differ between measured variables; the differences between plant dates, however, reflect the actual differences.

Data were analyzed using a fixed affects ANOVA with main sources being plant date, source and seedlot (source). Spring plant seedlings were significantly taller than summer plant when excavated. This is consistent, however, with the fact that the spring 1994 seedlings were significantly larger from the nursery. Although the seedlings planted in the summer of 1993 were smaller at planting, they had larger root collar diameters (RCD) than those planted in the spring of 1994. The summer 1993 and spring 1994 seedlings were similar in size when the spring plant occurred; meaning that the summer 1993 seedlings grew significantly in RCD during the first summer. Due to taller seedlings with smaller diameters, the mean height to diameter ratio (HDR) of the spring 1994 seedlings was larger than that of the summer 1993 seedlings. The mean root weight, shoot weight and shoot to root ratios did not differ significantly between seedlings from different planting dates suggesting, in this case, carbon allocation was not impacted by plant date.

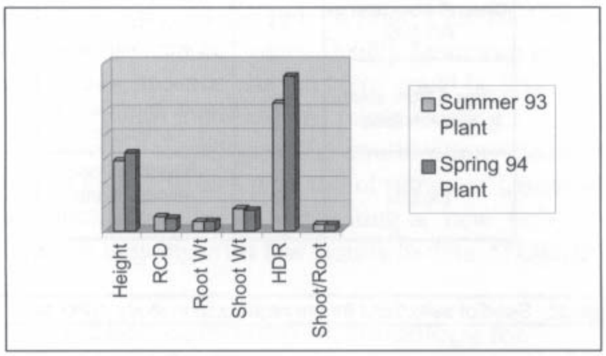


Figure 42. Relative Means of Measured Variables between Plant Dates.

Seed Source

Wild seedlings (WILD) showed the poorest growth with respect to each of the measured variables (Figure 47) Full sib seedlings (FSIB), however, showed the best growth. This is probably consistent with the genetic worth of the parents for height growth. Seed orchard seedlings (SORC) were intermediate. However, these data suggest that full sib material is tall and spindly compared to wild sources (an original concern of silviculture foresters).

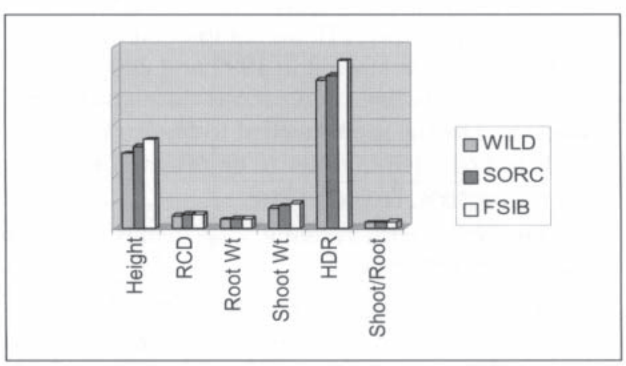


Figure 43. Relative Means of Measured Variables between Seed Sources.

There was no interaction between planting date and seed source, meaning that the sources displayed the same growth response regardless of plant date (Figure 48).

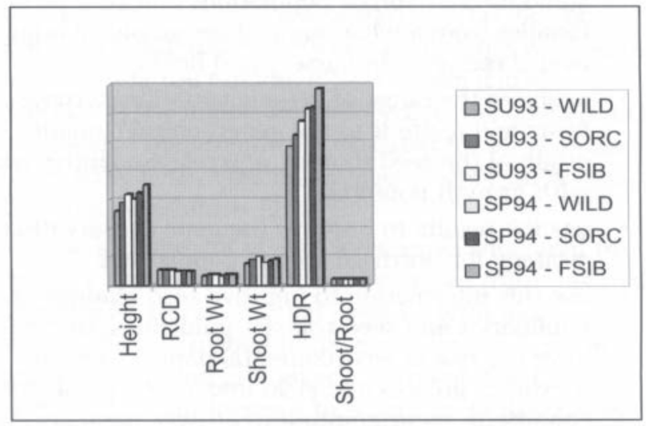


Figure 44. Relative Means of Measured Variables between Planting Date and Seed Source.

Conclusions

It appears that seed source plays the major role in the early growth of these seedlings. Further plant date has inconsistent affects among dependent variables. The absence of differences for root or shoot weight in this trial suggests the benefits of different plant dates can only be captured when specific site growth limiting factors are present. (SPU 1409)

2.3.45 Characterization of Adaptive Traits of Interior Spruce Populations From Northern B.C.

Sylvia L'Hirondelle, Wolfgang Binder, Greg O'Neill, and Barry Jaquish

This year we began a comprehensive adaptation study to examine the transferability of interior spruce stock in the Prince George seed-planning zone. Testing is needed to characterise adaptive traits of populations from a wide range of source environments and compare them with seed orchard progeny. This will help to verify elevational limits for class A seed, and the limits of seed transfer for class B seed. An improved understanding of the genetic variation in adaptive traits can significantly reduce the risk of damage from climate and microclimate extremes at the planting sites, and can increase growth and yield. This will help to deliver the best possible field performance from seed orchard progeny.

This information can also be used in developing a gene conservation strategy for northern spruce populations.

Our objectives for this study are to:

- characterize the adaptive and growth traits of wild stand interior spruce populations and seed orchard families from a wide range of geographical origins over three years in nursery and field trials,
- estimate the range of genetic variation in these traits and relate it to the geographical/climatic origin of the seed sources, and relate adaptive traits with growth potential,
- use the results to improve the gene conservation strategy for northern spruce populations.
- use this information to improve seed planning zone boundaries and seed transfer guidelines, to minimize the risk of environmental damage and to maximize growth and yield under a range of site conditions, by attempting to answer the following questions:
  a) Are the current seed planning zone boundaries reasonable for low-risk seed transfer?
  b) How many elevational bands (seed planning units) are needed in the Prince George seed planning zone, and what is the optimal location for the boundaries between SPUs?
  c) Do current breeding values for clones need adjustment based on new information from these tests?

One hundred forty-eight seedlots were selected to use in the study, from within and outside the Prince George Seed Planning Zone (PG SPZ).

Type	Number	Source
Class A from orchards	8	Two from each seed orchard for PG SPZ
Class A from breeding program	16	From the top families in the PG breeding program
Class B from PG SPZ	90	Selected from Seed Centre database
Class B from next to PG SPZ	24	From SPZ adjacent to PG, from Seed Centre database
Class B from south, sub-maritime	8	Other BC seedlots from Seed Centre database
Exotics	2	Seedlots from eastern North America

Table 30. Seedlot selections for characterization study, SPU 1411

Seed is being stratified and will be sown in spring 2002. Raised beds have been constructed to grow seedlings for short-term nursery tests of growth characteristics, phenology, frost hardiness, and other physiological traits. Field sites in the Prince George area are being selected for testing of seedlings at three elevations. Plans are in place for the sequence of testing that is scheduled to begin in September 2002.(SPU 1411)

2.3.46 Interior Cone and Seed Pest Management — Technical Support

Ward Strong

This project provided FTE for completion of several unfunded projects started in 1999 and 2000. These research projects had been carried through to cone collection, but the seeds needed to be extracted, X-rayed, and counted in order to determine the results of the experiments. Projects were:

a) soil drenches with systemic insecticides for control of seed orchard pests;

b) *Leptoglossus* damage potential on Sx and Pw;

c) Cone damage and seed reduction from larch adelgids;

d) spittlebug effects on Pli seedset.

The backlog of cones have all been extracted, seeds X-rayed, and empties and filled seeds counted. This provided about 0.44 FTE for auxiliary workers at Kalmalka. I'm now at various stages of entering the data, analyzing it, and writing reports for these projects. SPU 0715

2.3.47 Development of a Stratification Chamber for Western White Pine Seed

Dave Kolotelo

This project was withdrawn on August 29, 2001 as information from last years' Quality Assurance monitoring indicated that the 'problem' could be best addressed with modifications to our existing stratifiication techniques. The stratification "chamber" did not appear to be a wise use of resources based on our monitoring. Our current testing of 'new' techniques is ongoing with few results-to-date. SPU0810

2.3.48 Seed Sanitation Methodology for Amabilis fir.

Dave Kolotelo

This trial investigated seed sanitation treatments on six seedlots of Amabilis fir (Ba), two seedlots of grand fir (Bg) and two seedlots of subalpine fir (Bl). A 50-gram sample of each seedlot was treated with one of the six seed treatments presented in Table 31. The treatments with H_2O_2 were conducted after soaking (except T6) and the seed thoroughly rinsed following treatment. The Mycostop seed dressing is a biological control slurry composed of *Streptomyces* spp. Data was collected on the moisture content during stratification; resin vesicle damage rating after treatment and germination capacity (GC); incidence of *Caloscypha* (CAL%) and *Fusarium* (FUS%) following stratification.

Treatment	[H2O2]	Duration
T1 – Control	None	0
T2	3%	0.5 hours
T3	3%	2 hours
T4	3%	4 hours
T5	Mycostop	Seed dressing
T6	3% (pre-soak)	2 hours

Table 31. Treatments used to evaluate optimal seed sanitation methodology in *Abies* spp.

The overwhelming result of this seed treatment trial was the significance of the individual seedlots and their unique response to sanitation treatments. Significant Seedlot*Treatment interactions were found for resin vesicle damage and *Caloscypha*. For GC a significant interaction was not found ($p = 0.11$), but no significant differences between treatments were found either. Using the random effects model (PROC VARCOMP) the importance of Seedlot was obvious as it explained a majority of the variation for all variables: GC = 83%; Resin Vesicle Damage = 78%; *Caloscypha* = 85% and *Fusarium* = 86%.

Although treatment effects were small compared to seedlots some conclusion can be drawn from this trial. The general trend was that seedlots with more resin vesicle damage tended to have greater increases in damage following prolonged treatment. For Ba, there was a significant increase in resin vesicle damage by extending H_2O_2 treatment duration from 0.5 to 4 hours. This extension also resulted in a reduction in GC in Ba from 72 to 66%. Although the results were not statistically significant for Bg and Bl, one seedlot of each species showed increased damaged with increased durations of treatment. To be cautious it is recommended that *Abies* spp. should not be treated for more than two hours with 3% hydrogen peroxide.

The lack of a strong treatment effects on GC does not negate the importance of seed treatments it just illustrates that the selected seed sanitation treatments appear to have a small impact on the GC (i.e. no deleterious effects, but no benefit of the attempted seed sanitation treatments on GC).

For *Caloscypha* the contamination level varied considerably by seedlot ranging from 0.0% to an average of 26.2% for Bg 39215. For all seedlots the Mycostop treatment resulted in the lowest *Caloscypha* levels. This was unexpected as the Mycostop was expected to have a greater impact on the fungi contaminating the surface of the seeds (i.e. *Fusarium*) compared to the fungi infecting the seed (*Caloscypha*). Compared to the control, Mycostop treatment resulted in a 3% reduction in GC. Mycostop therefore shows some promise as a pre-stratification treatment for seedlots infected with *Caloscypha,* but there is a small cost in GC.

The results of *Fusarium* do indicate a Seedlot Treatment interaction although this could not be tested due to a lack of replicate data. The use of H_2O_2 reduced *Fusarium* in some seedlots, but in other cases the four-hour treatment actually increased the *Fusarium* contamination level. The Mycostop treatment did not control *Fusarium* very well, especially with seedlots exhibiting high Control levels of this pathogen.

Conclusions:

Although the results are not consistent across seedlots and one cannot recommend a universal seed sanitation treatment for *Abies* seedlots the following are general guidelines for the use of seed sanitation in *Abies* spp.

- The results of hydrogen peroxide treatment vary by seedlot and implementation should be used with caution and preferably when one knows that a disease problem is present during stratification or in the nursery based on historical records.
- The use of 3% hydrogen peroxide seed treatments generally has no impact on seed germination.
- Hydrogen peroxide treatments (3%) for *Abies* spp. should not exceed 2 hours in duration as this may result in increased resin vesicle damage.
- Hydrogen peroxide treatments (3%) should be performed after the initial 48-hour soak that is used for *Abies* spp.
- The Mycostop biological treatment appeared promising as a control for *Caloscypha*, but results were not promising with *Fusarium*. A 3% decrease in GC was estimated by the use of Mycostop. (SPU0903)

2.3.49 Temporal and Spatial Stability of Spruce Families from VSOC Orchard #214 at the Nursery and in the Field.

Russ Martin

Crop variability has been a significant concern for nurseries producing seedlings from orchard spruce. Results from VSO #214 family characterization have shown that nursery growth rate has a high level of stability within a family over several cone picks and throughout different nurseries. Creation of seedlots in the past has not been on the basis of how families grow in the nursery, which has created high levels of variability in nursery crops. The results of this trial allow for an approach toward bulking strategy that reflects the differences in nursery growth rate between the families. This will reduce the likelihood that genetic culling is taking place, while providing a greater opportunity for a more uniform crop to target specifications.

Characterization of the families has also shown that several families have problems with germination capacity to the point where overall bulked seedlot germination is only 90%, instead of the target of 96%, the level at which nurseries would single-sow. Roguing the poor-germinating families from the orchard is not a solution, as this removes some of the best plantation performers. Family characterization shows that family germination capacity is reasonably stable between pick years and growing facility. This information will be used to attempt to increase the seed quality to a single sow level. This helps to maintain the genetic integrity of the population while improving seed quality. Improving seed quality will also translate into dollar savings as less seed is required to produce a given amount of seedlings.

There have been expressed concerns that some families may be affected worse than others by damaging agents such as frost, when outplanted. Initial results of field characterization of families indicate that there is no strong correlation between family and terminal bud damage, when replicated across a number of sites and field conditions. Families with high levels of abnormal bud flushes at one site do not consistently have high levels of abnormal bud flushes at other replicated sites. (SPU 1410)

2.4 Extension and Communications

2.4.1 Tour of Research Plantations Demonstrating The Positive Progress Of The B.C. Tree Improvement Program.

Don Summers

On October 25th 2001, a field tour was organised to visit three research and demonstration installations. These were located near the centres of Mission and Maple Ridge. Two of the sites were planted with coastal Douglas-fir. The other site was a western hemlock and yellow-cedar progeny trial.

Figure 45. Spreading the word of progress with 'seedusers'

Thirty-one people participated on the tour and both formal and informal speakers presented information at each of the stops. Participants include a good cross-section of "seed-users" including nursery owners/ managers, MOF District staff, MOF tree-breeders, seed orchard managers, local industry personnel, Mission TFL staff, UBC Research staff, consultants and a BCIT lecturer with students.

Discussion regarding installation design, height, diameter and volume data, volume projections based on the data and cost of the volume occurred at each of the sites.

Figure 46. More progress

A report based on the questions, answers and discussions that took place during the tour was completed and submitted under the ETAC project. ES 0040.

Photos taken during the tour, courtesy Don Summers, TIB – Green Timbers. (ES 0011)

2.4.2 Tour To Operational Plantations That Demonstrate The Positive Progress Of The B.C. Tree Improvement Program.

Laughlan Glen

The goal of the project was to initially prepare a list of operational plantations that may demonstrate the success of the Fdc Tree Improvement program. Success would be gauged by the height and diameter of plantations established using A-class seed relative to those established from local seed sources.

The Chilliwack District ISIS (Integrated Silvicultural Information System) was used to identify forty-two sites where both A- and B- class seed were used to establish plantations.

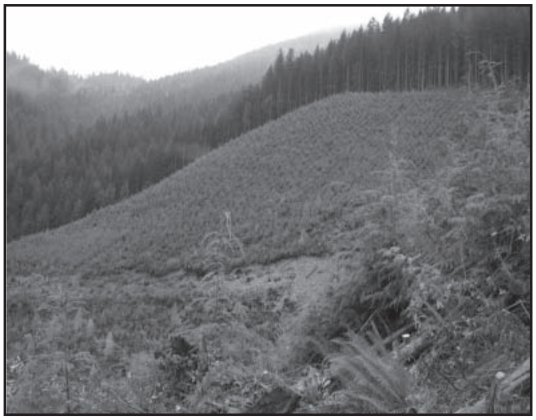


Figure 47. A plantation viewpoint on the tour

However, in the end, due to incomplete information with regard to stocktype, fill-planting, brushing frequency uncertainty of exact stock location within the site and inaccessibility, the proposed tour was cancelled.

The quality of operational information presently being collected for operational Fdc plantations in the Fraser Valley TSA is inadequate to confidently demonstrate the positive effects of the B.C. Tree Improvement program.

A recommendation was made to establish a program of operational trials designed to exclude extraneous factors such as nursery culture, stocktype, and various silvicultural operations from such a comparison. ES0012

2.4.3 Extension Workshops Tree Improvement

Diane Gertzen

A pilot Tree Improvement/Forest Genetics workshop entitled "Seed Planning, Policy and Programs in British Columbia" was held March 15, 2000 in Nelson with 54 people attending. Since then, additional workshops have been held in:

- Prince George, February 27, 2001 - 62 in attendance
- Smithers, March 1, 2001 - 42 in attendance.
- Williams Lake, February 19, 2002 - 34 in attendance
- Kamloops, February 21, 2002 - 58 people in attendance.

Attendees represented forest regions, forest districts, and licensees in the region as well as forestry consultants.

These workshops provided a brief history and current overview of forest genetics, seed transfer guidelines, seed supply and production and gene conservation in British Columbia. Seed from selected sources is produced in seed orchards throughout the province, and represents about 43% of provincial sowing needs.

The workshops were organized by Diane Gertzen and facilitated by Dave Trotter. Jack Woods gave an overview of Tree Improvement in B.C.. Barry Jaquish discussed his Interior Spruce, Western Larch & Interior Douglas-fir programs. Mike Carlson gave presentations on his Lodgepole Pine program, Gene Conservation/ Diversity and Genetic Worth. Ron Planden's presentation was on Tree Improvement and the Spatial Frontier; i.e. seed maps and future seed access.

Mike Madill, Anna Monetta, Gerry Pinkerton, Nola Daintith and Rocky Hudson discussed their specific regional seed supply and Tim Lee and David Reid gave presentations about provincial seed orchard development and seed production. Eric Wang provided a presentation on the impact of the seed orchard program on timber flow in the Arrow TSA at the Prince George workshop only.

Workshops like this promote a better understanding of select seed use and advantages, especially as its use relates to AAC and forest productivity. (ES0022)

2.4.4 Select Seed Workshop

Eric van Steenis, Dave Kolotelo, Dave Trotter, Diane Gertzen, and Michael Peterson.

Activities:

In November 2002, separate seed workshops were held in Prince George, Summerland, and Surrey, British Columbia.

Individual workshop objectives were:

- To update field foresters and nurseries on the impact of and changes to, the new SPAR seed sowing guidelines for 2002. Impacts were mainly in terms of increased seed use efficiency relative to seedlot germination capacity.
- Discuss the spreadsheets used to generate the sowing guidelines and provide these electronically as an industry ready version to anyone desiring to generate their own sowing guidelines. This could be either for seed owned as a licensee or for specific nursery seed sowing situations.
- To review species specific seed physiology and

stratification techniques.

- To review and provide solutions to seed pest problems originating from cone collection through to nursery sowing
- To provide a hands-on review of seed pest and disease problems in a laboratory setting.
- To provide results of current operational research being carried out at the B.C. Ministry of Forests Tree Seed Center in Surrey.
- Provide an overview of the influence of temperature on seed germination in the nursery.

The overall workshop objective was to increase conifer seed use efficiency through an understanding of seed biology/physiology in general, and an appreciation of the physics/biochemistry/economics of seed sowing and germination in the nursery.

The workshops were very well received with in excess of 100 individuals participating. Over 50% of these were industry and ministry field foresters wishing to increase their understanding of seed and seed issues. It is anticipated that similar workshops could be held successfully on a semi-annual basis. (ES0023)

2.4.5 The Reproductive Biology of Western White Pine

John N. Owens

From 1984 through 1986 five booklets were written covering the reproductive cycles of Lodgepole pine, Interior spruce, Western and Mountain hemlocks, Red and Yellow cedars, and the three *Abies* species native to B.C. These were printed twice and are now out of print and out of date. These were widely used by breeders and seed orchard staff in B.C. and other regions where these species occur or have been planted. Much new information has accumulated over the past 20 years regarding cone induction, pollination mechanisms, fertilization and embryo development and factors affecting embryo, seed and cone production in native stands and seed orchards. No booklets were done on Douglas-fir, Western white pine or larch species. With the rapid advancement of breeding programs and establishment of seed orchards with the goal of producing much larger quantities of Class A seed by the year 2007, there is a need for concise well illustrated booklets on all of our commercially important species.

The booklet being written this year is “The Reproductive Biology of Western White Pine” because it is potentially a very important commercial species, extensive work on rust resistance is being done and breeding programs and seed orchards are being established. There has also been a lot of new information on the reproductive biology of the species. The booklet will be completed by March 31, 2002 and will be about 35 double column pages with about 60 illustrations made up of high quality colour and black and white photographs, diagrams, graphs and tables. The photographs are of trees, cones, seeds, buds and light and electron micrographs of reproductive structures and stages of development. Diagrams are kept simple and show the internal structure and development of buds, ovules, seeds and embryos. The text is brief and kept simple with a minimum of technical terms.

Topics covered include: Distribution and Taxonomy, Economic Importance, The Reproductive Cycle, Shoot and Bud Development, Pathways of Bud Development, Identification of Buds, Cone Induction and Enhancement, Pollen-cone and Pollen Development, Seed-cone Bud and Ovule Development, Fertilization, Cytoplasmic Inheritance, Embryo Development, Seed Development, Cone Maturation, Seed Release and Regeneration, Seed Extraction, Handling and Germination, The Seedling, Summary, Glossary of Terms, and Selected References. ES0025

2.4.6 “Seed Supply Profile” Component of Extension Materials to Support TSA Committee Outreach.

Jordan Tanz

This project developed a prototype “Seed Supply Profile” for one TSA. The seed supply profile would describe the seed supply for the TSA by presenting and explaining the FGC Business Plan information for the SPUs in the TSA. It would summarize projections of plantables and expected genetic gain for the TSA, and describe who operates the orchards, who owns the seed, and expectations for future seed availability. The project deliverables are a “presentation kit” including PowerPoint presentation and supporting printed materials, and a report in print format that could also be deployed on the FGC web site. The PowerPoint presentation will be designed for use by the Program Manager in presentations to TSA Steering Committees. (ES 0027)

2.4.7 "Delivering Genetic Gain" Component of Extension Materials to Support TSA Committee Outreach

Jordan Tanz

The presentation materials developed in this product explained how timber supply analysis in the Timber Supply Review, including genetic gain, is used in the AAC determination process, and how AAC benefits can be realized from using improved planting stock. This information is generic in the sense that it will be relevant to all TSAs. The project deliverables are a "presentation kit" including PowerPoint presentation and supporting printed materials, and a report in print format that could also be deployed on the FGC web site. The PowerPoint presentation will be designed for use by the Program Manager in presentations to TSA Steering Committees. (ES0028)

2.4.8 Communication Products on Benefits of Improved Reforestation Materials.

Melissa Hadley

The purpose of this project was to produce communication products on thebenefits of improved reforestation materials. These include an FGC extension note on the topic, an article based on the extension note for submission to a journal such as the Forestry Chronicle and, as budget permits, the design and layout of a new panel for the FGC display unit. The extension note discusses improved reforestation materials — what they are, how they are developed and used in British Columbia, and why. It notes the types of benefits associated with the use of improved reforestation materials, and how these advantages might be enhanced in the future. (ES 0031)

2.4.9 Field Guide to Reproductive Biology for Western White Pine

Vivienne Wilson & Patrick Von Aderkas

The intent of this booklet on western white pine is to act as an information resource for technical staff, teachers and anyone who needs concise and basic information presented in an accessible format.

We have divided the booklet into the following sections: introduction, phenology, reproductive biology and technical applications.

We have completed the text in the following areas:

- introductory section, including an overview of the breeding program
- reproductive biology, including male and female cone development,pollen quality and storage
- technical applications, including the effects of: temperature on development, SMP, thinning and topping, fertilizer an water application and cyclical cone production.

The text for these sections is currently being edited and formatted. A section on future research directions is being added to highlight the scope of current research initiatives.

Considerable effort is being put into providing informative illustrations for this booklet, while considering the printing cost of reproducing photographs in the text. After consultation with Dr. Job Kuijt at the University of Victoria, we have decided that line drawings made from material collected and photographed during the cone development season in western white pine will provide the greatest detail. Line drawings will allow us to highlight important anatomical information, and the reduced printing cost will ensure that we can provide as many illustrations of key development processes as possible.

The two sections of the book that will use line drawings are:

- a graphical representation of the phenology of western white pine, that will use line drawings to illustrate various cone developmental stages. Please note that the format of this phenology is being developed exclusively for this booklet, and we hope that this can become the basis for similar phenologies in other species.
- a step-by-step illustration and description of the receptivity stages in the female western white pine cone, emphasizing anatomical features which identify times of pollen capture and uptake by the female cone.

The reference images for the line drawings have been collected, and the drawings themselves will be completed over the next two months. ES0036

2.4.10 Display Kiosk for Tree Improvement Information at Cowichan Lake Research Station. (ETAC)

Don Carson.

The ETAC subcommittee awarded funding to Don Carson, the Manager of Cowichan Lake Research Station, to install a display kiosk and develop posters that will provide information on tree improvement activities at the station.

Figure 48. Display Kiosk being installed.

The kiosk has been installed (Figure 52) and the posters are currently being laminated for weatherproofing, before being displayed. This work will be completed by the end of the fiscal year. (ES0010)

2.4.11 Production of the Seed Handling Guidebook

David Kolotelo, Eric Van Steenis, Michael Peterson, Robb Bennett, Dave Trotter, and John Dennis

The guidebook is 106 pages in length with 101 colour figures and 14 tables. It covers the introductory topics of seed condition, cone and seed insects and seed fungi and then fully covers the seed handling system. This spans all activities from cone collection to the sowing of seed in the nursery. Most of us deal with only part of this seed handling system, but it is important to understand the full spectrum of seed handling activities. Poor handling by others at any previous or subsequent stage may negatively impact your product.

The guidebook is intended for use by individuals who handle cones and seeds and by those who would benefit from an integrated view of seed handling. The guidebook focuses on conifers of the Pacific Northwest, but principles are applicable to most conifers. The intent is to provide readers with information on seed handling with an emphasis on:

- Guidelines for proper seed handling
- The tools required to recognize seed problems
- Techniques for avoiding or correcting seed problems.

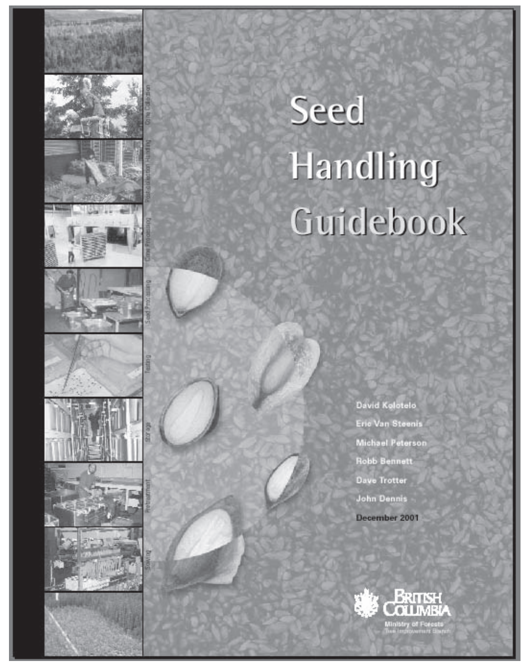


Figure 49. Front cover of the guide

An additional section on the germination microenvironment and its manipulation is also included. If you have not received a guidebook please contact Dave Kolotelo for information on obtaining a copy (1-604-541-1683 ext. 228).(ES0039) Dave.Kolotelo@gems7.gov.B.C..ca.

2.4.12 Report From the October 25th, 2001 Field Tour to Demonstrate the Results of the Coastal Douglas-fir Tree Improvement Program In B.C.

Lauchlan Glen

As a follow-up to the field tour organised under ETAC ES 0011, sixteen of the participants were contacted in order to record the questions, answers and discussions that took place between the participants on the tour.

These participants comprised a good cross-section of the interests represented on the tour.

A report based on the opinions voiced by these participants was submitted. This may provide future guidance to those working in forest gene resource management and extension as it tries to identify the apparent needs of some "seed-users". (ES 0040)

2.5 Seed Planning and Information Tools

Leslie McAuley and Susan Zedel

The Seed Planning and Information Tools sub-program in the 2001/2002 fiscal year continued to oversee the development of two web-based applications: SPAR Web and SeedMap. In addition, a new database systems analysis project was initiated to identify key business and data requirements for the management of information required for orchard licensing and seed and vegetative lot registration certification.

Projects carried out in the 2001/2002 fiscal year included:

- **SPAR** (Seed Planning and Registry system) is being converted from the existing mainframe application and database to a web-based application and Oracle database.
- **SeedMap**, a new web-based mapping system, will provide tree improvement clients (ministry and non-ministry) with access to seed planning maps and associated spatial and attribute data summary reports.
- **MS Access Database**, developed as a co-op project, with the primary goal of identifying key data and business requirements for the management of information required (i.e. parent trees, breeding values) for meeting technical standards for licensing and seed and vegetative lot registration.

SPAR Web Application

The primary objective of the SPAR (Seed Planning and Registry system) web application development project (SPAR Web) is to convert the existing Ministry of Forests IBM VM mainframe application and database to a web-based application and Oracle database. SPAR Web will provide a more intuitive and user-friendly interface to SPAR functions (e.g. seedling request ordering, tree seed registry and reporting) than that of the existing SPAR VM mainframe application. SPAR users will access the system via their web browser software (e.g. Internet Explorer). SPAR users will have direct access to a broad range of reports available in various reporting formats, including Adobe pdf, html, MS Word and MS Excel.

The SPAR Web application development is a multiple phase project.

Phase 1 was completed in September 2001 and includes the conversion and development of:

- SPAR data model from the existing format to an Oracle Designer format;
- VM database to Oracle 8I;
- Search functions;
- On-line seedlot and vegetative lot screens; and,
- Seedlot and vegetative lot reports and data extracts.

Phase 2 is due for completion on March 30, 2002 and includes the development of:

- Transfer guideline routines, suitable seed & vegetative lot searches, seedling request entry, update and approval;
- Direct withdrawals, cone and seed processing requests, seed sale requests, testing requests and other request types;
- Seedling request reports and data extracts; and,
- Copy management process for data transfer (from/to) the Cone and Seed Processing system (CONSEP).

Phase 3 is due for completion by September 2002, in time for the 2003 seedling request season and includes the development of:

- Table maintenance screens and listing reports;
- Seedling tender and nursery assignment screens and reports; and,
- Tree Seed Centre client functions and billing for services and seed sales.

Testing of the new SPAR Web application will be conducted by the SPAR user test group in Spring, 2002. Existing and new SPAR Web users will be assigned Extranet User ID's and passwords to access the new application.

The B.C. Forest Genetics Council and the Ministry of Forests are project sponsors for the SPAR Web systems development project. The ministry project lead is Susan Zedel, Tree Improvement Branch, Ministry of Forests. The Information Management Group, Ministry of Forests, is providing the technical guidance required for the SPAR database conversion, the web application development, and the web security infrastructure. Pangaea Systems Inc., of Victoria, B.C., is under contract for the SPAR Web software development.

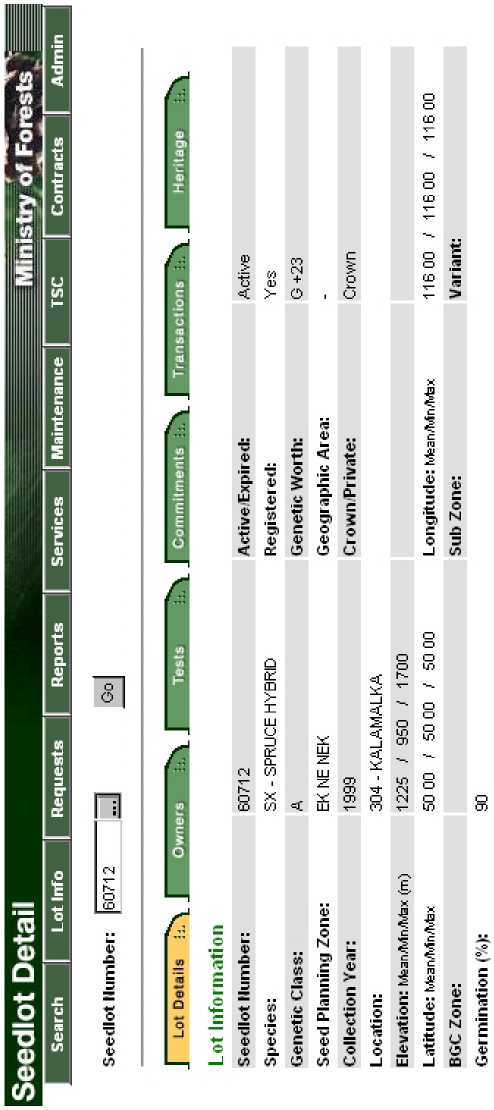


Figure 50. Example of a portion of the Seedlot Detail screen on the new SPAR Web Application.

SeedMap

SeedMap will provide tree improvement clients with the necessary tools for assessing current and projected seed needs, developing appropriate cone collection and seed supply access plans, identifying areas for orchard expansion and carrying out sound forest practices.

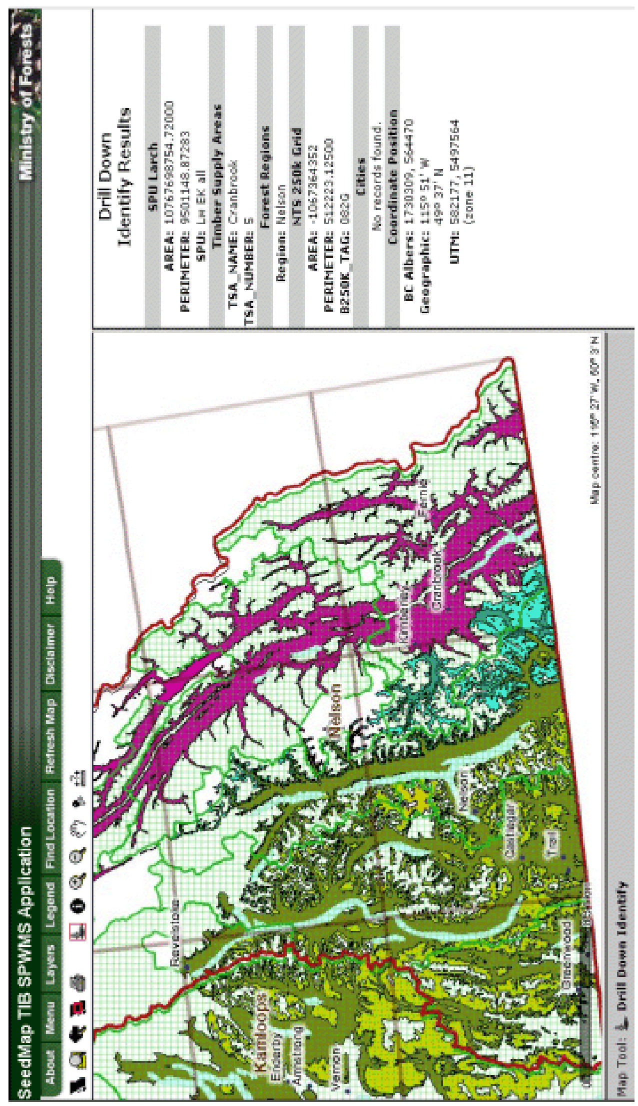


Figure 51 Example of a SeedMap screen where the spatial layers for a specific map location are identified.

SeedMap will also provide the ability to integrate seed planning with other resource management initiatives such as land use planning, timber supply reviews, strategic silviculture planning, forest certification and gene conservation programs.

SeedMap will enable clients to select multiple reference map layers (e.g. SPZ's/SPU's, BEC, TSA/ TFL, Region/

District) and view them on-line or as printed 8°” x 11” maps. Map themes, specific to seed planning, will also be available for quick look-up. Summary reports (e.g., Species Plan timelines, seed use, genetic gain, and inventory) based on current (SPAR) and projected (Species Plan) data will also be available through a report menu option or as a spatial query detail report.

The SeedMap application will be accessed directly through a client’s Internet web browser. Non-ministry clients will access SeedMap using an Extranet User ID. SeedMap will be available for client user group testing in Spring, 2002. A direct link to the new SPAR Web application is also planned (SPAR Web, September, 2002).

The B.C. Forest Genetics Council is the project sponsor for the SeedMap systems development project. Joint funding is provided by the Ministry of Forests and Forest Renewal B.C.. The ministry project lead is Leslie McAuley, Tree Improvement Branch. Esri Canada Ltd., Victoria, B.C. is developing the ARC IMS web-based mapping software for SeedMap.

MS Access Database project

A database systems analysis project was initiated to identify key business requirements for the data capture, transfer, storage and reporting of parent trees (PT’s) and their associated information (i.e. breeding values (BV’s). The focus of this project was to build an MS Access database that would link parent tree, orchard, seed planning zone/unit and seedlot data together to facilitate PT and BV validation required for orchard licensing and seed/vegetative lot registration certification. This project was administered as a six-month co-op work term with employment filled by a student from a computer science & technology program.

The B.C. Forest Genetics Council is the project sponsor for the MS Access Database development project. Funding was provided by Forest Renewal B.C.. The ministry project lead is Leslie McAuley, Tree Improvement Branch.

Appendix 1

Tree Species Names and Abbreviations

Conifers

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	P1
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 2

Page References of Articles by Tree Species

Unit #	Species	Planning Unit and Elevation
1	Douglas-fir	Maritime Low (south) (<700m)
2	Redcedar	Maritime Low (0-600m)
3	Western hemlock	Maritime (0-600m)
4	Interior spruce	Nelson Low (<1300m)
5	Interior spruce	Nelson High (1300-1700m)
6	Sitka spruce	Maritime All (0-750m)
7	Lodgepole pine	Nelson Low (<1400m)
8	White pine	Coast (<1000m)
9	Amabilis fir	Maritime (<700m)
10	Lodgepole pine	Thompson Okanagan Low (<1400m)
11	Yellow-cedar	Maritime (<1200m)
12	Lodgepole pine	Prince George Low (<1100m)
13	Western larch	Nelson Low (<1300m)
14	Interior spruce	Prince George Low (<1200m)
15	White pine	Kootenay/Quesnel Low (<1400m)
16	Lodgepole pine	Thompson Okanagan High (>1400m)
17	Lodgepole pine	Bulkley Valley Low (<1100m)
18	Lodgepole pine	Central Plateau Low (<1000m)
19	Douglas-fir	Sub-Maritime Low (200-1000m)
20	Lodgepole pine	Nelson High (>1400m)
21	Douglas-fir	Nelson Low (<1000m)
22	Douglas-fir	Nelson High (>1000m)
23	Interior spruce/Sitka spruce	Sub-Maritime/Nass-Skeena Transition (All Elevations)
24	Western hemlock	Maritime High (>600m)
25	Interior spruce	East Kootenay Low (<1700m)
26	Lodgepole pine	Prince George High Elevation (>1100m)
27	Redcedar	Sub-Maritime (200-1000m)
28	Interior spruce	Thompson Okanagan High (1300-1850m)
29	Lodgepole pine	East Kootenay High (>1400m)
30	Interior spruce	Thompson Okanagan Low (<1300m)
31	Douglas-fir	Maritime High (700+m)
32	Lodgepole pine	East Kootenay Low (<1400m)
33	Redcedar	Maritime High (600+m)
34	Western larch	East Kootenay Low (800-1500m)
35	Interior spruce	Bulkley Valley Low (<1200m)
36	Grand fir	Maritime Low (0-700m)
37	Douglas-fir	Quesnel Lakes (All Elevations)
38	Western hemlock	Maritime Low North (Merged)
39	Douglas-fir	East Kootenay (All elevations)
40	Interior spruce	Peace River Low (<1200m)
41	Douglas-fir	Prince George (All Elevations)
42	Interior spruce	Prince George High (>1200m)
43	Douglas-fir	Cariboo Transition (All Elevations)

Contributor	Affiliation	Phone #
Aitken, Sally	UBC	604-822-6020
Alfaro, Rene	CFS	250-363-0604
Ashley, Valerie	MoF	250-260-4753
Bates, Sarah	SFU	604-291-4163
Bennett, Robb	MoF	250-652-6593
Berger, Vicky	MoF	250-260-4758
Binder, Wolfgang	MoF	250-952-4136
Bird, Keith	MoF	250-749-6811
Borden, John	SFU	604-291-3646
Brown, Patti	CFP	604-885-5905
Browne-Clayton, Shane	Riverside	250-762-3411
Carlson, Michael	MoF	250-260-4767
Carson, Don	MoF	250-749-6811
Cartwright, Charles	MoF	250-387-6477
Cox, Keith	MoF	250-835-4541
Crowder, Tim	TFL	250-652-4211
Dennis, John	MoF	250-363-0684
Draper, Dale	MoF	250-356-9276
El-Kassaby, Yousry	UBC	604-822-1821
Fleetham, Carole	MoF	250-963-8416
Gertzen, Diane	MoF	250-930-3309
Giampa, Gary	MoF	250-549-5576
Glen, Lauchlan	Contractor	604-826-4721
Graham, Hilary	PRT	250-546-6713
Hadley, Melissa	FGC	604-885-4050
Hak, Oldrich	Contractor	250-727-3989
Hawkins, Chris	UNBC	250-960-5614
Heeley, Tia	PFC	250-363-0648
Hooge, Bonnie	MoF.	250-963-9651
Jaquish, Barry	MoF	250-260-4766
Kermode, Alison	SFU	604-291-3982
King, John	MoF	250-387-6476
Lee, Tim	VSOC	250-542-0833
L'Hirondelle, Sylvia	MoF	250-356-6902
Macdonald, Robert	Ramsoft Systems.	250-389-6221
Martin, Russ	MoF	250-962-3583
McAuley, Leslie	MoF	250-356-6208
Mehl, Helga	MoF	250-952-4172
Meier, Michelle	CFS	250-363-0648
Mitchell, Ken	MoF	250-387-6673
Morrow, Gordon	MoF	250-757-2015
Murphy, John	MoF	250-260-4754
Newton, Craig	BC Research	604-224-4331
Nicholson, George	Riverside	250-546-2293
O'Neill, Greg	UBC	604-822-1845

Contributor	Affiliation	Phone #
Owens, John	UVic	250-721-7113
Painter, Roger	MoF	250-356-9276
Peterson, Michael	Contractor	250-478-8358
Piggott, Don	Yellow Point	250-245-4635
Pomeroy, Norm	MoF	250-749-6811
Ritland, Kermit	UBC	604-822-8101
Rudolph, Dan	MoF	250-652-5600
Russell, John	MoF	250-749-6811
Ryrie, Lynette	MoF	250-260-4772
Stoehr, Michael	MoF	250-356-6209
Strong, Ward	MoF	250-549-5696
Summers, Don	MoF	604-930-3301
Tanz, Jordan	FGC	250 360-1492
Trotter, Dave	MoF	604-930-3303
Van Neijenhuis, Annette	WFP	250-652-4023
Van Steenis, Eric	MoF	604-930-3303
Von Aderkas, Patrick	UVIC	250-721-8925
Walden, Dave	MoF	250-260-4757
Walsh, Chris	MoF	250-260-4777
Webber, Joe	MoF	250-952-4123
Wigmore, Bevin	Contractor	250-748-0357
Wilson, Vivienne	UVIC	250-721-7114
Ying, Cheng	MoF	250-387-3976
Zedel, Susan	MoF	250-356-1598

Back Cover Interpretations

The interior spruce gene resource management program is the oldest program in the BC Interior. Initially, in the early 1960's small provenance tests were established near Prince George and Smithers. The tree improvement program was established in two phases. Phase one began in 1967 and focused on three zones. Phase two began in 1973 and focused on 16 small zones. Over time, and as test results became available, these small seed zones were consolidated into six large zones. In total, more than 2,600 mostly open-pollinated families have been planted on 79 test sites throughout the Interior. Nearly 500 full-sib families from the first phase program have been planted on nine second-generation progeny tests in three zones. Presently, seed orchards for all but one seed zone are in full production. Ongoing research projects to support the program includes screening of families from the natural range of white spruce, developing trees resistant to white pine weevil, studying genetic variation in important wood properties, and field-testing emblings from somatic embryogenesis programs.

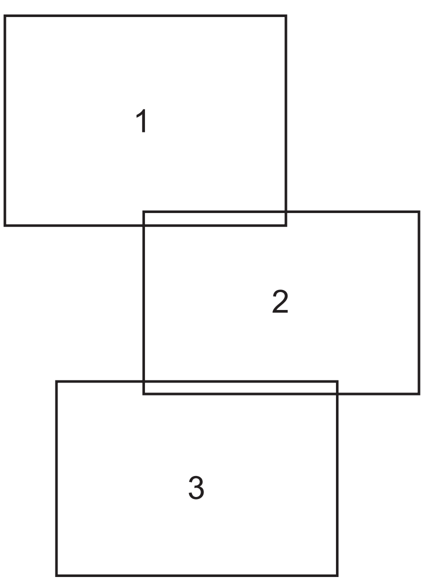
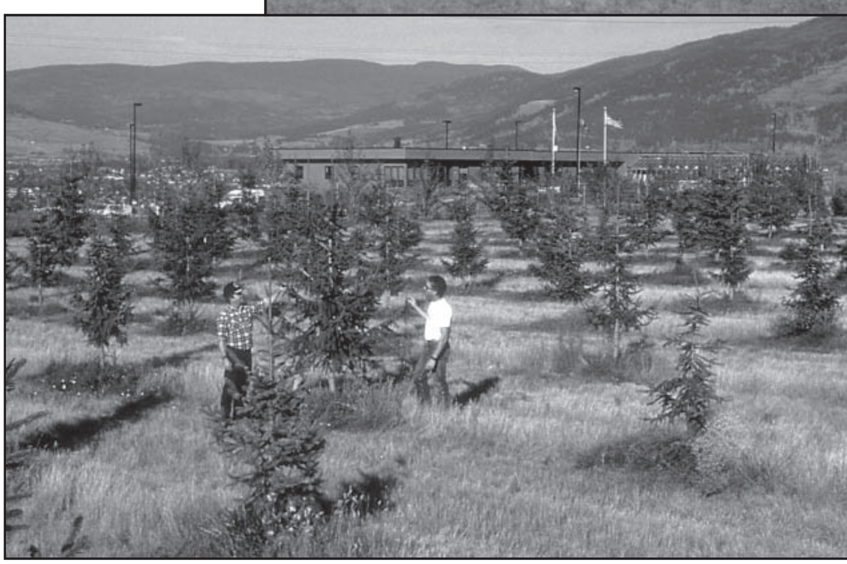


Plate 1. Breeding interior spruce. Controlled crossing among select parents from the new Prince George seed planning zone is in progress to produce full sib seedlings for second-generation selection. Progeny tests are expected to be established in spring of 2004.

Plate 2. About 12,000 white pine weevils (*Pissodes strobi Peck*) are released onto individual trees in a full sib progeny test at Kalamalka Forestry Centre to study the genetics of weevil resistance in Interior spruce.

Plate 3. A young interior spruce seed orchard in the Okanagan. Spruce orchards in this area regularly produce large cone crops.



BRITISH
COLUMBIA

FGC