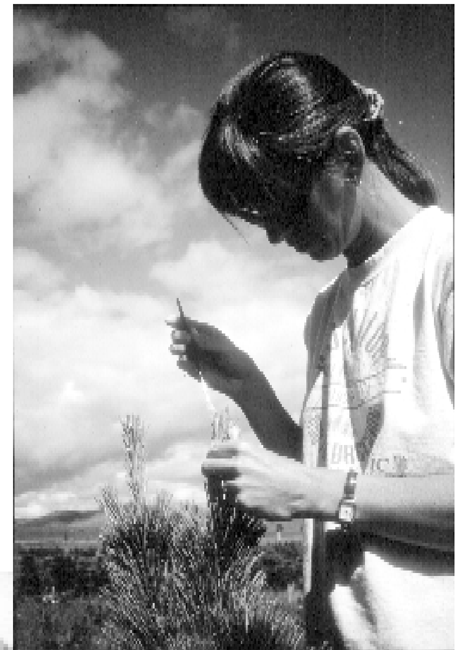
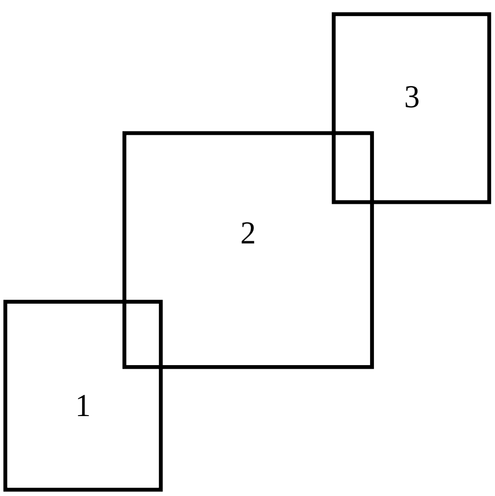
Forest Renewal BC Operational Tree Improvement Program



Project Report 1998/99



Front Cover Photos Interpretations

Photo #1 — Keith Cox of Skimikin Seed Orchard near the edge of the Ponderosa pine provenance trail Plantation at the orchard site. Seventy-three seed sources (31 BC, 42 U.S.) were planted in 1992 at the “mesic” Skimikin and “xeric” Grandview Bench sites. Results across these very different test environments suggest that ponderosa is an “intermediate” in genecological specificity i.e., seed sources can be transferred over a reasonable range of elevation and moisture regime (different from source) with minimal dangers of maladaption and growth loss.

Photo #2 — John Murphy of Kalamalka Forestry Centre (KFC) standing at the edge of the Cripple Lake Interior lodgepole pine progeny test plantation planted in 1987. This is one of three test sites in the Central Plateau Seed Planning Zone that has provided growth and adaptedness data for roguing the selected base population down to 45 seed orchard parents. Vernon Seed Orchard Company has planted, and manages, the Central Plateau orchard with a production goal of 6-7 million seedlings by the year 2005, with an estimated genetic gain in rotation age wood volume of 10%.

Photo #3 — Lynette Ryrie of Kalamalka Forestry Centre pollinating a white pine female strobilus in the KFC breeding arboretum. Fifty white pine tested/selected parent clones from the US breeding program are grafted at the BC Ministry of Forests (MoF), Kalamalka Seed Orchards, Bailey Site (est. 1995). Each parent exhibits one of four different blister rust resistance mechanisms, and Lynette is intercrossing parents so as to create families with different mechanism combinations for future testing/selection/improvement. The Bailey orchard is expected to provide seed/seedlings with *65-70%* blister rust tolerance, and should be in full production (IMM seedlings) by about 2006.

Forest Renewal BC Operational Tree Improvement Program

Project Report 1998/99

Coordinated and compiled by:

Mike Crown, Reports Unlimited
and Roger Painter,
Tree Improvement Program

British Columbia Ministry of Forests

Acknowledgements

This report sees the Operational Tree Improvement Program (OTIP) continuing to expand after two years of investment. During that time, the tree improvement community has come a long way. The Forest Genetics Council has restructured itself (with a new name), and provided considerable leadership and direction. It has developed a provincial Business Plan to meet the goals and priorities established for tree improvement and the OTIP. Through the hard efforts of Janet Gagne at Forest Renewal BC, the Council has worked to create an investment plan that will expand and provide a truly province-wide program. The Technical Advisory Committees have also taken on greater emphasis by providing detailed species plans in order to give clear direction for investments. They have also provided review committees that have performed technical evaluations for the funding proposals.

Again, my thanks goes to the Project Leaders who have made time in their busy work schedules to write-up their parts of the Report. For the most part this is their Report and their opportunity to provide us with a view of their accomplishments. Asking for contributions never comes at an opportune moment, particularly as our industry prepares for the spring, the most intense part of our year. I would also like to recognize the work of the editorial review team, Michael Stoehr, Patti Brown, Oldrich Hak and Ron Planden for cleaning up our presentations. Thanks also to Mike Crown and his team for compiling this Report.

A special thanks to Mike Carlson for providing the material for the front and back covers. We wanted to showcase one of the many programs in tree improvement and give a visual display of the projects and the people who do the work. Mike is a driving force in the Interior and we feel he is an excellent first choice for this approach.

It's been a most productive year. Considerable work has been completed and indications are that the coming year will offer even greater possibilities. Thanks to all participants in the OTIP during the last year for their patience and understanding. We will continue to work on the nuts and bolts of the program to make it as efficient and manageable as possible.

Good luck with the coming year.

Roger A. Painter
Tree Improvement Coordinator
Forest Genetics Council

Introduction

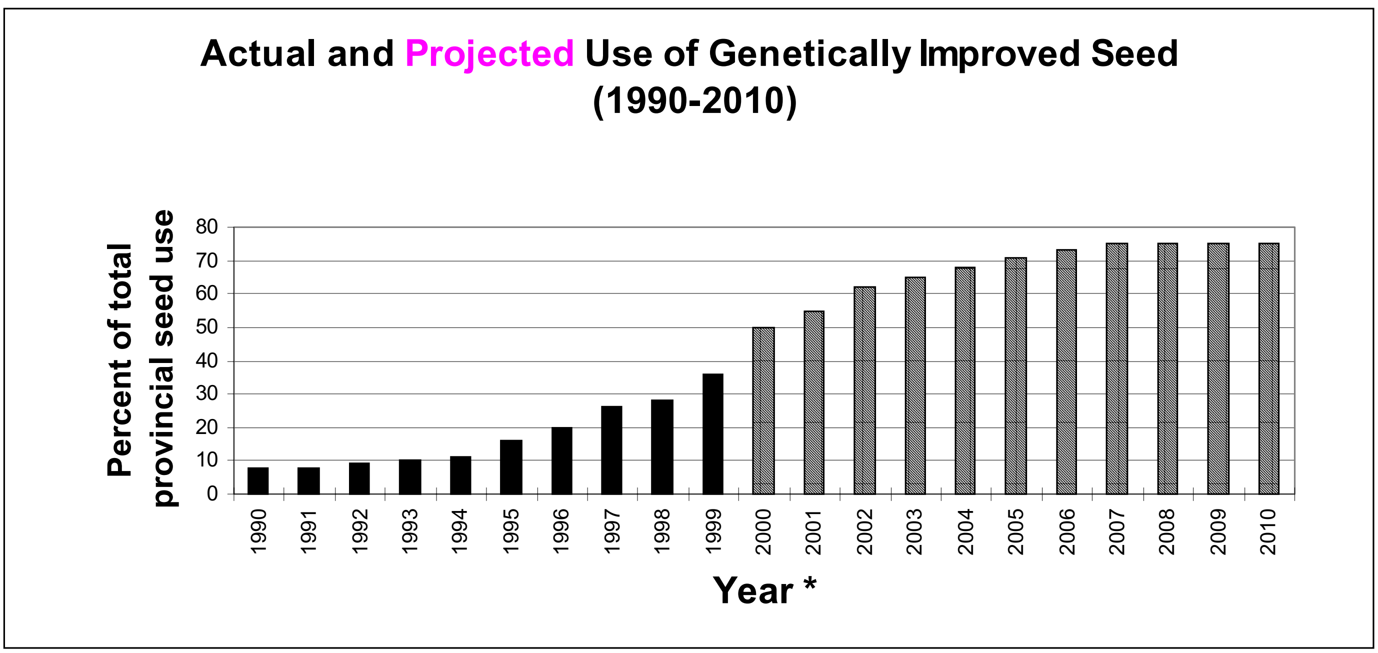
Dale Draper, and Shane Browne-Clayton, Co-Chairs, Forest Genetics Council of British Columbia

This report marks the second anniversary of the Forest Renewal BC- sponsored Operational Tree Improvement Program (OTIP) delivered by the Forest Genetics Council (FGC). The operational program enhances existing tree improvement investments in British Columbia and moves toward the FGC goals of:

- doubling the average gain in potential harvest volume from using improved seed (from 6% to 12%);
- increasing the use of genetically improved seed to 75% of total provincial sowing by 2007;
- managing a gene conservation program to maintain genetic diversity in commercial tree species; and
- supporting the long-term production capacity needed to meet the priorities of Council's business plan.

Evidence of the success of the program is found in statistics drawn from the Seed Planning and Registry system (SPAR). The figure below shows improved seed use up to and including the current (1999) sowing year. Average improved seed use increased by 4% in 1998 and a further 8% in 1999 (province wide for all species) and currently averages 36%. The projections from 1999 onward show the council is on track with its interim goal of 50% use by year 2000, and its year 2007 Forest Renewal BC goal of 75% improved seed use.

Overall, 72% of planted material of Coastal Douglas-fir, western hemlock, western redcedar, Sitka spruce, white pine and Interior spruce is now derived from improved sources (see table). Lodgepole pine and high gain western hemlock seed orchards are well-established and just reaching their first productive years.



* SPAR production year (June - July)

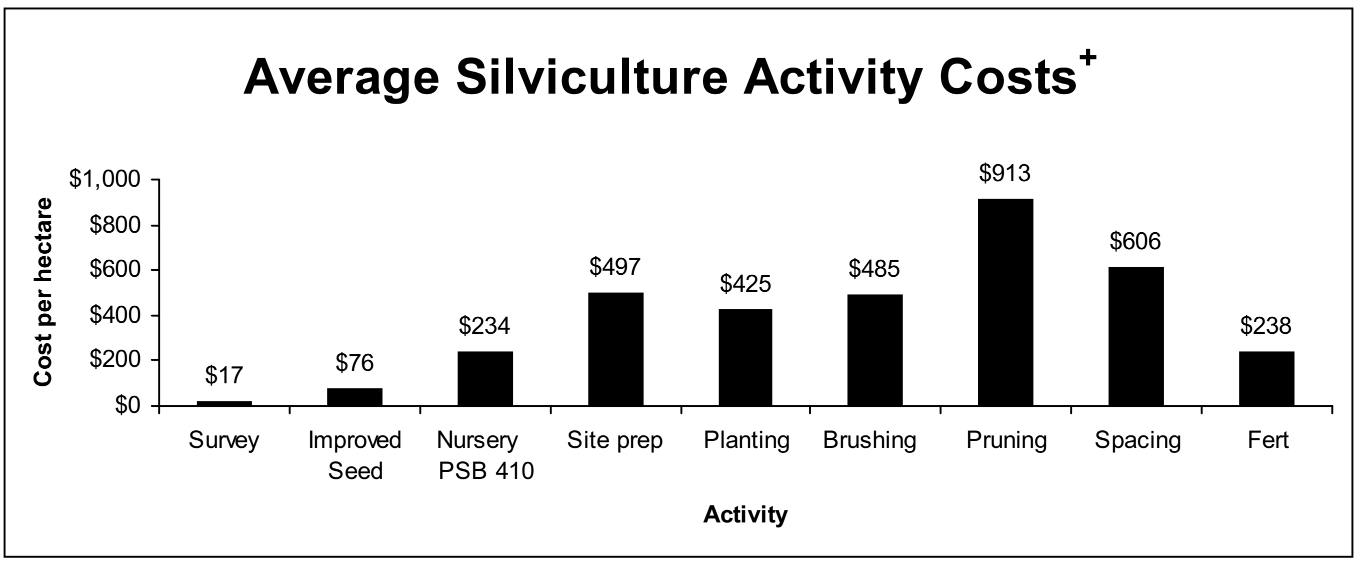
Introduction

Improved* Seed Use 1998 By Major Species			
Improved	Total Seed Requests (M)	Improved Seed Requests (M)	%
Redcedar	8,530	4,293	50
Coast Douglas-fir	10,724	9,984	93
Western hemlock	4,412	2,306	48
Lodgepole pine	92,279	10,882	12
White pine	1,142	860	75
Sitka spruce	759	486	64
Interior spruce	61,956	45,294	73

* from SPAR Jan 18, 1999; improved seed = seedlot with GW > 1

Improved seed remains amongst the most cost-effective of silviculture investments in British Columbia.

This is due, in part, to the relatively low cost of improved seed when compared to other silviculture activities (see below).



+ based on the 1996/97 MoF Annual Report Seed - based on 1,200 stems per hectare and 1998 seed prices Nursery - based on PSB410 price of $0.195/seedling Brushing - average of all Brushing method costs

In this progress report, you will read about projects enhancing the genetic gain of seed from existing seed orchards; about the introduction of advanced generation breeding material into production; about cone induction and improved seed yields; and, about high-gain cutting production projects. Advancements in tree breeding and associated projects remain a corner stone of OTIP, and project examples, such as white pine blister-rust resistance trials, are included in this report.

Introduction

To those land managers concerned with forest productivity and the importance of short and long-term fibre supply at competitive prices, this report describes activities that may be of interest to you. Whether your goals originate from Enhanced Forest Management Pilot Projects (EFMPP), or the Innovative Forest Practices Agreement (IFPA), or, more broadly, from Jobs and Timber Accord - Fibre Targets, or British Columbia's Incremental Silviculture Strategy - operational tree improvement has a place in your strategy. The Forest Genetics Council appreciates the continued support of forest industry, academia, the Ministry of Forests and Forest Renewal BC. Each of these stakeholders play a critical role in the planning, development, funding, and implementation of this program.

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1.0 Goals and Priorities

1.0 Goals and Priorities

Roger Painter

In the past year, the goals and priorities of the Operational Tree Improvement Program (OTIP) have been better defined. As with last year, the main areas of investment continue to focus on:

- Breeding and Testing
- Seed and Vegetative Material Production
- Program Development and Support
- Gene Conservation
- Communications and Extension

The long term goals continue to be: increasing the genetic quality of reforested material from the current 6% to 12%, and the amount of genetically improved material from the current 30% to 75%, within the next 10 years.

This past year has seen the program provide greater depth in prioritization by the development of individual species plans through the Coastal and Interior Technical Advisory Committees(TAC's), the further refinement of the Tree Improvement Investment Priority(TIIP) matrix and through the development of an overall Business Plan for tree improvement by the Forest Genetics Council(FGC). With these in place the FGC is better positioned to prioritize the investment needs, and direct funding to meet long term goals.

In this second year of the OTIP, the general approach continues to focus on improving existing orchards, and in enhancing existing breeding programs for the purpose of producing new material for current orchards, and for Seed Planning Zones where capacity is lacking. The FGC is currently working with Forest Renewal BC to develop a long term investment program for new orchard capacity and propagule development. We in the tree improvement industry look forward to seeing the establishment of new orchards in the not too distant future.

2.0 The Call for Proposals

2.0 Call for Proposals

Roger Painter

The 1998/9 Call for Proposals was issued on November 15,1997. Forest Renewal BC granted approval to proceed with funding projects to a total of $3.2 million. The Call was distributed to an increased audience, with an attempt to cover all possible groups, organizations and individuals related to tree improvement. Proponents were asked to prepare their requests for proposals and submit them prior to January 29,1998. As this industry is very dependent on biological timing, it was important to ensure that funding was available for projects as soon as possible in the spring. A total of 133 proposals were received with requested funding of $5.6 million. This was almost double the requests from 1997/8. The Coastal and Interior Technical Advisory Committees again struck sub-committees and reviewed projects based on their techinical merit and their scope. All provincially focused proposals were reviewed by both committees. Experience with the first year's review resulted in some changes in the evaluation criteria, based mostly on the weight given to each as listed in the evaluation criteria (Section 3.0).

3.0 Evaluation Criteria

3.0 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. See Appendices 2a, 2b,and 2c.

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 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 product meet a specific seed need?
- 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 Tree Improvement Council. The Tree Improvement Council received the recommendations of the Review Committees in early March, ratified their findings and passed them on to Forest Renewal BC for final approval.

4.0 Project Rating

4.0 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.

5.0 The Second Year in Review

5.0 The Second Year in Review

Roger Painter

The second year of the Operational Tree Improvement Program (OTIP) has provided much needed funding in a year when the Forest Industry has been suffering from depressed markets and economic challenges. For a program that produces long-term gains, it is important to ensure that funding is not adversely affected by the economic fluctuations in the overall industry. Forest Renewal BC has recognized this fact, and has not only maintained its commitment to Tree Improvement, but has increased funding in 1998/9.

Final approval of the second year of the OTIP was given in early May of 1998, and the Forest Genetics Council (FGC) (formerly known as Tree Improvement Council) approved a total of 93 of the 133 proposals submitted. The total amount of proposals received was just over $5.6 million, almost double the previous year. Slightly over $3.2 million in proposals were finally approved with actual funding of $3 million provided. The extra $260,000 represented 10 projects that were important, but not as highly ranked as others. Funding for these projects was arranged by finding cost savings from the other approved projects. In an industry that is dependent on biology, there is always work that cannot be completed because of nature. Relying on such potential under-expenditures shows the confidence that both Forest Renewal BC and the Council had in our industry. This resulted in a maximum amount of work being undertaken and permitted the use of all available funding. Sufficient savings were found from all sectors of the tree improvement industry to fund these projects.

This program is divided into Coastal, Interior and Provincial areas. Funding for each is fairly evenly distributed between the two former areas. Although the Coast represents a smaller area overall, the tree improvement program in this region is more advanced and diverse. The Interior, however, did receive a substantial amount of funding and will be expanding in the future. The breakdown by region follows:

Number of Projects and Funding by Region		
Interior projects	53	$1,575,325
Coastal projects	36	$1,512,525
Province wide projects	4	$179,553
Overall Total	93	$3,267,400

As with the first year, the figures are consistent with the areas of investment that tree improvement currently needs. Breeding and Testing continues to receive considerable funding. This shows the initial necessity to develop genetic material to provide new orchards for Seed Planning Zones where seed capacity is low, and/or where priorities for genetic quality seed are high. Continuation of the first year's focus on work in Breeding and Testing will make sure that more genetic material is produced for new orchards. The development of a long-term investment program, currently nearing completion with Forest Renewal BC, will take advantage of this work in initiating new orchard capacity starting in 1999/2000. There also continues to be a strong emphasis on Program Development. Tree improvement is a technically demanding field, and it must continue to develop better methods of operation in delivering its product. A project breakdown by areas of investment follows:

Number of Projects and Funding by Area of Investment		
Breeding and Testing	23	$1,589,312
Seed and Vegetative Material Production	53	$926,735
Program Development	11	$569,233
Communications and Extension	6	$173,123

The tree improvement industry consists of both forestry companies, the provincial government, universities, the Canadian Forest Service and private bio-technical companies and individuals. A total of 44 separate proponents, representing all parts of the industry, participated in 1998/9. However, it is impossible to fund all requests. Proposals must be aligned with the operational needs of tree improvement. The FGC, through it's TAC's, has continued to review and update it's goals and priorities to provide guidance for funding. The definition of the species investment plans (Appendices 2a - 2c) is a good example of the intensity with which the FGC has approached this opportunity with Forest Renewal BC.

The 1999/2000 Call for Proposals is currently in progress and has again received considerable requests for funding. This third year will see a stronger emphasis placed on ensuring that proposals meet the long-term goals and priorities set out by the Council. It is the meeting of these goals, and the development of a long-term investment program for new orchards, that will see the opening of the final door for a comprehensive tree improvement program.

6.0 Project Descriptions

6.1 Breeding and Testing

Projects that are funded under this section involve identification, development, and production of genetically improved sources of material for reforestation. It also involves the study and development of techniques and genetic processes for improving breeding capabilities and methods.

6.1.1 Genetic Variation in Resistance to Keithia Leaf Blight In Western Redcedar

Harry Kope, John Russell, Dave Trotter, and Heidi Collison

Background:

The aim of this two-year project was to ascertain from populations and families of western redcedar trees, whether there was genetic variation in disease resistance to Keithia leaf blight (*Didymascella thujina)* and to relate this variation to seed origin (i.e., is resistance adaptive?).

Activities:

Keithia leaf blight is endemic to the range of western redcedar trees and its occurrence on the foliage was used as an assessable variable of western redcedar performance. Open-pollinated and outcrossed populations and families of five year-old western redcedar trees from seven established field sites were surveyed. Individual trees where rated for Keithia leaf blight incidence, and measured for height and stem diameter. It is known that western redcedar follows a generalists adaptation strategy. However, the severity of Keithia leaf blight seems to be an exception to the generalist adaptation strategy; it is thought that Keithia leaf blight has a close adaptation to seed origin.

Results:

Results showed that there are genetic differences in resistance with respect to disease severity and stem diameter, and it is significant at population levels of western redcedar. As well, population genetic variation was related to seed origin. Populations originating from low elevation Coastal sites, when grown in similar environments, were highly resistant to Keithia leaf blight; whereas populations from Coastal high elevation and Interior dry and/or high elevation sites were susceptible to Keithia leaf blight (Figure 1). Keithia leaf blight resistance is an example of a population genetic change, in response to environmental selection pressure that appears to be more adaptive than other fitness traits. Physiological measurements of western redcedar trees showed there was a significant negative correlation between stem diameter and blight severity with those populations, with the highest disease severity having the smallest stem diameter.

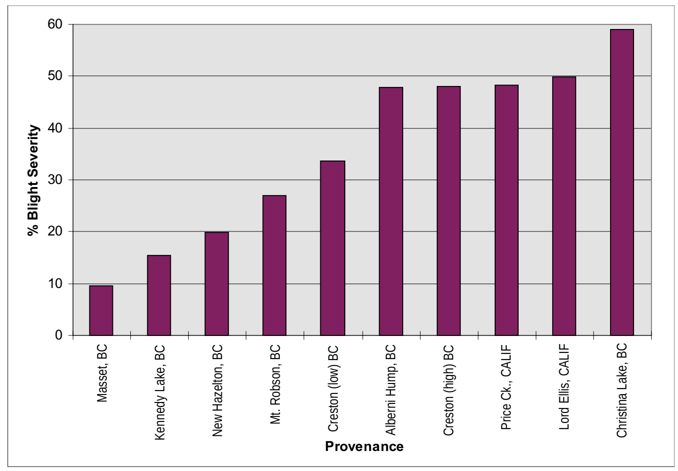


Fig.: 1 5 - year old western redcedar seedlings grown at Jordan River, a low elevation, humid site.

These results suggest that seed transfer guidelines be modified such that low elevation Coastal areas be planted with seedlots from similar environments (i.e. putative Keithia leaf blight resistance). However, this study had limited populations and a Keithia leaf blight nursery screening of a broader genetic base is recommended until changes are made to seed transfer.[OTIP 174]

6.1.2 Screening Western Redcedar for Natural Durability

John Russell

Background:

Currently, 12 million western redcedar are planted annually in BC. Natural durability of these future second growth cedar is of concern. Tropolones, in particular the thujaplicans, have been strongly correlated with decay resistance. It has been thought that old-growth trees are, on average, more durable than second-growth because of higher concentrations of tropolones. However, the tropolone content of both old and second-growth western redcedar shows considerable phenotypic variation from tree to tree, with some second growth trees showing as much as old-growth. There is the potential of selecting second growth trees with higher than average tropolone content, resulting in enhanced durability similar to average old growth trees. These selections can be incorporated into breeding and seed production populations, ensuring minimal failure in future durable redcedar products from second growth trees.

Objective:

The objective of this project is to screen western redcedar clones for enhanced natural durability, by analyzing wood cores for tropolones, (in particular the thujaplicans) using chemical analysis, and rot resistance, using wood blocks inoculated with fungi. 300 clones from 18 year old parent trees will be screened for natural durability. Six copies from each clone, one half from the respective seed orchard (Mt. Newton, Lost Lake) and the other half from clone banks at CLRS, will be cored, and wood analyzed for 1) tropolone concentration using mass spectrometry, and 2) rot resistance using fungi block tests. Data will be analyzed for genetic differences in natural durability among clones and clonal values will be calculated.

Activities:

Sampling has been delayed for one year in order to refine chemical analyses techniques. It is important that durability information from cores taken at breast height of immature trees can be confidently extracted to the tree as a whole and to rotation age. Phenotypic samples were collected from two old growth and four second growth stands, to refine the techniques for analyzing small samples of wood cores, and to determine the chemical relationships within a tree. These samples have been analyzed for tropolone content and rot resistance. Sampling of the 300 clones will commence in year two of the project and will be finished in the third year.

It is anticipated that at the end of this project we will have clonal values for durability for 300 parent trees. These values can be incorporated into second generation orchard and breeding populations. [OTIP 186]

6.1.3 Western Redcedar Genetic Tests for Identifying Elite Populations

John Russell

Background/Project Description:

Twelve million western redcedar seedlings are planted annually in BC. Of this, nine million are planted in the wet Maritime under 600 metres, which is the target area for the Coastal industrial seed orchards. These orchards provide up to 100% of the seed to meet the reforestation needs in this area. Currently, genetic gain in volume growth for these first generation orchards is estimated at 2%. An FGC-endorsed western redcedar breeding program involves progeny testing of 600 polycrossed parent trees. Selection of the top parents in existing orchards, or developing new 1.5 generation orchards based on progeny testing, will result in a one year reduction to reach free-to-grow on productive redcedar sites (***TIC Progress Report to 1996***), and a 10% to 15% volume gain at rotation for western redcedar reforested sites. Improving or maintaining the wood quality of elite redcedar populations will also be a priority.

Four annual series of trials, each composed of 150 families, whose female parent has been crossed with a mixture of 20 unrelated males, will be established in low elevation wet Maritime sites. Included in each annual series of tests will be five groups of wild-stand seedlots (each group containing three seedlots) from representative biogeoclimatic subzones for checks across sites and series, comparisons to select families, and a baseline for measuring adaptive responses to environments.

In addition, each year one or two smaller sites, with a subset of families and all of the controls, will be planted at higher elevations in the wet Maritime SPZ or in the Sub-Maritime SPZ.

Activities:

This year's project was the second of four annual series of western redcedar polycross progeny trials. Four main sites were planted on low elevation coastal sites, using an incomplete block design with 15 tree blocks, 10 blocks per replication and 35 replication. The sites were located at: 1) Nahmint Lake (300 m), MB Port Alberni West Division; 2) Buckley Bay (100 m), MB NW Bay Division; 3) Nimpkish (350 m), Canfor Woss Division, and; 4) Raft (200 m), WFP North Island Division. Two smaller sites were established in the south Sub-Maritime: 1) Pemberton (800 m), WFP South Division, and; 2) Brew Creek (550 m), WFP South Division. All sites will be maintained to minimize competition and deer browsing.

The first series of sites were well maintained and have excellent survival with no deer browsing. It is anticipated that five year growth data will be collected from each series, and orchards upgraded based on calculated breeding values.[OTIP 188]

6.1.4 Red Alder Provenance Testing

Cheng Ying

Background:

Red alder has long been recognized for its value as a nurse crop, as a soil builder and for quality wood, and potentially a species for value-added products such as furniture and veneer. Export of high quality log and lumber is bringing higher per unit-volume value than even prime Douglas-fir in the US. The red alder provenance testing was initiated in 1990 to address the following questions: (1) Can we grow quality logs of red alder in plantation forestry? (2) Is there enough genetic variability to enhance plantation growth and yield through selection of seed sources? (3) What will be the risk in planting non-local sources? This has led to the establishment of three long-term field tests on Vancouver Island and Terrace in spring 1995. The objectives for 1998 were to continue with maintenance, height measurements and observations of tree condition.

Results:

After four growing seasons, site and provenance effect on growth and hardiness were large. Results are summarized in Table 1. Trees at Bowser were, on average, twice as tall as Terrace. Most trees from the top 10 provenances at Bowser maintained over one meter annual growth for the past four years. This suggests a rotation age of about 20 years at productive sites, if this rate of growth is maintained. Productive provenances at the two Vancouver Island tests were concentrated along the coast of Georgia Strait, south of Campbell River including Quadra and other Gulf Islands. It is a different story at the northern test at Terrace, where these fast growing provenances were among the poorest and suffered severe winter injury, and the most hardy and productive provenances were mostly from lower Skeena River. These results reveal the negative relationship between growth and hardiness, and thus the necessity of regulating seed transfer.

Mortality at Terrace was almost the whole cause of winter injury, and is expected to increase substantially in coming years. Drought in spring and poor soil drainage in winter contributed largely to the mortality at Saanichton, an old farmland with heavy clay forming hard pan only 20cm or 30 cm below the surface. We plan to prepare a milestone report after the fifth year to recommend seed source selection and seed transfer.[OTIP 196]

Site	Height(cm)	Range(cm)	Survival(%)	Range(%)
Saanichton	284	197-380	67	40-90
Bowser	358	234-443	78	50-93
Terrace	184	119-285	75	37-100

Table 1 Site mean and range for fourth year height and survival (provenance material).

6.1.5 Douglas-fir Second Generation Progeny Testing (Maritime SPZ)

Jack Woods, Keith Bird and Norm Pomeroy

Objectives:

To establish a first series of second generation progeny tests for Coastal Douglas-fir. These tests will provide information and material for third generation production and breeding population selections. Specific objectives for this two year project include:

i) Sow and grow stock for 108 polycross and 120 full-sib families. (year 1)

ii) Locate, site prepare and fence (if needed) six test site areas. (year 1)

iii) Plant tests. (year 1)

iv) Prepare maps and long-term records. (year 1 and 2)

v) Control brush and weeds on all sites as necessary. (year 2)

Progress for 1998/1999:

The following activities were performed successfully:

- 228 families (108 polycross and 120 full-sib) plus wild-stand controls, were sown and grown in 6-15 styroblock containers during 1998.
- Trees were labelled individually with code numbers representing families.
- An Alpha incomplete block design was developed

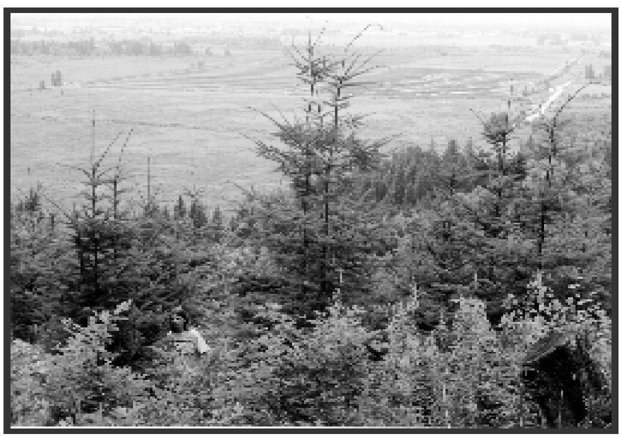
and trees lifted and sorted to appropriate boxes representing site, replication and block.

- Six test sites were located with co-operation from forest companies; five sites on Vancouver Island and one near Powell River.
- Two sites were cleared, stumped and cultivated for farm-field testing.

The following activities will be carried out before March 31st, 1999:

- All six sites will be staked to mark planting spots and the test design on the ground.
- Site planting and mapping of individual tree locations.
- Deer fencing of one site; repair of an existing fence at one site.

This project is progressing as planned, and is expected to provide material for initial evaluation and selection by 2004.[OTIP 189]



Coastal Douglas-fir genetic-gain demonstration plot at the University of British Columbia demonstration forest. The row of trees on the left is from a wild-stand (non-selected) seed lot, the middle row is a better full-sib family selected for stem volume growth, and the row on the right is from a first-generation orchard seedlot.

6.1.6 Maintenance of Existing Coastal Douglas-fir Progeny Test Sites

Jack Woods, Norm Pomeroy, Keith Bird

Background:

There are currently 151 test sites associated with the coastal Douglas-fir breeding program. These sites are distributed throughout the south Coastal and Sub-Maritime areas, as far north as the Bella Coola river. The oldest of the sites were planted in 1967. All of these sites were carefully established with identities labelled in the field. They were measured at intervals, but as needs changed many older sites have not been of high priority for maintenance. As a result, some older sites have not had any maintenance for up to 15 years.

Activities:

To secure these sites for future assessment and study.

Maintenance was carried out on a total of 18 test sites of various ages, with the oldest being 29 years. This work has been successful, as many of the old sites were difficult to find, and label tags were beginning to fall from the trees.

Signs have been upgraded, tags re-hung, maps checked, access notes brought up-to-date, and GPS latitude and longitudes noted for each site.

A minimal amount of non-test tree removal was needed within the sites, and some spacing was done around site boundaries to make the sites easier to identify by forestry crews working in the area.

Results:

This two year project is now complete, with a total of 49 older test-sites visited and upgraded. These sites are now secure until the time of harvest.[OTIP 190]

6.1.7 Seed Transfer of Douglas-fir in the Sub-Maritime Seed Zone

Jack Woods and Steve Grossnickle

Project Description:

This is a four year project that will evaluate the physiological response of 43 populations of Douglas-fir, previously collected throughout the Sub-Maritime (SM) seed zone (Coast mountains). Population collections include four west to east transects through the zone (Fraser, Whistler, Kliniklini and Bella Coola). The populations also sample the elevation range. These populations, along with Coastal controls, Interior controls and specific Coast by Interior hybrids, were planted on six field sites in 1996; five sites in the SM zone, and one on a Coastal location (CLRS). The long-term field trials were established as part of a separate project. This project was initiated to evaluate frost hardiness and drought response of the various populations. This summary outlines work in progress for the first year.

Objectives:

- To provide information for the refinement of Douglas-fir seed transfer guidelines in the climatically diverse SM zone, and to identify populations with the highest wood production potential.
- To evaluate the ecophysiological patterns of genetic variation for the primary site-limiting environmental conditions.

Methodology:

Genetic differences are being screened in response to the following source differences:

- Latitude.
- Elevation.
- Relative position in the Coast to Interior cline.

The following traits are being evaluated:

- Water use efficiency (gas exchange and growth) during the summer growing season.
- Acclimation and deacclimation timing during the fall and winter, as indicated by freezing tolerance, gas exchange and growth rhythms.
- Drought response as indicated by gas exchange, water relations and morphological traits.

Progress to Date:

Work plan:

A detailed work plan was prepared following a review of test sites, sources and remaining seed.

Gas exchange patterns:

Gas exchange response to vapour pressure deficit (VPD) changes during the summer growing season were tested on the farm field test-site at the Cowichan Lake Research Station. Initial statistical analysis indicates that there are slight population differences in gas exchange response to summer VPD conditions.

Freeze tolerance:

Freeze tolerance was assessed, using samples collected from a lower elevation site in the central part of the SM zone (Lillooet river area north of Pemberton). Samples were taken biweekly, through the fall of 1998, from trees representing a range of populations, including controls and hybrids. Sampling continued until trees were completely buried in snow in early December. The samples were assessed under laboratory conditions for index of injury (II) at various freezing temperatures. The seasonal freezing tolerance pattern has been completed for assessment at -10 and -20ºC (Figure 2). Only the initial stage of the seasonal pattern for -30ºC was completed prior to snow, cover ending the fall measurement period.

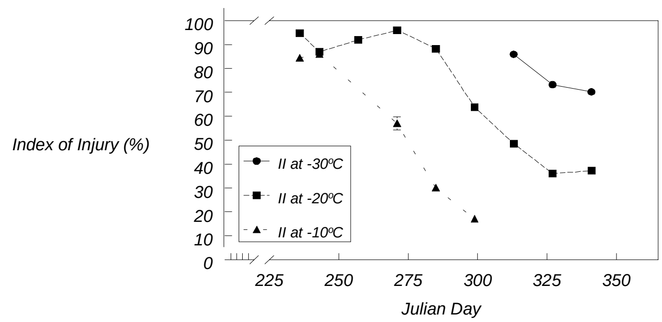


Fig.: 2. Seasonal trend for freezing tolerance for Douglas-fir planted on the Lillooet field site.

Preliminary results for -10 & -20ºC data indicate that populations from higher elevations exhibit a trend for higher freezing tolerance. This trend appears consistent for all west to east transects. [OTIP 191]

6.1.8 Third Generation Coastal Douglas-Fir Breeding Program Assistance

Gordon Morrow

Project Activities:

The project provided assistance in the controlled crossing of clones in Orchard #149 to provide seed for testing in the breeding program. In addition, a plantation of one thousand ramets was maintained for use in the MoF's third generation Coastal Douglas-fir breeding program.

This project was completed.[OTIP 213}

6.1.9 Brushing, Maintenance and Measurement of Interior Douglas-fir Progeny Tests

Barry Jaquish

Background:

Between 1984 and 1992, members of the Interior Tree Improvement Council (ITIC) cooperated in establishing 39 Interior Douglas-fir progeny tests in nine seed planning zones. The main objective of these tests was to evaluate the genetic worth of first-generation parent trees. Research results would be used to establish first-phase 1.5 generation seed orchards, rogue seed orchards to improve their genetic quality, and construct advanced-generation breeding populations. In total, more than 250,000 test trees from 1,661 wind-pollinated families were established in the tests.

Objectives:

The objectives of this project were to brush, maintain and record tree height measurements on seven Interior Douglas-fir progeny tests described in Table 2.

Seed Planning Zone	Plantation age	Number of test sites	Number of test trees per site
Mica	10	5	6,400
Cariboo Transition/Quesnel Lakes (CT/QL)	15	2	12,000
Total		7	

Table 2 Summary of Interior Douglas-fir progeny tests scheduled for brushing, maintenance and measurement: 1998/99.

Progress and Results:

All seven plantations were manually brushed, maintained and measured as planned. One Mica site (Revelstoke Dam) was thinned and wood disks were collected from thinned trees for wood density determination. In addition, two sites in the Mica and West Kootenay zones (Mitchell Bay and Wilson Ck, respectively) were access pruned to diameter breast height. Data analyses for the CT/QL sites and Mica wood density determination are in progress. Data analyses for the Mica zone are complete.

Mean 10-year-height of the Mica sites ranged from 209 cm at Spikers Ck. to 387 cm at Revelstoke Dam (Table 3). Individual heritabilities ranged from .14 at Spikers Ck. to .41 at Revelstoke Dam. Unfortunately, the Spikers Ck site suffered high mortality and damage due to small mammals. Mean family height across all sites and parental breeding values (BV) ranged from 176 cm (BV = -45.0%) to 352 cm (BV = 20.2%).

Site	Mean height (cm)	Survival (%)	Damage (%)	Individual tree Heritability	Family Heritability
Akokalux Ck	251	95	10	0.32	0.54
Key Road	336	93	9	0.32	0.59
Revelstoke Dam	387	92	14	0.41	0.59
Spikers Ck	209	53	15	0.14	0.24
Trinity Valley	269	95	4	0.37	0.51
Combined analyses	290	87	9	0.23	0.76

Table 3 Ten-year summary statistics and heritabilities for Mica Interior Douglas-fir progeny tests.

Families from the CT, QL and West Kootenay high elevation zones generally lacked the growth potential of families from Mica, Shuswap Adams and West Kootenay low elevation zones (Table 4). Results from this test series will be used to identify superior Mica parents for use in the new Nelson Interior Douglas-fir seed orchard, and to guide advanced-generation breeding. [OTIP 194]

Seed Planning Zone[1]	Number of families	Mean 10-year-height (cm)	Survival (%)	Damage (%)
Cariboo Transition	5	255	82	13
Quesnel Lakes	14	266	82	14
Shuswap Adams	10	295	74	14
West Kootenay High	10	260	76	13
West Kootenay Low	10	298	79	12
Mica	145	301	85	9

[1] Indicates old seed planning zone names.

Table 4 Ten-year summary statistics of Interior Douglas-fir families from different seed planning zones in the Mica zone.

6.1.10 The Genetic Improvement of Western Hemlock

Charles Cartwright and John King

Background:

Western hemlock is the most important commercial timber species in Coastal BC, comprising 40% of the Coastal harvest, and nearly 60% of the province's export market.

Natural regeneration of hemlock stands can at times be prolific, yet annual plantings of western hemlock have been between five and eight million seedlings. The faster green-up and more even stocking associated with artificial regeneration, more than compensates for the additional costs of planting stock; and the utilization of improved seed can further justify planting hemlock. Considerations of timely regeneration are even more important with the implementation of the adjacency requirements of the Forest Practices Code.

Western hemlock exhibits an exceptional level of biological versatility - enabling it to be either an aggressive pioneer or a venerable climax dominant. Rapid growth rates and marked thinning responses, together with precocious and prolific flowering, combine to make this an attractive species for enhanced forest management, including both intensive silviculture and tree improvement.

Hemlock tree improvement began in the 1970's, but has had a chequered history of on-again/off-gain activity. Because of the small program in BC, and the realization it was not cost-effective to establish a stand-alone program, an international co-operative tree improvement program (HEMTIC) was established with private and governmental organizations from across the Coastal regions of BC, Washington, and Oregon.

A pool of over 1,500 tested first-generation parents are currently represented in Cooperators' seed orchards (only 150 in BC, the rest are from Oregon and Washington).

Objectives:

The objective of this proposal is to establish the *F-1* filial generation, as outlined in the breeding plan proposal.

The objectives of this *F-1* population are:

- to provide a population for recurrent selection for advanced generation gains;
- to estimate genetic parameters in order to most efficiently make selections, and
- to test for provenance effects and seed transferability. This is especially important for the BC program, as we will want to know how much of the Washington and Oregon material will be of use to us here.

Selections will be made for vigour, health and wood and fibre traits.

Progress to Date (December 31st, 1998):

In 1997, we established the first two of the *F-1* progeny trials at Jordan River in Southern Vancouver Island and Kiyu near Woss, Northern Vancouver Island. This is what we referred to in last year's proposal as the phase 1 progeny tests. They were somewhat incomplete, as they missed two of the CZ/Willamette diallel sets. The phase established this year has all the HEMTIC material, including the CZ/Willamette families that originate from the mouth of the Columbia River. Sites were outplanted with phase 2 material near Jordan River, Rupert Inlet, Raft Cove, Vernon Camp and the Tsitika Valley. This would leave us a total of two full *F-1* sites and five partial sites. This should be quite adequate for the local diallel testing phase. Seed for the cross program, across diallel elite parent trials, was sown in February, with lifting scheduled for January 1999 and subsequent test establishment.

As well as the sowings and establishment of the advanced generation trials, all seven were brushed and survival surveys carried out. Results from the two year old Kiyu trial were interesting, with a very pronounced geographic trend in mortality. British Columbia and Forks Washington diallels survival was much higher than for more southerly material. Results will be varified through processing the data from the other test sites. Fill planting was done for the most complete sites- Jordan River and Rupert Inlet.

Other data collected included five year old height on two high elevation hemlock trials, as well as eight year old height and diameters on three realized-gain trials. Analysis leading to selections for a new high elevation orchard, and preparation of extension materials, will take place early in 1999.

The eventual focus of the advanced generation tests is to provide for selection of parents yielding gains in the order of our early realized gain trials. Most recent results from these follow (Figure 3). [OTIP 142]

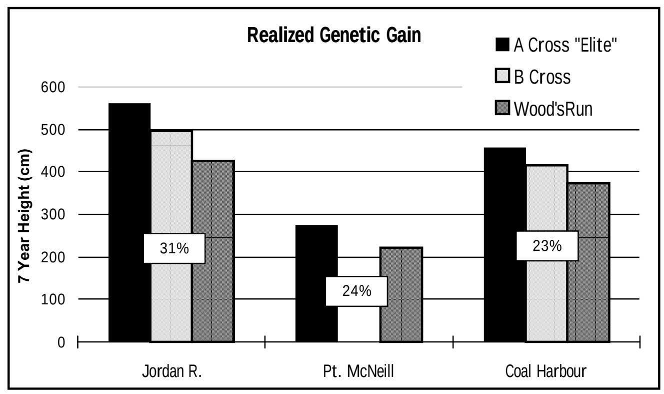


Fig. 3: Western hemlock realized gain trials; 7 Year Height

6.1.11 Brushing, Maintenance and Measurement of Western Larch Progeny Tests in the Nelson and Kamloops Forest Regions

Barry Jaquish

Background:

The BC western larch breeding population consists of 608 parents selected in natural stands in two seed planning zones: the East Kootenay and Nelson (formerly West Kootenay/Shuswap Adams). Grafts of each parent tree have been established in breeding orchards and holding beds at Kalamalka. In 1989, two first-generation seed orchards, each with more than 140 parents, were established at Kalamalka. At the time of orchard establishment, progeny tests had not been planted so parental breeding values were unavailable.

Between 1991 and 1996, members of the Interior Tree Improvement Council (ITIC) cooperated in establishing 17 progeny tests in the two seed planning zones. The objective of these tests was to evaluate the genetic worth of all first-generation parent trees. Information from the tests would be used to rogue first-generation seed orchards, refine western larch seed transfer rules and seed planning zones, and construct advanced-generation breeding populations. In total, more than 115,000 test trees from 607 wind-pollinated families were established in the tests.

Objectives:

The objectives of this project were to brush, maintain and record three and six-year tree height and condition in nine Series I and II western larch progeny tests for the new Nelson planning zone.

Progress and Results:

Seven of the nine plantations were manually brushed, maintained and measured as planned. No work was conducted at both the Lake Ck. Face and Eureka Ck sites because of high mortality (>60%). These sites will likely be abandoned. Data analyses for both series are complete, and recommendations for seed orchard roguing have been forwarded to the seed orchard manager.

Series I Results:

Cross Ck., a site located north of Shuswap Lake outside western larches' natural range, had the highest average tree height (234 cm) (Table 5). Wilson Ck, north of New Denver, was the shortest site (172 cm). Across all sites, mean family height and parent breeding value (BV) for percent volume gain at rotation age ranged from 145 cm (BV=36) to 268cm (BV=33). Individual heritabilities on three of the four sites were moderate-to-high.

Site	Mean height (cm)	Survival (%)	Damage (%)	Individual tree heritability	Family heritability
Beaverdell	176	61	21	0.12	0.24
Cross Ck	234	79	11	0.49	0.66
Miriam Ck	209	78	14	0.71	0.72
Wilson Ck	172	79	22	0.8	0.72
Lake Ck Face	abandoned				

Table 5 Six-year summary statistics and heritabilities for individual sites in the Nelson seed planning zone western larch Series I progeny tests.

East Kootenay and Thompson Okanagan families were generally shorter than West Kootenay and Shuswap Adams families (Table 6).

Seed Planning Zone [1]	Number of families	Mean 6-year-height (cm)	Survival (%)	Damage (%)
East Kootenay	26	178	72	25
Thompson Okanagan	25	196	74	19
Shuswap Adams	59	201	73	16
West Kootenay	112	203	75	15
Siberia	1	197	74	19

[1] Indicates old seed planning zone names.

Table 6 Pooled six-year summary statistics of Series I western larch families from different seed planning zones.

Series II Results:

Sparkle Ck., another test site located north of Shuswap Lake outside western larches' natural range, had the highest average tree height (139 cm) (Table 7). Cameron Lake, just west of Arrow Lake, was the shortest site (71 cm). Across all sites, mean family height and parent breeding value (BV) for percent volume gain at rotation age ranged from 73 cm (BV=-11) to 119 cm (BV=5.2). Individual heritabilities on all three sites were moderate ($h^2_{individual}$ = .27 - .39).

Site	Mean height (cm)	Survival (%)	Damage (%)	Individual tree heritability	Family heritability
Cameron Lk	71	96	7	0.27	0.51
Miriam Ck.	86	77	4	0.31	0.53
Sparkle Ck.	139	96	3	0.39	0.64
Eureka Ck.	abandoned				

Table 7 Three-year summary statistics and heritabilities for individual sites in the Nelson seed planning zone western larch Series II progeny tests.

East Kootenay and Thompson Okanagan families were again shorter than the West Kootenay and Shuswap Adams families (Table 8). Thompson Okanagan families in this series were from the Tyner Lake stand, north of Merritt. Series I and II results both indicate that movement of natural stand seed from the Thompson Okanagan zone into the West Kootenay/Shuswap Adams zones should be avoided.[OTIP 193]

Seed Planning Zone [1]	Number of families	Mean 6-year-height (cm)	Survival (%)	Damage (%)
East Kootenay	16	91	84	9
Thompson Okanagan	11	92	83	6
Shuswap Adams	56	100	90	5
West Kootenay	125	101	90	5

[1] Indicates old seed planning zone names.

Table 8 Pooled six-year summary statistics of Series I western larch families from different seed planning zones.

6.1.12 Maintenance and Protection of Lodgepole Pine Provenance Tests

Cheng Ying

Background:

BC's network of lodgepole pine provenance tests is one of a kind in the world. They have generated extremely valuable data on growth and yield, tolerance of insects and diseases, and environmental adaptability. The results formed the basis for seed transfer guidelines, seed zone delineation, and provided the essential data base for modelling climatic effect on adaptability and productivity of managed forests. These tests are often used by MoF and industry silviculturists for demonstration and education purposes.

Maintenance and protection has been lacking in recent years, resulting in the loss of one test to highway expansion. This project is seeking to accomplish: (1) physical maintenance of removal of invading vegetation inside the tests (a surrounding 5-10 m wide buffer strip) and access trail to the tests. (2) updating of documents including status of legal reserve of the lot and accurate site location on district forest cover maps, and in district silviculture information system.

Activities:

We did physical maintenance (brush, retag, mapping, etc.) at 22 test sites in Prince George and Prince Rupert regions. During the maintenance, the supervising technician attempted to visit all the district offices to brief district sliviculturists about our work. We are now in the process of updating all site location maps, which will be done according to the research plot standard.[OTIP 199]

6.1.13 Realized Genetic Gain Trials to Quantify Productivity Increases from Genetic Selection in Lodgepole Pine

Michael Carlson, John Murphy, Lynette Ryrie and Vicky Berger

Background:

To date, productivity gains from selective breeding programs have been estimated from young open grown trees in progeny test plantations. Accurate estimates of productivity gains on a per unit area basis for adjustment of growth models, and ultimately for timber supply area planning, are not available today. With increasing amounts of genetically improved planting stock being used each year, and the expectation that by 2007 approximately 75% of all reforestation will be with genetically improved seedlings, we need per unit area productivity gain estimates for several commercial species.

Objectives:

For lodgepole pine in the a) Central Interior and b) Southern Interior, the objectives are:

- to develop generalized predictions of unit-area volume gains for a range of genetic levels (three) from individual-tree progeny tests;
- to generate accurate growth and yield information from genetically improved stock to calibrate growth models (TASS, etc.), including interactions among genetic gain, site index and stand density; and
- to demonstrate unit-area gains due to genetic selection.

Information pertaining to early realized genetic gain impact on green-up/adjacency issues, will be available by 2002, with above objectives realized approximately by 2010 and beyond.

Progress to date:

Breeding for realized genetic gain trials was completed in 1997. Seedlings for the Thompson -Okanagan Seed Planning Zone trial were grown in 1998. Also in 1998, six trial sites were selected: two of low site index (15-17), two of mid site index (20-22) and two of high site index (25-27), site prepared and staked for 1999 planting. These steps will be repeated for the Prince George Seed Planning Zone in 1999/2000.

Six small genetic gain demonstration plantations were planted in 1998, five in the Thompson-Okanagan and Nelson Seed Planning Zones and one in the Prince George Seed Planning Zone. Using replicated row plots, these plantings will provide managers and foresters with a visual demonstration of the early differences in growth potentials of elite, orchard run and wild seedlots. [OTIP 200]

6.1.14 Screening Adaptive Traits of Lodgepole Pine Progeny from Elevational Crosses

Sylvia L'Hirondelle and Wolfgang Binder

Project Description/Overview:

This project will support the lodgepole pine operational breeding program by developing and improving guidelines for deployment of seed-orchard seed from sources covering a wide range of elevations. Seed orchards of lodgepole pine in the southern Interior of BC, include parents from an 800 m elevational range. Progeny from intercrossing between different elevational sources may vary considerably in growth and adaptive traits. We will apply recently developed technologies for screening adaptive traits to estimate the genetic differences in growth potential and stress resistance (frost, drought, heat) of progeny on field sites and in a nursery environment. Estimation of this variation will improve deployment decisions and help to increase growth and decrease the risk of damage from environmental stresses.

Objectives:

- To determine how seedlings from different seed sources (elevational crosses) of lodgepole pine vary genetically in adaptive traits, such as frost hardiness, drought tolerance, phenology, and growth patterns. This will be done in nursery and field tests over two growing and fall acclimation seasons.
- To relate seed source genetic variation with geographical and site factors, and to estimate genotype by environment interactions.
- To make recommendations for possible changes to existing seed transfer and seed orchard seed-use guidelines.

Activities:

Seedlings from 16 elevational crosses of lodgepole pine were grown in Vernon and transferred to Glyn Road Research Station in July. They were transplanted to 28 racks of 16 seedlings each (one per cross) and placed in a greenhouse. Primary needles were sampled from all 16 seedlings in 10 randomly selected racks on each of three dates from September to October 1998, and from all racks in November. Needles were held at 4°C (controls) or frozen to one of three sub-zero temperatures in a programmable freezer using standard freezing protocols. After thawing and pre-conditioning under bright light, damage was assessed with quantum yield from chlorophyll fluorescence.

Results:

Data were analyzed with ANOVAs including seed planning zone, cross within zone, and replicate within cross as factors. The considerable variation between replicate crosses within a zone often masked any significance of variation among crosses. There were significant differences in frost hardiness between zones. There was a trend for increasing frost hardiness with parental elevation within a zone on some dates, but this relationship was not consistent across zones and dates.

Needle samples were also taken from the current year growth of trees at the three field sites on three dates in September, October, and November 1998. Samples were frozen and measured as above, and data were analyzed for each site using the same models. There were large differences in frost hardiness among sites, with needles from the low elevation Skimikin site being hardiest in September and November. Needles from the mid elevation Eagle Bay site were usually the least hardy, indicating that factors other than temperature may be affecting the acclimation patterns on the three sites. Trees from the field site also showed considerable variation between replicate crosses and the greatest range in hardiness was often among the high by low elevation crosses. Although not all data analyses are completed, it appears that there was no clear trend of increasing frost hardiness with increasing parental elevation of the seed source.[OTIP 206]

6.1.15 Incorporation of Major Gene Resistance into White Pine (Pinus monticola) Seed Orchards

Abul Ekramoddoullah

Project Description/Overview:

Western white pine is a valuable and fast growing species. However, the potential for the commercialization of this species cannot be realized in British Columbia because this species is being decimated by the blister rust fungus, which was introduced in Vancouver in 1910. White pine is resistant to laminated root-rot, and hence offers a good management option for utilizing this species as an alternative species in the reforestation of root-rot hazard sites. Work at Pacific Forestry Centre, in collaboration with the MoF, was undertaken to select disease-free white pine tree, and screen the progeny for resistance, with the ultimate purpose of building seed orchards in Coastal and Interior BC. Specific objectives, in support of this ongoing selection program, are given below.

Objectives:

- To inoculate white pine seedlings with putative major gene resistance to blister rust.
- To evaluate inoculated seedlings in ribes gardens for resistance.
- To clone resistant seedlings.
- To pollinate Coastal and Interior selected white pine trees with pollen from Dorena (OR) trees carrying major gene resistance (MGR).
- To bag cones.
- To collect seeds from these control crosses.

Progress to date:

Screening, selection and propagation of resistant western white pine seedlings:

Seeds from two seed orchard trees carrying MGR were selected from the Dorena Tree Improvement Program. Seeds were stratified and grown in styroblock containers using a well-established protocol.

64 four-month old seedlings, representing two families, were inoculated in August 1996. They were assessed continually throughout 1996, 1997 and 1998. In October 1996, all 64 seedlings showed infection spots on their needles, indicating successful inoculation. In August 1997, 10 seedlings out of 24 (seed lot 3277) and seven seedlings out of 40 (seed lot 3278) had developed cankers. On the July 30th assessment, several seedlings had died of root-disease (*Pythium/fusirium*). 42 seedlings that were canker free were re-inoculated in August 1998.

784 one-year old seedlings, representing two families, were inoculated in August 1997. On July 2nd 1998, about 13% of these seedlings were killed by root-disease. The remaining seedlings were placed in the ribes garden, along with another 800 new seedlings in August 1998. Out of original six trees that were canker free following inoculation in 1995 and 1996, a total of 35 scions were made.

In August 1998, a total of 1,520 seedlings had been inoculated. Of these, 38 seedlings were inoculated in 1996 and are still free from cankers.

All these seedlings are being monitored monthly for the development of cankers. Seven seedlings inoculated in 1994 and 1995 remain canker free. From these resistant seedlings, 34 ramets (11 in 1997 and 23 in 1998) were made.

Control Crosses:

Trees with slow canker growth were used. 70 cones from seven trees, representing three families, were bagged and pollinated in May 1998. All bags were removed in July, 1998. Trees will be checked for developing cones in 1999, and mesh bags will be installed to protect against insects until harvest. [OTIP 120]

6.1.16 Realized Genetic Gain Trail to Quantify White Pine Blister Rust Tolerance Increases from Genetic Selection

Michael Carlson, Lynette Ryrie, Vicky Berger and John Murphy

Background:

Western white pine produces the highest value wood of any BC Interior species. Supplies of available white pine timber are rapidly decreasing in the Southern Interior, and little reforestation with the species is taking place due to a lack of blister rust tolerant planting stock. A similar situation existed in the Pacific Northwest of the U.S. until recently. Today western white pine is again being planted in parts of the Pacific Northwest. The U.S. Forest Service long term breeding effort (1960 to present) has produced seed orchard seedlots with an estimated 60% plus tolerance to white pine blister rust.

A breeding program in BC began in 1980, a cooperative effort of the MoF and the Canadian Forest Service. This program has successfully identified several dozen partially resistant white pine trees. In 1995, a six hectare grafted white pine seed orchard was planted by the MoF in Vernon. 80% of the trees in this orchard are from the US program with the remainder coming from BC selection and screening efforts. Full production of approximately two million seed per year is expected by 2006.

Estimates of blister rust tolerance are needed for seedling crops from our MoF, Kalamalka Seed Orchard. Also needed are demonstration plantings of rust susceptible and rust tolerant seedlots, to show field foresters and forest managers the benefits of using genetically improved seed in future reforestation efforts in the southern Interior. The “realized genetic gain” trial proposed will accomplish these objectives. We are on the way toward restoring this valuable species to our future forested landscapes, and this project will facilitate that process.

Objectives:

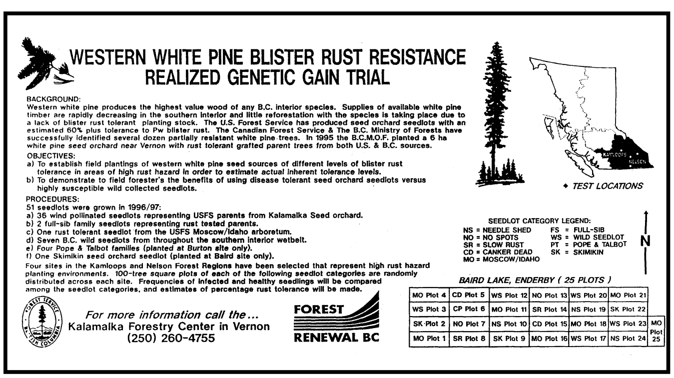
To establish field plantings of western white pine seed sources of different levels of blister rust tolerance in areas of high rust hazard, in order to estimate actual inherent tolerance levels. We will develop estimates of the levels of tolerance to be expected from our future seed orchard seedlots.

To demonstrate to field foresters the benefits of using disease tolerant seed orchard seedlots versus highly susceptible wild collected seedlots.

Progress to date:

Approximately 14,000 western white pine seedlings, representing 57 wind pollinated seedlots, were grown in styroblocks at the Kalamalka Forestry Centre in 1997. Most of these seedlots will display blister rust tolerance levels similar to the seed that will be produced by our Kalamalka Seed Orchard starting in approximately 2006. Seven seedlots were wild-collected from throughout the Pw range in the southern Interior, and serve as rust “intolerant” ‘controls’. Also represented, was the genetically improved Moscow Arboretum seed source, now in operational use in the southern Interior.

Four field sites, one in the Kamloops Forest Region, and three in the Nelson Forest Region were located, site prepared and staked in 1997. Between 2,200 and 2,700 trees were planted at each site in 1998.



Interpretive signs as above were produced and erected at each of the test sites, explaining objectives, materials and project design. The first rust tolerance assessments of these plantations will occur after three field seasons in fall 2000. [OTIP 183]

6.1.17 Evaluating Resistant Traits Within Blister Rust Resistant Western White Pines

Rich Hunt

Objectives:

To determine the relative resistance of clones within seed orchards by: 1) evaluating half-sib families; 2) making crosses among selected clones; 3) establishing plantations to demonstrate the effectiveness of the resistance trait “reduced needle lesion frequency”.

Progress to date (March 31, 1998):

Two Interior plantations (Smallwood and Garrity, near Nelson) have been brushed-out and re-monumented. Crosses were made among trees with the resistant trait “slow-canker growth” within the Coastal seed orchard. 48 strobili were pollinated on five trees using pollen from three trees. One plantation was established demonstrating the effectiveness of the resistant trait “reduced needle lesion frequency”. Within the plantation, there are 16 families in total; eight which were statistically high in needle lesion frequency, and eight which were statistically low in needle lesion frequency, based on inoculation data. Eight replicates in four tree plots of 1 + 1 stock were planted per family. An identical plantation will be established in the spring near Duncan Lake. [OTIP135].

6.1.18 Weevil Resistance Improvement in Spruce Populations

John King and Charles Cartwright

Outline of Project:

Genetic resistance to the white pine weevil damage in spruce has been noted now for several years. This resistance can be quite marked with resistant families having only one tenth the level of attack, and indeed some Sitka clones have shown themselves to be immune under natural conditions. Work has been carried out identifying putative mechanisms of this resistance. This project seeks to determine the inheritance behind these resistant mechanisms, by continuing the screening of populations and accelerating the construction of pedigreed breeding populations.

Progress to Date (January 31st 1999):

A detailed analysis of the Jordan River trials, and the age 20 results of the IUFRO series, has been made.

A genetic worth resistance (GWR) system of classifying resistant material (parents, clones and seedlots) was introduced at a January species TAC subcommittee meeting.

The IUFRO trials have been used as a data base to establish two sets of controls (highly susceptible - QCI material and moderate resistance - Big Qualicum) based on mean annual attack rate, and material can be calibrated against these controls.

A linkage between GWR and the SWAT models developed by Dr. Rene Alfaro of the CFS, is also planned. Formal documentation of this system will add another part of the breeding plan implementation.

So far, we know that on East Vancouver Island the resistance is concentrated around the Big Qualicum source, but also that there is a strong resistance in sources from the Fraser Valley, and there may be different mechanisms involved between these resistant populations. This year we will have the opportunity of testing Fraser Valley and Big Qualicum along side each other, and will have complementary test designs with sites at Harrison Mills in the Fraser Valley, and Coombes on Vancouver Island. A good part of the work done this year has been the selection, layout and establishment of these sites. A series of smaller sites will also be established that can investigate the interaction of genetic resistance and site hazard rating. This will be used to help calibrate and test the deployment model mentioned earlier.

Weevil assessments were made by the CFS at Jordan River and Port Renfrew, but also the clonal trials established by C. Ying at Espinoza and Sayward. Analysis of this information is currently being done, and we are in the process of selecting and grafting material based on these analyses. [OTIP 143]

6.1.19 Accelerated Establishment of a Progeny Test for the Peace River and Six Year Height Measurements of the Shuswap Adams Realized Gain & Demonstration Plantation

Clare Hewson

Outline of Project:

Tree improvement for spruce in the Peace River planning zone has been identified as a very high priority by the 1997 Tree Improvement Council, requiring an estimated 18.2 million seedlings annually. The proposed progeny test for this zone will provide data to establish a genetically improved seed orchard within six years, with the potential of providing gain in excess of 15% at maturity. This program was initiated through the selection and preparation of test sites for a progeny test.

Also included in this project was the measurement of six year heights in the Shuswap Adams Realized Gain & Demonstration plantation to provide data for comparing the performance of seedlings originating from orchard seed with that from natural stands and other sources.

Progress to Date:

Peace River Progeny Establishment:

In co-operation with Research Branch, District and Industry silviculturalists, four test sites, each 4 ha, were selected in the Peace River planning zone. These sites will be established with progeny in 1999 to provide data for the establishment and management of genetically superior seed orchards for the Peace River Planning zone.

Shuswap Adams Realized Gain/Demonstration Plantation:

Six year height measurements were completed as proposed for the Shuswap Adams Realized Gain/ Demonstration plantations located near Adams Lake at an elevation of 1680 m. The realized gain plantations did not show significant differences between seed sources and no interactions occurred between seed sources and sites or blocks. Overall survival was 70.5%. The demonstration plantations showed highly significant effects for height growth between site, block and the interaction of seed source by site, but no effect of seed source. Mortality varied considerably with seed source, with two of the best surviving sources being a high elevation natural source (85%) followed by the Shuswap Adams high elevation seed orchard lot. The poorest surviving sources originated from Birch Island B+ seedlot - source elevation 500 m - 24.4% and surprisingly, the seedlot from the original untested Mica seed orchard (32.5%). This orchard has since been rogued to contain only tested clones from the East Kootenay planning zone.[OTIP 180]

6.1.20 Interior Spruce Progeny Test Establishment, Maintenance and Measurement

Barry Jaquish

Background:

The BC Interior spruce progeny testing program represents a huge investment of time and resources. Since 1972, more than 350,000 test trees have been established in first-generation wind-pollinated tests across 87 sites. The objectives of these tests are: 1) to estimate parental breeding values to establish and rogue first-generation seed orchards, 2) provide estimates of population genetic parameters and gain, and 3) guide advanced-generation breeding. As of spring 1998, more than 100,000 second-generation seedlings, derived through controlled crossing among select first-generation parents, have been established on six test sites in the Prince George and Nelson Forest Regions. These second-generation tests represent the products of nearly 30 years of Interior spruce tree breeding in BC. They serve as test populations in which to select parents for second-generation seed orchards and third-generation breeding.

Objectives:

The objectives of this project were: (1) to brush, maintain and, if necessary, irrigate 36 Interior spruce progeny tests, (2) measure 19 of these sites, and (3) site prepare and layout three second-generation tests in the Bulkley Valley seed planning zone.

Progress:

Because of funding shortfalls, we brushed and maintained only 29 of the 36 sites. Nine o.p. tests in the Bulkley Valley zone still require brushing and pruning. All 19 sites were measured as planned, and data analyses are in progress. The three second-generation tests for the Bulkley Valley zone were site prepared and laid out for planting in spring 1999. Test seedlings were grown at the Riverside (Armstrong) forest nursery. [OTIP 192]

6.1.21 Yellow-cedar Genetic Tests for Identifying Elite Populations

John Russell

Background/Project Description:

Currently, up to two million yellow-cedar seedlings and rooted cuttings are planted annually in Coastal BC. Seed for this valuable resource originates from wild-stand collections and from untested parent trees in MacMillan Bloedel's and TimberWest's seed orchards. Cuttings originate from mostly untested cutting-donors in various government and industrial hedge orchards. Selection of the top parents in the seed orchards, based on progeny testing, will result in a one year reduction to reach free-to-grow (TIC Progress Report to 1996) and a 10% to 15% volume gain at rotation (Russell unpublished data). Selection of the top clones, based on cloned progeny testing and incorporated in hedge orchards, will result in even greater gains for reaching free-to-grow and up to 20% volume gain at rotation. Overall, this project involves three annual series of clonal field trials. To date, two series have been established (funded by Forest Renewal BC). Breeding for the third series is complete. This project involves establishing the third series, and maintaining and labelling field sites from the first two series.

For each annual series the procedure involves establishing field trials of yellow-cedar clones from pedigreed material. One-year-old seedlings, grown from seed from six eight-clone partial diallels, will be used as donor-stock for producing 1 + 0 rooted cuttings. Included in the cloned progeny tests will be:

1,800 clones from 96 full-sib families for progeny and clonal testing; and

one group of wild-stand seedlots (containing 3-4 seedlots) from representative biogeoclimatic subzones, for checks across sites and series and comparisons to select clones and families.

The rooted cuttings will be established in randomised incomplete block field trials.

Objectives:

The objectives of this project are to provide up to 100% of the yellow-cedar seed and cutting needs with genetically-improved material, which will deliver 10%-20% volume gain and reduced time until free-to-grow by the year 2007 through:

- clonal progeny testing of parent-trees in existing seed orchards and gene archives;
- roguing of existing seed orchards, or developing new second generation seed orchards; and
- development of new seed and hedge orchards, based on seven year clonal values.

Activities:

This year's activities included:

- The sowing and growing of seed from 96 full-sib families from six partial diallels in styro 615 containers in a greenhouse, to serve as 1 + 0 cutting-donors.
- 24 cuttings were taken from each one-year-old seedling and set into containers; these cuttings currently have rooted and are being treated as would a rising 1 + 0 seedling crop - the cuttings will be lifted and planted out into field trials Spring 2000.
- Sites from Series 1 and 2 have very high survival and are growing well.
- Sites have been brushed for weed competition, trees individually labelled and deer browse minimised.
- It is anticipated that five to seven year height data will be taken for each series, and seed or hedge orchards upgraded or established, based on either breeding or clonal values.[OTIP 185]

6.1.22 Planting, Brushing, Maintenance and Grafting at the Barnes Ck Clone Bank

Barry Jaquish

Background:

The Barnes Creek Clone Bank was established in 1977 by the MoF to serve as the long-term reserve for important tree breeding materials. The 35 ha reserve is located on Crown land east of Enderby. It contains grafted trees from most of the parent trees in the provincial Interior spruce, Douglas-fir and western larch tree breeding programs. It also contains several important tree improvement and growth and yield research installations. The reserve was established with three goals: long-term preservation of important breeding material, *ex situ* gene conservation, and a source of male and female flowers for advanced-generation breeding and scionwood for grafting. For many clones, Barnes Creek represents the only site where they will be held in perpetuity. Recently, most activity on the site has been directed toward establishing a transplant bed for Douglas-fir and western larch grafting. Presently, the western larch clone bank is about 30 percent complete.

Objectives:

The objectives of this project were to:

- transplant 100 young grafted Douglas-fir trees from the Kalamalka Forestry Centre to Barnes Ck., and make approximately 1,000 grafts in the grafting bed;
- maintain and protect the site by mowing the grass cover crop, spraying Roundup along tree rows, irrigating young grafts, and controlling pests as necessary;
- prune rootstocks, and stake and winterize young grafts; and
- weed, water and maintain the area's recently established grafting bed.

Progress:

About 100 grafted Douglas-fir trees were planted on the site. All routine site maintenance and graft maintenance was completed as planned. Fortunately, despite a long, hot and dry summer in 1998, very few trees were lost because of drought. In the new grafting bed, about 980 and 120 grafts of Interior Douglas-fir and western larch were made, respectively. These grafts will be transplanted into their final locations in the archive in spring 2000. [OTIP 195]

6.1.23 Support for Operational Research Plantations at Skimikin

Keith Cox

Project Description/Overview:

40 research plantations at Skimikin provide information to increase genetic gains, to verify the transferability of high gain material, to screen seed sources, to compare stock types, to rank progeny, and to compare the genetic diversity of seed orchard seedlots to wildstand seedlots. Some of the younger plantations need to be managed to optimize growth and survival, so that meaningful data can be collected as soon as possible.

Objectives:

- to promote rapid growth and high survival in the plantations, and
- to accelerate the availability of reliable data.

Final Results or End Product:

Insects and competing vegetation were controlled resulting in good growth. This was done by applying herbicides, spraying Vendex for spider mites, and mowing. Two plantations were thinned to extend their usefulness. Fall measurements were taken in several of the plantations.[OTIP 140]

6.2 Seed and Vegetative Material Production.

Projects that are funded under this section are designed to enhance seed and vegetative production, and the production capacity for seed orchards and vegetative facilities. It also involves the study and development of techniques and genetic processes that improve production capabilities.

6.2.1 Management and Maintenance of Abies amabalis Orchard #129

Tim Crowder

Objective:

The objective of this project was to provide management and maintenance of this orchard, in a way that will promote consistent and copious production seed, as it is currently the only remaining Ba orchard.

Activities/Results:

- 2,230 orchard trees were fertilized, irrigated, pruned, and sprayed against insects, and competing grass and vegetation.
- Surveys for reproductive buds, insect and disease damage, cone production and cone maturity were carried out.
- Two litres of pollen were collected, extracted and stored for supplemental mass pollination.
- 78 litres of cones were collected, extracted, and the seed stored.
- Trees were tagged and pruned.[OTIP 223]

6.2.2 Establishment of Second Generation Western Redcedar Seed Orchard-Phase 1

Oldrich Hak

Objective:

The objective of the project is to bulk-up clonal material currently in field trials under the Western Redcedar Breeding Program, administered by the MoF at the Cowichan Lake Research Station. The breeding strategy of the program involves testing of approximately 450 parent trees from Western Forest Products, Timber West, and Canfor orchards. This project involves bulking-up 50 clones represented in the 1998 field trials. The bulking-up strategy will accelerate the genetic upgrading of the existing Cw orchards, by reducing the time for the establishment of the genetically improved orchard by half, thus meeting the FGC target to produce genetically improved seed by year 2007.

Results:

A total of 150 parent trees, tested in the 1998 progeny trials, were re-propagated by rooting of cuttings.

This bulked-up genetic material will be held in a holding area until the assessments of the progeny trials are completed in 2003.

At that time, clones with high breeding values will be selected from the holding area and planted in the genetically improved orchard.[OTIP 170]

6.2.3 Enhancing Genetic Gain and Seed Production in Western Redcedar

Oldrich Hak

Objectives:

- To increase cone production in two western redcedar orchards at Lost Lake by means of hormonal treatments.
- To enhance genetic gain in two western redcedar orchards at Lost Lake by using supplemental mass pollination and by developing high gain custom seedlot.
- To improve pollen viability for breeding and for supplemental mass pollination (SMP), by investigating proper pollen handling and storage techniques.

Activities:

Approximately 600 trees in two western redcedar orchards were treated in July 1998 with foliar application of GA3 hormone.

SMP on the GA3 induced trees will be carried out in February 1999.

Approximately 40 clones will be selected from two orchards at Lost Lake and control pollinated in February 1999, with pollen extracted from genetically improved material at Timber West orchard.

Pollen will be extracted in February 1999 in different environments, with combination of high and low temperature and humidity, to determine the optimum extraction conditions for high pollen production and viability. The pollen will be dried to various levels of relative humidity and stored at different temperatures to determine optimum storage conditions for high pollen viability.[OTIP 171]

6.2.4 Enhancing Genetic Gain in Second Generation Douglas-fir Orchard

Oldrich Hak

Objectives:

Produce a high gain custom seedlot at the Saanich Forestry Centre (Fd 166) by selecting and breeding superior clones.

Results:

A high gain custom seedlot, breeding value of 17.5, was produced at the Saanich Forestry Centre in fall 1998. Approximately 1.5 hl of cones were harvested, producing an estimated 0.6 kg of seed, or 28,113 plantables.[OTIP 141]

6.2.5 Orchard #149 1999 Crop Initiation

Gordon Morrow

Project Description/Objective:

The objective of the project was to increase the 1999 crop volume potential of Orchard #149, at Bowser Seed Orchards, by the application of circumferential stem girdling and gibberrellic acid treatments to approximately one half of the orchard ramets.

An annual need for 110 kilograms of enhanced gain Coastal Douglas-fir seed has been identified for the Maritime Seed Planning Zone. Orchard #149 is designed to produce 36.7 kilograms toward this need. The project will increase the number of cone and pollen bearing ramets in the orchard above that which would naturally occur, and thereby increase the volume and effective population size of the 1999 crop.

Activities:

425 ramets, in one contiguous half of the orchard were assigned to two induction regimes. The orchard, is double planted on a 9 meter by 4.5 meter grid and designed to be rogued to 9 meters by 9 meters. Ramets in temporary locations will be assigned to an induction treatment, including both circumferential stem girdling and gibberrellic acid 4/7 (GA). Ramets in permanent locations will be assigned to an induction treatment of girdling alone. All treatments will be administered in late April and early May before vegetative bud burst. Ramets undergoing stress will be exempted from the project.

GA 4/7 treatments were administered in holes bored in the stem of the ramet between the bottom and second whorls. Numbers of holes per ramet were varied with stem diameter. GA solutions were developed in the light of past experience. Treatments with stem girdling consisted of double overlapping semi-circumferential knife cuts through the bark and cambium layers. Treated ramets were given supplemental irrigation to prevent excessive moisture stress until the wounds have completely healed. Treated ramets were examined after treatment to identify *Dioryctria abietivorella* infestations. Infestations will be removed by mechanical excision.

Results:

This project has resulted in an estimated 50% increase in the volume of the 1999 seedlot. Seedlots from this orchard have a genetic worth of approximately plus 9% for stem volume (B_vVol => +9%) and not less than -1% (B_vWood => -1%). Seedlot effective population size (N_e) will also be increased to an as yet unknown degree. Autumn surveys conducted in the orchard indicate it to be carrying an estimated potential of 100 hectiliters of cones. [OTIP 211]

6.2.6 Fertilization and Maintenance of High Elevation Douglas-fir Progeny Test Sites

Patti Brown

Activities:

The two high elevation Douglas-fir progeny sites outplanted in 1997 on TFL 37 had 100% survival and good growth. However, one site is extremely poor nutrient wise, and the other site is on a very steep slope, which results in slash creep. Fertilization and removal of slash is intended to result in better and quicker results from these sites.

Results:

The sites were fertilized with Scotts ForestKote 22-4-6 in May 1998, when the progeny were also checked for survival status, and slash/brush was removed. Progeny are doing well and survival was 99% on both sites.[OTIP 104]

6.2.7 Field Testing of Western Hemlock Cuttings with High Volume Gain
Patti Brown

Objective:

The objective of this field trial is to compare the field growth and performance of hemlock cuttings and seedlings of the same stocktype and genetic makeup, to determine if cuttings are an acceptable alternative to seedlings for reforestation.

Activities:

The outplanting of this trial occurred in March of 1998 on five different Coastal sites in each of the partners' operating areas, M&B, Western, Timberwest, Canfor, and Interfor. The average cutting and seedling heights were not significantly different at time of planting. The trial sites are currently being weeded and measured for height, diameter and form, the first year after planting.

Results:

This is a multi-year project. Results are expected in the year 2002. [OTIP 103]

6.2.8 Upgrading of Douglas-fir Orchard #134
Tim Crowder

Objective:

The object of this project was to increase the genetic gain of seed produced from orchard #134 to an average of +15%.

New high gain clones transplanted.

Activities:

- 724 trees were grafted from 19 families with breeding values over 15%.
- Grafts were maintained in a greenhouse for two months, then potted up and maintained in a holding area.
- Planting plan and planting sites within the orchard were prepared. [OTIP 225]

6.2.9 Delivering High Gain Western Hemlock Reforestation Material to Fulfill all of our Coastal Requirements Between 0 and 800 Metres.
Patti Brown

Background:

The goal of this project is to meet all of our western hemlock needs under 800m with reforestation material of a genetic value greater than 10 for areas between 600m and 800m, and greater than 13 for areas under 600m. Emphasis during this period will be on the 600m - 800m range, as that is where the majority of logging is currently taking place.

Activities:

- 237 litres of cones were obtained from the 1998 controlled crosses, and are in the process of being registered as SL60379 with a genetic worth (GW) of 15.5. This will produce approximately 400,000 seedlings for operational usage. In addition, 30 litres of controlled cross cones for elevations between 600m and 800m were collected, and are being stored until next year when more parents can be added to the mix for registration.
- 95 ramets with GW greater than 8 were induced with GA4/7 for operational controlled crosses in 1999.
- 68 ramets from Forks selections and high gain BC selections were added to Orchard #179 in August 1998 to increase the value and productive capacity of our new high gain hemlock orchard.[OTIP 105]

6.2.10 Enhancing Genetic Gain in Western Hemlock Seed Orchard
Oldrich Hak

Objectives:

Produce a high gain custom seedlot at Lost Lake (Hw 126) orchard, by control pollinating clones that have breeding values higher than 10.

To upgrade breeding value of the existing second generation (Hw 170) seed orchard from 7% to approximately 13% volume gain at age 60.

Results:

A high gain custom seedlot, breeding value of 15.7, was produced at Lost Lake (Hw 126) orchard, in fall 1998. Approximately 0.4 hl of cones were harvested, producing an estimated 0.25kg of seed, or 61,040 plantables.

Existing second generation Hw 170 seed orchard was upgraded from 7% to 14.5% breeding value, in fall 1998.[OTIP 167]

6.2.11 Incremental Orchard Management Activities at Kalamalka Seed Orchards

Chris Walsh

Outline of Project:

The project involved a number of activities which increased the quantity and genetic quality of seed produced at Kalamalka.

Activities:

- Stem girdling in two larch orchards to induce flowering.
- Sanitation picking of cones to reduce pest populations.
- Renewal of tree labels so that requested customized seedlots and special pollen lots could be collected and so that directed cone induction treatments could be made.
- Survey for, and manual removal of, various pine pitch moths (*Petrova spp.* and *Synanthedon spp.*).
- Basal pruning of trees in several orchards to reduce pest populations.
- Shaping and topping of selected trees in several orchards to improve access to crops.
- Application of insecticidal soap to reduce adelgid populations, and the resultant negative effect on cone production.
- Soil sampling survey at both orchard sites to check soil nutrient status.
- Manual removal of weevil infested leaders to reduce weevil damage, and sustain productivity of orchard trees.

Work completed:

All activities were successfully completed.

Product:

Improved orchard health and efficiency, resulting in sustainable delivery of improved seed of Interior spruce, Interior lodgepole pine, western larch, western white pine and Interior Douglas-fir.[OTIP 107]

6.2.12 Improving Orchard Composition at Kalamalka Seed Orchards

Chris Walsh

Outline of Project:

The availability of new progeny test data creates new opportunities to improve the genetic worth of seedlots produced at Kalamalka. In consultation with Tree Breeders, trees of lower breeding values were removed from orchards for which there was new data. Concurrently, trees of high breeding value were added to orchards through grafting.

Work Completed:

- Major new grafting was done in the EK zone Lw orchard, based on three year data from the series two progeny tests. The lower ranked trees served as rootstock. Approximately 210 grafts were made, 160 were alive in the fall. The lower than predicted success rate is attributed to the extraordinary heat and drought of the summer of 1998.

New Lw graft to improve orchard composition

- The other large grafting effort was for the EK/ Nelson zone Sx orchard. Approximately 260 grafts were made on seedling rootstock established earlier at orchard locations, 187 survived, an acceptable rate for Sx field grafting for last summer.
- A smaller number of grafts were made in holding beds and at orchard locations for other Sx and Lw orchards at Kalamalka.
- Low breeding value clones and untested clones were removed from Sx and Lw orchards.

Product:

Greater quantities of higher genetic worth Sx and Lw seed will be produced.[OTIP 108]

6.2.13 Supplemental Mass Pollination to Increase Genetic Worth of Seedlots Produced at Kalamalka Seed Orchards

Chris Walsh

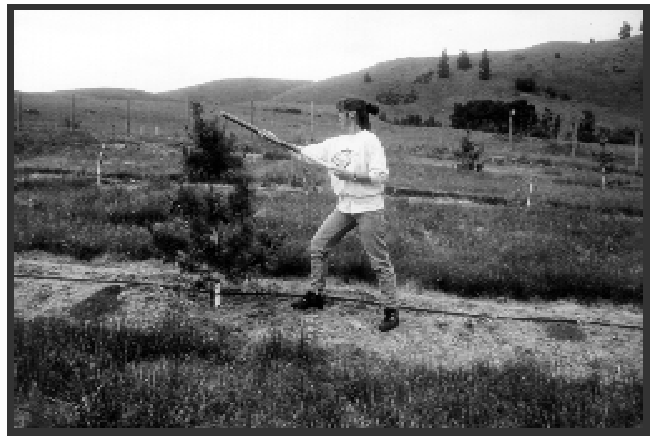
Outline of Project:

High breeding value pollen can be collected from clone banks and applied to various seed orchards at Kalamalka, improving overall fertilization efficiency, reducing pollination by undesirable parents, and increasing seedlot genetic worth. The result will be an increase in both the quantity and genetic quality of seed produced.

SMP of Pli at Kalamalka

Work Completed:

Considerable quantities of high breeding value pollen were collected, extracted and stored, over 28 litres Sx, 4.8 litres Pli and 1.8 litres Lw. Approximately 1.5 litres of Pw pollen from rust-tolerant sources was purchased from the Inland Empire Tree Improvement Cooperative. No Sx pollen was applied because of the lack of an Sx cone crop, but SMP was applied in two Lw orchards, one Pli orchard and one Pw orchard.



SMP of Young Pw at Kalamalka

Product:

Greater quantities of higher genetic worth Lw seed was produced in 1998, and greater quantities of higher genetic worth Pli and Pw seed will be produced in 1999. The 1999 Sx crop will benefit, in that the pollen collected under this project will be applied in the coming year.[OTIP 109]

6.2.14 Orchard Establishment at the Bailey Site of Kalamalka Seed Orchards

Chris Walsh

Outline of Project:

The proposal consisted of the continued establishment of two ITAC approved seed orchards (Fdi WK low and Pw south Interior) and the continued establishment and maintenance of the Fdi propagation bed.

Work completed:

- After the adoption of the revised seed planning zones, it was decided by ITAC to amalgamate the planned Fdi WK low with the existing Fdi SA low, to form the NE low orchard at Grandview. As a result, this portion of the project was not completed and funds were returned.
- Approximately 420 ramets from the CFS rust tolerance screening program were planted in the existing Pw orchard at Kalamalka's Bailey Site,

which will serve the new KQ (Kootenay Quesnel) seed planning zone.

- The existing 2,250 seedlings in the Fdi propagation bed were maintained; by the fall of 1998 the majority were ready for grafting.

Product:

Increased capacity to produce rust tolerant western white pine seed.

Graft-compatible rootstock for the production of Interior Douglas-fir orchard trees.[OTIP 110]

6.2.15 Collect Supplemental Mass Pollination (SMP) Enhanced Crops at Kalamalka Seed Orchards

Chris Walsh

Outline of Project:

SMP can significantly enhance the quantity and/or genetic quality of seed produced. The proposal estimated the crop volumes for orchards that were eligible for SMP enhancement and the costs of cone collection.

Work completed:

The Sx crop was extremely light, no SMP was applied and no operational crops were collected. Funding for this portion of the project was returned.

- 13.5 hl of cones were collected from two larch orchards, yielding 9.6 kg of seed.
- 1.2 hl of cones were collected from the white pine orchard, yielding 0.18 kg of seed.

Product:

- Improved larch seed for the Nelson and East Kootenay seed planning zones.
- Rust-tolerant western white pine seed for the Kootenay Quesnel seed planning zone.[OTIP 113]

6.2.16 Graft Maintenance - VSOC Holding Area for 1998

Tim Lee

Project Description/Overview:

The need to care for newly grafted ramets has made the development of a holding area a necessity to promote the development of our orchards. Due to the size of many of the orchards, this holding area has aided in establishing the grafts before they were taken out into the orchard, where individual care is not possible. With a larger healthier graft, orchard establishment is quicker, as mortality is less than if grafts are planted out in orchard position when smaller.

Objectives:

To provide cost effective, quality care for the development of new ramets prior to outplanting into the orchard location, and to expedite the establishment of VSOC orchards for the production of genetically improved seed.

Final Results or End Product:

Grafts have grown to a good size for establishment in the orchard positions. This will be the final planting for most of the orchards, and will complete most of the orchards at VSOC. Once orchards are completely planted, it is closer to the production of the target amount of seed. As so little improved seed is available for the Interior, the completion of orchards is a vital step towards that eventual seed production.[OTIP 122]

6.2.17 Drainage Systems for Water Problems within Orchards

Tim Lee

Project Description/Overview:

The installation of a permanent drainage system that removes unwanted seepage or surface water from entering our orchards. An area of approximately 1.74 ha will be drained overall, thus improving the growing conditions for up to 900 ramets. The drain pipe will be installed two to three feet deep, and drainage rock will be used to help collect excess water. Drained water will be disposed of in a safe area outside the orchard boundaries. The system is simple and future maintenance will be easy. This will aid the orchards in achieving their target production levels.

Objectives:

- The installation of a permanent drainage system that is easy to maintain and that will provide adequate drainage for problem areas.
- The collection of surface and seepage water before it enters the orchard.
- The removal of unwanted water before it can affect the orchards ramets.

The projected production of these orchards is in excess of 30 million seeds per year. All protective measures must be taken to aid production ramets.

Installation of drainage system

Final Results or End Product:

The drainage system will help ensure the target production of genetic improved seed for the planning zones. The permanent system is easy to maintain and expand, if required in the future. No genetic improved seed of this quality is available for the planning zones of these orchards. The target production for the involved orchards is in excess of 30 million per year.[OTIP 126]

6.2.18 VSOC - All Orchards on Site. Tree Nutrition Activities - Foliage Analysis

Tim Lee

Project Description/Overview:

The monitoring of ramet health in each orchard is a common practice in managing orchards to ensure optimum seed production. Samples of foliage from each orchard are dried separately in a laboratory oven, and needles then ground for analysis. A contract laboratory reports the results, which are then graphed and assessed for fertilizer required in the coming year. This practice is carried out annually and is a common management practice for most orchard sites.

Objectives:

Monitoring of nutrients will ensure optimum ramet development and seed production. By monitoring nutrient levels, we have an opportunity to add nutrients if they are found to be deficient. The projected annual seed production for the VSOC site is over 76 million. The seed produced is for the three main species harvested in the central Interior of British Columbia.

Final Results or End Product:

Healthy ramets are capable of carrying healthier cones and a greater quantity of them. This will help VSOC meet its target production level of more than 76 million seeds per year. Most seed planning zones in the Interior have little, or no, genetically improved seed available at this time. As the demand increases yearly for improved seed, management of our orchards plays a vital role in this supply.[OTIP 129]

6.2.19 VSOC - Pest Management Activities for the Control of *Adelges Cooleyi* and *Cinara*

Tim Lee

Project Description/Overview:

Monitoring pests in the early spring and throughout the summer is essential to understand the life cycles, populations and timing of orchard pests. The timely application of the correct pesticide is required to control a population that have the potential to damage the ramets present or future seed production. The correct equipment and clothing is needed to apply pesticides safely.

Objectives:

Monitoring for pests in the spring and periodically throughout the summer, will ensure timely spray applications. *Adelges cooleyi* overwinter in the Douglas-fir and affect both the spruce and the Douglas-fir during the growing months. *Cinara* often are treated, as required, on affected trees by hand applications. Insect monitoring and spraying are essential for proper management of orchard health and seed production.

Final Results or End Product:

Monitoring and spray applications have been needed to control the infestations of pests this year. Early spring through to the beginning of summer was the busiest period for pest control. A number of outbreaks required repeated spray applications to lower the population of harmful insects. Monitoring continued until early fall, when the populations of pests were at normal levels.[OTIP 130]

6.2.20 Harvesting of Crop Enhanced through Supplemental Mass Pollination (SMP) Treatments in 1997
Tim Lee

Project Description/Overview:

Surveys are taken of cones to be harvested. The data taken will aid in the picking of cone crops, and in calculating the genetic worth of the seedlots produced. Cones are picked, cleaned, dried and seed extracted. Seed is then sent to the Tree Seed Centre for testing and storage.

Objectives:

Cones harvested in the late summer of 1998 are from pollen treatments applied in May of 1997. Surveying the cone crop to be picked is important. The data collected is used to aid the harvest of cones, and in the calculation of the genetic worth of the seedlots produced. Target production for the orchards at maturity is greater than 30 million seeds per year. The production of genetic improved seed begins earliest in orchards where pollen is managed with the use of SMP. The demand for seed is greater than the supply for seed planning zones, as presently no improved seed is available from these orchards.

Final Results or End Product:

Early production of genetic improved seed is imperative to the affected seed planning zones. Management techniques used to aid seed production in the early life of orchards has been practised for many years in BC. As a result, early seed production is possible from relatively young orchards, with very little pollen development to this point in the orchards life. SMP ensures that pollen is applied to the receptive flowers to aid in early seed set. No genetic improved seed of this quality is available for the affected seed planning zones.[OTIP 131]

6.2.21 Pollen Collection and Supplemental Mass Pollination (SMP)
Tim Lee

Project Description/Overview:

Pollen work is required in the early years of an orchard's production life. Other orchards are in stages of production where a certain seedlot is required to address a reforestation need. Pollen work was required in the Bowron Lake spruce #214 and the Bulkley Valley #219 and Willow Bowron #222 pine orchards. Surveys are taken in the orchard to ensure the inclusion of all this year's producing clones. Pollen is processed and immediately used or stored for future use. SMP applications are made to ensure pollen is available for the receptive flowers of the current year. All pollen was processed by clone, to ensure the quantities and identity. Pollen can than be mixed for SMP applications. SMP applications were made to the lodgepole pine orchards.

Objectives:

Collect pollen from the top 12 breeding and weevil resistant clones in the Bowron Lake Spruce Orchard #214. Surveys were taken to include all possible clones, and what little pollen was produced was picked and processed for use in the future. As little flowering took place in Bowron Lake Spruce Orchard this year, our work shifted to the Bulkley Valley and Willow Bowron lodgepole pine, where both male and female flowering was good. Surveys were taken to include as many clones as possible in our pollen processing and mixes for SMP applications. Four SMP applications took place over the two weeks of receptivity. The female flowering has increased dramatically over what flowered last year. The number of clones involved in production has increased to include near to 40 and more, in both orchards. Pine orchards will have a good crop to harvest next year.

Final Results or End Product:

Future genetic improved seed will be produced from processed pollen and SMP applications to orchards. The beneficiaries of this project include: the Vernon Seed Orchard Company partners, the MoF (through their eventual share in seed production), and other licensees in the area, through surplus seed sales.[OTIP 132]

6.2.22 Orchard Development - Layout, Drilling and Planting
Tim Lee

Project Description/Overview:

McGreger Spruce #211, Central Plateau #218, Bulkley Valley #219 and Willow Bowron #222 lodgepole pine orchards are in the development stage. Planting sheets are required to mark positions, drill, flag, hole and plant ramets. Both the Bulkley Valley and the Willow Bowron are nearing production, with the initial ramets planted, so it is important to complete the planting of the remaining open positions.

Objectives:

Orchards under development require layout and planting of ramets. Ramet positions in the orchard were marked, drilled, the ramets delivered and final planting completed. Ramets were lifted from the VSOC holding area for this planting project. This planting will bring the orchards closer to establishment and to the production target for the planning zones.

Final Results or End Product:

When all the orchards in question are fully developed, the total production will be greater than 50 million seeds per year. The genetic gain will range from 10+ % for pine and well over 20+% for spruce. The beneficiaries of this project include: The VSOC partners, MoF (through their eventual share in the seed produced), and other licensees in the area, through surplus seed sales.[OTIP 133]

6.2.23 Incremental Orchard Management Activities at Skimikin Seed Orchards

Keith Cox

Project Description/Overview:

Several activities were undertaken to improve the genetic quality of the seed produced, and to either

Drilling tree for hormone injection.

increase the size of crops or to improve crop protection.

Objectives:

To produce seedlots with increased genetic worth in the West Kootenay/Bush and Central Plateau high and low elevation spruce seed orchards. To increase the size of crops in western white pine.

Final Results or End Product:

In the West Kootenay spruce seed orchards 247 low-ranked trees were removed, based on three year progeny data. Also, a total of 1,390 high-ranked trees were labelled and 1,345 of them were given injections of Gibberillic Acid (GA) and/or drought stressed to induce a high quality crop for 1999. In the Central Plateau high elevation spruce seed orchard, 92 high-ranked trees were injected with GA and another 151 were drought stressed. Surplus cones were picked in June, as they were infested with the spruce cone maggot. From these cones, approximately 8,500 larvae were extracted and sent to researchers who are working on control methods.

Signs of a good Pw crop for 1999.

The spruce grafts in the holding area were pruned, watered, and fertilized. Another 800 were received in the fall and will be planted in the spring. The older grafts will be ready to plant into the new orchard for the Peace River zone in the spring of 2000. The white pine orchard is carrying a sizeable crop that will mature in 1999.[OTIP 137]

6.2.24 Accelerated Propagation - Skimikin
Keith Cox

Project Description/Overview:

Increases in the sizes of several Interior seed orchards are required to meet the demand for improved seed.

Objectives:

To propagate up to 5,000 extra grafts in 1999.

Final Results or End Product:

Finalized requirements in March showed that there was a need for 2,500 extra lodgepole pine grafts in 1999. This extra amount was potted up in May, grown outside throughout the summer, then moved into a greenhouse for over-wintering. It will be used for grafting early in the spring of 1999.[OTIP 144]

6.2.25 Pollen Management Activities to Increase the Genetic Worth and Yield of Seedlots at the Prince George Tree Improvement Station
Carole Fleetham

Outline:

Two rogued lodgepole pine orchards at the Prince George Tree Improvement Station required pollination to increase the yield and genetic gain of the seed currently produced. High gain pollen collected from clone banks was applied. The two provenance seed orchards are beginning to produce seed that will have a genetic gain of 6% at rotation, but are at risk from outside pollen contamination. These orchards are designed to meet 25% of the seed needs for central and northern BC. To decrease the risk from mal-adapted seed, supplemental pollination was carried out.

Activities:

- In May 1998, 20 litres of high gain pollen (6%-16%) were collected from the lodgepole pine clone banks at Red Rock Research Station, and from orchard trees at the Prince George Tree Improvement Station. Pollen was collected with cyclone vacuums. The pollen was cleaned, tested and stored for supplemental mass pollination (SMP) in 1999 in orchards #220, #223 and #228.

Pollen collection with cyclone vacuum.

- Pollen collected in 1997 (7% gain), was used for SMP in May and June of 1998 in orchards #223 and #228. A total of 5,280 ml was used in three applications. SMP is carried out by discharging compressed air through a container of dried pollen and into the tree crown.
- Phenological surveys were completed in Orchards #220 and #228. Identification of early and late clones in an orchard is necessary to maximize SMP effectiveness.
- Beginning in late May and continuing into early June, two representative ramets of each clone within each orchard were identified and used to score female receptivity in accordance with ***"Protocols for Rating Seed Orchard Seedlots in BC"***.
- Pollen shed was also surveyed, following the standards in the same publication.
- Pollen density was monitored using seven-day recorders.[OTIP 146]

6.2.26 Collection of SMP Enhanced Crops at the Prince George Tree Improvement Station
Carole Fleetham

Activities:

In 1998, 6.5 hl of lodgepole pine cones were collected from two orchards (#203 and #228) previously enhanced with pollen. This collection represents approximately .5 million seedlings for reforestation in the PG low and BV low planning zones. Pollen was applied to increase the production of seed and improve the genetic worth of the seedlots.[OTIP 147]

6.2.27 Incremental Orchard Management Activities at the Prince George Tree Improvement Station

Carole Fleetham

Background:

Three lodgepole pine seed orchards at the Prince George Tree Improvement Station (#220, #223 and #228) produce seedlings for the PG low, CP low and BV low planning zones. All three orchards are young and require various management activities to improve seed production and quality for these zones.

Activities:

To increase the production of flowers, the tree crowns in these orchards were pruned in June 1998. Non-cone bearing shoots greater than 20 cm. in length, were cut in half. The result was an increase in the number of intra-fasicular buds and the potential for more flowers in 1999.

To increase the quality of seedlots, old cones were removed from orchard #228 and discarded. These cones were produced without supplemental pollen and, therefore, the genetic quality was less than optimal.[OTIP 150]

6.2.28 Orchards 313, 311, 308, and 321 - Phenological Surveys

Janet Lane

Background:

This proposal was to characterize the phenological attributes of the one mature and three developing orchards on the Armstrong site. The project is important to understand the impact of orchard to orchard pollination and possible clone combinations.

Activities:

Unfortunately, the proposal approval came too late to characterize the flower receptivity. However, data files were set up on a HP200LX Palm top, and the pollen shed was characterized for three pine orchards and downloaded into SOIS. The data on pollen shed will be used to calculate the genetic worth of seed from Orchard #308 picked in 1999.

Additional phenological surveys may be possible in early spring. [OTIP 156]

6.2.29 Supplemental Mass Pollination (SMP) to Increase Seed Production and Provide Seed to Confirm SMP Efficacy

Clare Hewson

Outline of Project:

SMP is a recognized orchard operational tool used to improve genetic worth of seedlots and to increase seed production, particularly in developing orchards. This program was initiated in 1998, with the primary purpose of increasing seed production in one private and four ministry seed orchards. Concurrently, as pollen was collected from clones with unique DNA markers, this program will provide seed for future studies to determine the contribution made by the supplemental application of pollen, identified as a high priority program in the Tree Improvement Council's ***Summary of Priorities for Operational Program*** proposals.

This is a co-operative project involving seed orchards at the Prince George Tree Improvement Station, Weyerhaeuser Seed Orchards, Armstrong, and Kalamalka Seed Orchard, Vernon, with collaborators from the MoF Research Branch and BC Research Inc.

Progress to Date:

Pollen collection commenced May 2, 1998 in Orchard #307 (Shuswap Adams Lodgepole Pine Orchard). The pollen vacuum was used to collect a total of 8.0l of pollen from seven clones identified as having unique DNA markers in this orchard. In addition, 7.8l of pollen was collected from unique clones or trees located at the Prince George Tree Improvement Station. The pollen has been extracted, cleaned and placed in storage.

In 1999, the pollen will be bulked by planning zone. It will be reapplied operationally to developing seed orchards #228 and #220 and mature orchard #204 at the Prince George Tree Improvement Station, developing orchard #313 at Weyerhaeuser Seed Orchard in Armstrong, and mature orchard #307 at Kalamalka Seed Orchard. Pollen will be applied to orchard trees using standard operational techniques. SMP will not be applied to specific portions of each orchard and these areas will act as controls. The crop will be harvested in the fall, 2000, and samples of cones will be collected from each orchard area, and extracted separately to confirm the increased productivity resulting from SMP.

In addition, individual cones will be collected from each area in each orchard and stored for future analysis of chloroplast DNA to confirm the contribution of SMP applied pollen.[OTIP 179]

6.2.30 Cone and Seed Pest Management – Interior Operations

Robb Bennett

Project Description/Overview:

Provide cone and seed pest management services to Interior conifer seed production industry including government and private seed orchards and natural stand cone and seed collectors and dealers.

Objectives:

To provide wages for one pest management biologist and money for travel to orchard sites and related field work and extension activities, vehicle and facility maintenance, and laboratory and office supplies.

Activities:

During the period 1 April – 31 December, the pest management biologist (Dr. Ward Strong) provided the following services to the Interior cone and seed production community:

- 83 pest surveys and identifications, damage predictions, and assessments.
- 45 written reports to orchard managers and other personnel.
- 53 other pest identification services to forestry personnel and others.
- Seven extension education presentations to students.
- Eight professional presentations to various groups.
- Numerous “tail-gate” type extension presentations to operational personnel.[OTIP 214]

6.2.31 Flower Stimulation on Seed Orchards #134, #152 & #154.

Tim Crowder

Objectives:

The objectives were to produce the following amount of improved seed:

- Douglas-fir seed with a genetic rating + 10% 2,500,000 Plantables.
- Western redcedar 2,500,000 Plantables.

Activities/Results:

- 475 Douglas-fir trees and 102 western redcedar trees were treated with G.A. growth hormones, and irrigation was withheld to induce reproductive buds.
- All trees that were induced have both male and female flower buds initiated, and are classed as heavy crop trees. This provides options for increasing Genetic Values by controlled crosses and supplemental mass pollination through pollen collection, extraction and re-application.

This growing season the orchards have the potential to produce:

- Douglas-fir seed with a genetic rating + 10% 2,500,000 Plantables.
- Douglas-fir seed with a genetic rating + 7% 1,000,000 Plantables.
- Douglas-fir seed with a genetic rating + 5% 2,000,000 Plantables.
- Western redcedar 2,500,000 Plantables. [OTIP 222]

6.2.32 Central Plateau Pli #218 - Enhanced Genetic Quality through Roguing

Tim Lee

Project Description/Overview:

The latest measurements of progeny tests for the Central Plateau lodgepole pine breeding zone indicate that six clones have fallen in the rankings and require removal. 330 ramets will require removal from their planted position in the orchard. Removed ramets will be shredded and positions renewed for the six improved clones that will replace each ramet. The orchard is not completely established, so the addition of new clones at this time is opportune.

Final Results or End Product:

Establishment of this orchard is not complete, so changes to the clonal complement at this point is optimum timing, as all clones will come into production together. The production target for this orchard is 12.9 million seeds annually. The beneficiaries of this project include: the VSOC partners, the MoF (through their eventual share), and the other licensees in the area, through surplus seed sales. At this time no improved seed of this quality is available for the planning zone.[OTIP 125]

6.2.33 Inadequate Root Development of Lodgepole Pine Ramets

Tim Lee

Project Description/Overview:

The use of a stake and tree rope is required to help some 1,000 ramets to remain upright in affected orchards. The development of stronger root systems is essential, as the orchards are beginning production, and the loss of some ramets is expected if they were not anchored immediately. Some of the first anchored ramets have developed stronger root systems, and supporting ties have been removed.

Final Results or End Product:

Many ramets have developed strong roots and the production potential remains intact. Seed production has begun and any improvement to the orchards health will aid in future production. Target production for the orchards is greater than 30 million seeds per year. No genetically improved seed is available for affected seed planning zones that the orchards supply.[OTIP 127]

6.2.34 Central Plateau Fdi #225 - Installation of Cooling System for Flowering Delay

Tim Lee

Project Description/Overview:

A cooling system was required to delay the flowering in the Central Plateau Fir orchard. An automatic cooling system was designed and installed, using a misting system to dampen foliage and take advantage of transpiration in the early spring. This cooling is felt to delay the reproductive flowering of fir by as much as a week to ten days. The permanent system is now complete and works very well. As the system will operate during a period of frost danger, the design required all irrigation lines to drain after each application of water. The filter system and automatic controls were housed in a small insulated irrigation building.

Installation of cooling system for flowering delay.

Final Results or End Product:

The cooling system has been installed and tested. The system will eliminate pollen contamination, and aid in the production of Genetic Improved class A seed for the Prince George and Quesnel Lake Planning Zones. The orchards concerned are nearing initial production and the timing is opportune.[OTIP 128]

6.2.35 Orchard Improvement: Expansion of Seed Orchards #311 and #313 to Meet Seed Demands

Hilary Graham

Background:

In order to produce an adequate supply of lodgepole pine seed for the Thompson Okanagan (TO) low and the West Kootenay/Shuswap Adams (WK/SA) seed zones, expansion of orchards #311 and #313 was proposed.

Activities:

Activity in the first year included the potting up of 3000 Pli seedlings (at least three years old), and the establishment of a holding area. These seedlings will provide the rootstock for grafting in the spring of 1999.

In the summer of 1998, a holding area was established for the rootstock. A backhoe was used to dig 10-inch deep by 24-inch wide trenches. An irrigation system to maintain the grafts for two years was installed.

The rootstock material was obtained from existing outplant trial beds at the nursery. These seedlings were grown in the outplant beds until October of 1998, when they were potted up.

Transporting potted rootstocks to the holding area.

The potted seedlings were then moved to the established holding area and placed in double rows in the furrows. Bark mulch was placed over the top of each pot to reduce weed growth and evaporation from the pots. Two layers of .9 mil ground cover were laid down to reduce weed growth between rows. Finally, the irrigation system was set up for spring watering. [OTIP 154 & 155]

6.2.36 Lodgepole Pine Pollen Monitoring in Orchards #311, #313, and #308

Hilary Graham

Background:

The intent of this project was to purchase and install pollen monitors prior to the 1998 pollen release, and to monitor pollen between orchards and from outside sources (Pli holding area). This information was to be used to calculate the genetic worth of the 1999 crop from seed orchard #308, and to provide information on pollen movement on the orchard site.

Activities:

Unfortunately, approval was received too late in the season to conduct this work in 1998.

Instead, pollen monitors have been purchased and installed for monitoring in the spring of 1999. [OTIP 157]

6.2.37 Pollination: Pollen Collection, Extraction, and Re-application (SMP) - Orchard #313

Hilary Graham

Background:

In order to increase seed set in this young orchard, we proposed to use SMP using pollen from the highest ranked clones in the holding area.

Activities:

In 1998, year 1 of the project, we planned to collect pollen from the highest ranked clones in the Pli holding area. Unfortunately, approval was received too late in the season to purchase equipment and collect pollen. Therefore, progress to date has been the purchase of a vacuum collector, and the necessary supplies to conduct this work in the spring of 1999. [OTIP 159]

6.2.38 Roguing and Sanitation of Pli SA/TO Holding Area

Hilary Graham

Background:

This project involved the removal of lower ranked clones, and the removal of galls and insects in our Pli holding area. Because this holding area contained early selection clones, it contributed to pollen contamination in adjacent orchards. Also, this holding area had not been actively managed for some years, and removal of insects and disease was necessary to protect the remaining ramets and the nearby orchards.

Activities:

Selection of higher ranked clones was done by MoF personnel at the Kalamalka Research Station. The ramets to remain in the holding area were labeled and employees proceeded to remove the lower ranked clones by chainsaw. Once the lower ranked clones were removed from the holding area, the remaining ramets were inspected for the presence of insects and disease, and any damage or infestation was removed. The final result of this work is a Pli holding area with clones of a higher breeding value, and a reduction in insect and disease contamination from this holding area, which will be used as a source of pollen for future SMP. [OTIP 160]

6.2.39 Pli Thompson/Okanagan Realized Gains Demonstration
Janet Lane

Activities:

A demonstration planting of progeny, produced from the lodgepole pine Thompson Okanagan (TO) low breeding program, was established in a highly visible area of the PRT Armstrong Nursery Site. The demonstration will allow a visible comparison of growth rates between the progeny of highest ranked clones, the progeny of low ranked clones and a natural seed source. It is an appropriate location since the two TO orchards are located on this site.

The site was prepared and the seedlings were planted in early spring. A drip irrigation system was set up to ensure survival of the seedlings. The seedlings received a hand weeding, grass mowing and a spot application of herbicide for maintenance. There was some mortality in the first year, fortunately some extra stock had been supplied. Some replacement stock was moved in the fall.

The one year old seedlings, demonstration layout and interpretive signs were provided by Michael Carlson MoF. [OTIP 161]

6.2.40 Western White Pine Resistant Seed Production for Operational Usage
Patti Brown

Objectives:

- To produce an operational crop from Orchard #174, by collecting and processing pollen, applying individually to cones to maximize seed yield/cone.
- To increase the surface area available for future cone production through crown pruning techniques.
- Increase the resistance value of the orchard, by adding clones that have recently been identified as having a slow canker growth mechanism.
- Outplant crosses from different resistant types, along with operational collections from Dorena orchards, Texada Island, Saanich and Sechelt seed orchards, to determine relative values of resistance for current field use options.

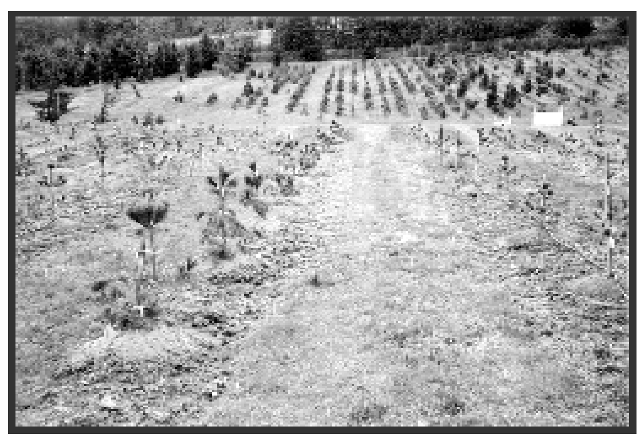
Activities:

- Pollen was collected from all producing ramets and either redistributed or stored for future pollinations. 2,000 cones were hand pollinated in June and monitored for *Leptoglossus* activity on first year cones. Douglas-fir cones were sanitation picked in July to reduce the potential *Leptoglossus* population. No *Leptoglossus* appeared to be feeding on the first year cones, and the 1998 population was concentrated in the hemlock orchard.
- 1997 cones were insect bagged in April 1998 to prevent losses from *Leptoglossus*. 500 cones were collected in August of 1998 from 1997 pollinations, and extracted by clone. An average of 60 filled seeds/cone was obtained from 1997 pollinations yielding a potential 20,000 seedlings.
- Some ramets were top and side pruned in May at time of elongation to see if this method would still produce female flowering branches; while others were pruned, in the way we've successfully done in the past, in August to compare future female production on both types.
- 350 ramets were added to Orchard #174 in August 1998 to replace orchard mortality and to replace four parents with better slow growth canker parents.[OTIP 106]

6.2.41 Consolidation and Expansion of Rust Resistant White Pine Orchard #403
Tim Crowder

Objectives:

The objectives of this project were to consolidate the existing orchard trees that are eight years old and just starting to produce, and add existing families to build up the genetic base of resistance.



New high gain rust resistant Pw clones out planted.

Activities/Results:

- 158 large eight year old trees were moved.
- 307 smaller three to four year old trees were established in the orchard.
- Irrigation was installed.
- Trees were fertilized, tagged and mapped.[OTIP 224]

6.2.42 Controlled Pollination of Sx Orchard # 303
George Nicholson

Objectives:

To produce a crop of high gain seed by collecting pollen from clones with breeding values greater than 8%, creating a poly mix and reapplying this mix to clones with breeding values of 8% or greater. The current genetic gain of this orchard is 4%, and this project would produce seed with a higher genetic value.

Activities:

A vacuum cyclone pollen collector was built to collect the pollen, and small pressurized air guns were used to reapply the pollen to the clones.

Results:

Due to the lack of flowering on clones that were identified to meet our objectives, this project was reduced in size significantly. Pollen was collected from 15 ramets within 13 clones. The flowers from these clones were bagged and control pollinated three times during the receptive stage of the flowers.

The small amount of seed collected produced 250 grams of seed with a genetic gain of 12%. The pollen collecting equipment worked well. [OTIP 116]

6.2.43 Clonal Roguing of Sx Orchard #303
George Nicholson

Background:

Orchard #303 is a first generation orchard with 210 families. Progeny tests have been planted and six-year field data measurements have been completed. This project will remove 390 ramets from 58 clones from the orchard, which represents all the clones with negative breeding values at this time.

Objectives:

The specific goal of this project is to increase the genetic gain of the entire orchard, by removal of negative breeding value clones, without detrimental effects on seed production in the orchard.

Results:

The roguing of these clones has been completed, and the improved seed produced from this orchard in 1998 reflected the genetic gain. The average breeding value of the clones in this orchard has increased from 4% to 6%.

The direct benefits from this project will flow through to the clients using the improved seed from this orchard. These clients will be the Licensees and those participating in MoF Small Business Program in the Thompson Okanagan and Thompson Okanagan Nelson seed zones.[OTIP 117]

6.2.44 Cone Induction Treatment - Orchard #303
George Nicholson

Background:

The Interior spruce orchard #303 is designed to supply improved seed to the Thompson Okanagan and the newly created Thompson Okanagan Nelson seed zones. This is a rogued first generation orchard, producing seed with an average genetic gain of 6%.

Objectives:

The objectives of this project is to ensure a constant and increasing seed supply, by using cone induction techniques with GA4/7 to increase flower production within the orchard.

Activities:

There were a total of 364 ramets treated in the spring of 1998. The GA was mixed with absolute alcohol and injected into the stem of each ramet selected.

Results:

The selected ramets in this project are projected to produce approximately 6.5 kilograms of seed in the 1999 seed crop. This seed production will benefit all Forest Licensees and those participating in the MoF Small Business Program within the seed planning zones.[OTIP 118]

6.2.45 Bowron Lake Sx #214 - Identification of the Top 12 Clones
Tim Lee

Project Description/Overview:

The identification of the top 12 clones will aid greatly in the management of pollen for improving seedlots. A map was made to identify all positions in the orchard that were to be marked. A painted marking was sprayed onto the lower stem for a quick and easy method of identifying ramets for all phases of pollen work in the orchard. An airless paint sprayer was used for the application of the exterior latex paint. The marking will last for many years and aid in seed production for the Prince George Spruce Zone.

Objectives:

An identifying mark was to be placed around the base of each affected ramet to identify the top 12 breeding value clones in the Orchard. The painted marking was to be placed on the stems for years of easy, quick identification. This will aid in the picking, processing and application of SMP pollen for improving the breeding values of future seedlots. Approximately 1,300 ramets were marked.

Final Results or End Product:

A painted marking has been placed on the stem, near the base of all ramets of the top 12 clones. The marking is easily seen, and has already aided in the collection of only improved pollen. This project will assist our orchard works in improving seedlots for the Prince George Spruce zone.[OTIP 121]

6.2.46 McGregor Sx #221 - Enhanced Genetic Quality through Addition of Higher Performance Clones
Tim Lee

Project Description/Overview:

A review of the clones selected for the orchard had left out a number of the better performing clones. The addition of these clones before the orchard was fully developed, was foremost in our decision. One clone had fallen dramatically in rating and was to be removed. All remaining clones had their total ramets lowered to accommodate the addition of the 18 new clones. The orchard was re-randomized, and all written and computer files were changed to reflect the new orchard design.

Objectives:

Remove one clone from the orchard and adjust all others to allow the addition of 18 new clones to improve the genetic gain. 1,060 positions in the orchard were changed to the better clones. The latest measurements of the McGregor progeny tests had shown the need to remove the one clone as its breeding value had fallen. The inclusion of the 18 new clones will achieve a greater genetic gain and diversity in the seed produced. These changes will require re-randomizing of the clone positions in the orchard, and the reorganization of the records, including the Orchard Information System (OIS).

Final Results or End Product:

The development of the orchard has progressed to include the new clones. All future seed produced from this orchard will have a higher breeding value because of the changes. Scion was collected and grafts were made to fill the open positions. The changes occurred at a good time, as grafting for the orchard was not completed. All files have been changed to reflect the new orchard design.[OTIP 123]

6.2.47 Alternate Host Removal for Inland Spruce Cone Rust Control
Keith Cox

Project Description/Overview:

Inland Spruce Cone Rust causes seed losses by infecting individual cones during pollination, then growing in June and killing the developing cone. Infections on the alternate host, One-Sided Wintergreen (*Pyrola asarafolia*), release air-born spores that travel to the receptive spruce conelets during periods of high humidity, usually at night. Removal of the alternate host plants closest to the spruce seed orchards reduces the concentration of rust spores available to infect the spruce cones.

Objectives:

To reduce the amount of seed lost to spruce cone rust in the seed orchards, to ensure adequate supplies of seed are maintained, and to reduce the amount of pesticide used to control the cone rust.

Final Results or End Product:

The alternate host plants were removed along the perimeter of one seed orchard and part of the perimeter of another. The cone rust infection rates were the lowest ever recorded in these two orchards (0.7% and 2.5%). It was not necessary to spray in the orchards. Ten plots were assessed for the recurrence of the alternate host plants. Plots treated twice had a recurrence rate of only 10%. Dense concentrations of plants were sprayed with Vision (glyphosate) at two different times with no effect. Based on this, changes will be made to the spray formulation in 1999.[OTIP 138]

6.2.48 Operational Crown Management in Two Interior Spruce 'High Density' Seed Orchards and Two Interior Western Larch Orchards

Clare Hewson

Outline of Project:

The management of 'high density' clonal row orchards and conventional seed orchards consisting of rapid growing species, pose major crop management problems to the orchard manager with regard to excessive height growth. This was the second year of a long term crown management program, with the primary objective to determine the most cost effective treatment for controlling height growth in these orchards, while, at the same, time maintaining optimal cone and seed production.

Larch orchard.

Activities:

This program was initiated in 1997 under OTIP 69. In the last two years, six crown management treatments were applied to over 600 ramets in the 'high density' spruce orchards and over 2,200 ramets in the western larch orchards. These treatments included various degrees of height control through leader pruning and/ or various degrees of lateral branch pruning to obtain and maintain the desired hedge effect .

Unpruned larch ramet.

Pruned larch ramet.

As this project is being conducted on developing (not producing) orchards, effects of the various treatments on enhancing cone production are still inconclusive. However, the treatments have definitely contributed to more effective orchard and crop management practices (pesticide application, pollination, row access, cone collection, scion collection etc.). It is proposed that these operational treatments be continued to assess their effect on orchard and crop management and crop enhancement in the future. It is anticipated that recommendations for operational crown management of ‘high density’ clonal row orchards and conventional rapidly growing seed orchards could be available as early as 2001. [OTIP 178]

6.2.49 Establishment of High Gain Yellow-Cedar Clonal Orchard

Oldrich Hak

Background:

In 1984, Western Forest Products Limited adopted a clonal approach to produce and genetically improve yellow-cedar planting stock. Problems associated with sporadic seed production, poor seed germination, and high seed prices were the principal reasons for the clonal alternative. Higher initial genetic gains can be made and captured through clonal testing and clonal re-propagation than by breeding and subsequent use of seedlings for reforestation. The genetically upgraded clonal orchard at Western Forest Products will consist of a synthetic population of elite and stable clones that will supply genetically improved planting material for reforestation. The clones have been tested and evaluated for rootability in a greenhouse, for growth performance in the field, and for their adaptability to a variety of sites and locations. The estimated average volume gain at rotation is 18%. The planting of the elite clones in the orchard is planned to commence in year 2000.

Objectives:

- To complete the initial site development for the high gain clonal orchard.
- To produce 50 partially rejuvenated elite clones with approximately 150 stecklings per clone.

Results:

- The site for the genetically upgraded orchard was cleared of vegetation and cultivated.
- The first phase of rejuvenating 50 selected elite clones is completed.[OTIP 169]

6.2.50 Yellow-cedar Seed Orchard Cone Induction and Seed Production

Don Pigott

Project Description/Overview:

This project will carry out cone induction using GA_3 foliar spray applications for the purpose of producing more yellow-cedar seed for both end users and the breeding program. The effects of elevation and climate on the production of viable seed orchard seed will also be determined. Cone crops of this species are infrequent, problems in seed maturation are often encountered, and current supplies of seed, particularly from seed orchards, do not meet the demand from end users. For the yellow-cedar breeding program to progress, the ability to carry out controlled crosses and produce seeds for test material is essential. Thus obtaining more yellow-cedar seed from BC orchards is a priority.

Objectives:

- To increase seed production in MacMillan Bloedel’s Seed Orchard #137, located at two sites, and the MoF Cowichan Lake Research Station (CLRS) clone 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.

Final Results or End Product:

Over the five months data have been summarized, mean temperatures appear to be lowest at Rheinhart Lake than at the other two locations. Mean monthly temperatures were highest at Yellow Point during May and June, after which mean temperatures were highest at the Cowichan Lake Research Station (CLRS). During August and September, mean hourly temperatures at Rheinhart Lake reached levels higher than at Yellow Point, earlier in the day. However, night temperatures were lower at Rheinhart Lake than at Yellow Point during each month between May and September. Hourly data are not available for the CLRS; however, it is likely that a similar process is operating here, where higher hourly temperatures were reached earlier in the day than at the other stations, resulting in slightly higher monthly means than were observed at Yellow Point during July, August and September.

The greatest climatic differences seen between each of the three locations is that of total monthly rainfall. The total rainfall among the three stations was lowest each month at Yellow Point. Except for May, rainfall was highest at Rheinhart Lake for each month.[OTIP 070]

6.3 Program Development, Support and Gene Conservation.

Projects that are funded under this section support provincial- wide tree improvement needs, including gene conservation, seed pest management, and program planning and development.

6.3.1 Cone Enhancement in *Abies amabilis* Seed Orchards

John Owens, Luke Chandler and Jordan Bennett

Background:

Seed cone production is infrequent in clonal *Abies amabilis* (Pacific silver fir) seed orchards, whereas pollen cone production is common. Ramets from grafts often have plageotropic growth, and infestation with the balsam woolly aphid is common. Faced with these many problems, several agencies have abandoned or removed these orchards. In a developmental study carried out in the old Tahsis seed orchard (Pacific Forest Products) in 1996, we determined that cone initiation in Saanich occurred in late May to early June, four to six weeks earlier than in natural stands on Vancouver Island.

Ba cones in the old Tahsis orchard.

Objectives:

Abies pollen cone buds are easy to identify on dormant shoots, but their presence is not an indication that seed cone buds were initiated. Therefore, the presence of seed cone buds can only be easily determined by bud counts at pollination in the spring. The success of the various treatments will be determined by a count of pollen cones and seed cones at pollination in the spring 1999.

Activities:

In 1998, a cone induction experiment was set up in the Timber West Seed Orchard in Saanichton. In the clonal seed orchard, 120 trees were selected that had orthotropic growth were 2 to 3m tall and not heavily infested with aphids. Five treatments were given with 20 trees per treatment:

- Controls received one treatment of ethanol on May 30.
- Early (May 20 and 27) application of GA 4/7 + fertilizer.
- Late (May 27 and June 3) application of GA 4/7 + fertilizer.
- Early GA 4/7 + fertilizer + tenting + girdling.
- Late GA 4/7 + fertilizer + tenting + girdling.

The amount of GA 4/7 applied was based on tree diameter at waist height. Trees < 5cm had two holes drilled on opposite sides of the trunk and a total of 128mg of GA 4/7 was injected into the drill holes. Trees 5 to 7.9 cm in diameter had three holes drilled and 192mg of GA 4/7 injected. Trees > 8 cm had four holes drilled and 256 mg of GA 4/7 injected. Holes were drilled down at a 45 degree angle to a depth of 3 cm. One ml aliquats of GA 4/7 (32 mg/mL) in 80% ethanol were injected into each drill hole. Holes were plugged with *Hold It Puddy Adhesive* after injections. Nitrate fertilizer (34-0-11) was applied around the base of trees in a 1 m radius. Tents were made from 2x2 in boards hinged at the top in an A-frame manner and covered with polyethylene leaving a vent at the top and around the base. Shoot elongation was measured on four trees selected from each treatment and the control. Two shoots were flagged per tree, and these shoots were measured weekly from May 18 through July 7, at which time the tents were removed. Thermocouple wires were attached to four trees, two tented and two untented, and temperatures were recorded at 30 sec. intervals and averaged every 10 minutes. Theremocouples were attached on the north side of trees, shaded from the sun and protected by two plastic spoons. Temperatures were recorded from May 23 through July 7.[OTIP 163]

6.3.2 Open Pollinated, Full-Sibling, Elite Seed Production is an Operational Reality for Douglas-fir

Joe Webber and Michael Stoehr

Project Description/Overview:

Success of the tree improvement program relies on orchard management procedures that can deliver seed lots with an optimum genetic worth (GW). Substantial improvements to GW can be obtained by practising pollen management techniques, most notably supplemental mass pollination (SMP). The goal of this project is to demonstrate under what orchard conditions SMP techniques can be successfully implemented. The two principal factors we are testing are orchard design and parent tree size. We have addressed the issue of orchard design and tree size by developing a micro orchard concept for Douglas-fir, as well as developing the diagnostic tools to accurately assess the genetic worth of SMP crops. We can routinely induce flowering crops on 2 m and 3 m trees and have been successful in raising SMP efficacy values to 50%-60% (see OTIP Summary Report for 1997). Assuming the crop is accessible, (i.e., crown pruned trees) then the next most important factor affecting SMP efficacy is competing pollen cloud density. Last year (1997) was a moderate year for pollen cloud, and 1998 was very low. Our results for 1998 are a good example of the effects of competing pollen cloud density.

Activities:

Cone Analyses For 1998:

There was no flowering crop in the micro orchard (heavily pruned the year prior to 1998) so we used what few flowering clones were available in the Mount Newton Seed Orchard. Single ramets per clone were pollinated with a single pollen lot, using our controlled crossing pressurized pollinators. We compared one [at bud burst (BB) + 2 days)] and two pollination (BB + 2 and BB + 4 days) treatments with and without a following water spray. Results are summarized in Table 9

	Pollination Treatments									
Clone	OP		SP-1		SP-1/Mist		SP-2		SP-2/Mist	
	FSPC	%FSPC	FSPC	%FSPC	FSPC	%FSPC	FSPC	%FSPC	FSPC	%FSPC
Means	4.23	12.36	10.28	32.88	7.12	26.94	19.61	43.21	11.24	27.02

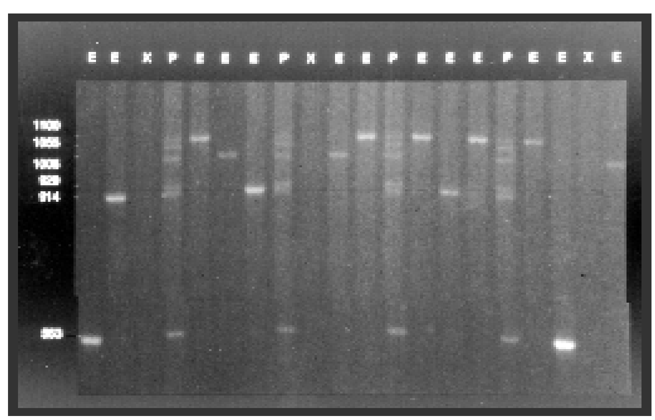
Table 9: Seed yield summary for the 1998 supplemental pollination trials in the Mount Newton Seed orchard.

Legend to Table:			
OP	open pollinated, untreated cones		
	SP	supplemental pollination	
		1	one pollen application only at BB + 2 days
		1/Mist	one pollen application followed by mist spray
		2	two pollen applications at BB + 2 and BB + 4 days
		2/Mist	two pollen applications each followed by mist spray.
	FSPC	filled seed per cone	

SMP pollination procedures increased seed yields, and the results were better for two pollination treatments. In general seed yields were low. Poor yields were attributed to poor vigour of the treatment trees (stress crop) and a high incidence of insects (*Megastigmus* (seed wasp) and the Gall Midge).

Paternity Analyses For 1998:

Activities for the final quarter include paternity analyses of the seed lots (by clone). DNA is extracted from the embryos and amplified using polymerase chain reaction (PCR) techniques, with specific chloroplast primers of known DNA product for the pollen parents. The electrophoresis gel (below) shows the embryo DNA for six different pollen parents of a polymix. Paternal identity is determined by matching the embryo DNA band with one of the paternal bands. Numbers on the left axis refer to the size of the individual paternal DNA bands.
E = amplified embryo DNA
P = mixture of amplified paternal DNA (6 bands = 6 pollen parents)
X = reaction that failed to amplify embryo DNA[OTIP 205]



A typical DNA agarose gel.

6.3.3 Pheromone-based Mass Trapping and Mating Disruption to Reduce Damage by the Douglas-fir Pitch Moth (*Synanthedon novaroensis*) at the Prince George Tree Improvement Station

Robb Bennett

Project Description/Overview:

Douglas-fir pitch moth (DFPM) damages stems of lodgepole pine trees in seed orchards at the Prince George Tree Improvement Station (PGTIS). Using DFPM sex pheromone, this project aims to control DFPM by mass trapping it in one infested orchard and disrupting its mating behaviour over a two year period.

Pitch mass and pitch moth larva removed from lodge pole pine stem.

Objectives:

To conduct mating disruption and mass trapping, respectively, in the two seed orchards at the Prince George Tree Improvement Station, most severely affected by pitch moths, in order to reduce the moth populations and subsequent damage to the trees.

Activities:

In the mass trapping program, 100 insect traps, each baited with synthetic DFPM sex pheromone were placed systematically throughout the PGTIS #202 lodgepole pine seed orchard in May 1998. In the mating disruption program, one small plastic pheromone dispenser containing synthetic DFPM sex pheromone was placed in each tree in the PGTIS #201 lodgepole pine seed orchard in May 1998. Both programs produced good results and are scheduled to continue in the 1999 field season. A late season survey for pitch masses on lodgepole stems in orchard # 201 and #202 will be done in 1999. DFPM has a two year life cycle. If effective, the two years of trapping or disruption should have eliminated DFPM from the two orchards, and no new pitch masses will be found.[OTIP 217}

6.3.4 Enhancement of Seed Quality through Family Processing

David Kolotelo

Objectives:

- To determine the cost-effectiveness of family processing, and investigate a variety of seed deployment options.
- To investigate the variability in a variety of attributes through the collection, processing and testing of individual families of Coastal Douglas-fir, Interior spruce and Interior lodgepole pine.

Activities:

This project entered into its fourth and final year of family processing with an additional 20 families of Interior spruce for a total of 120 families processed (Sx-60; Pli; 40; Fdc-20) plus 12 bulk lots representing a ten clone bulk for each species/year combination. Half-day presentations on ***Family Forestry: Policy, Seed Processing, Cost Effectiveness and Nursery Concerns*** were presented in Vernon and Saanich to update tree improvement personnel on the status of the project. Work on cost effectiveness for 1998/99 will focus on cost effectiveness of small bulk lot processing with respect to new seed prices, current genetic gain level, variability in annual data on seed processing and various deployment options.

Results:

Seed processing by family is far less cost effective than bulk lot processing based on increased volume, discounted for rotation length, versus costs associated with individual family processing. Although this project was initiated with individual family processing in mind, the lack of cost effectiveness and restrictive deployment policies have shifted the cost effectiveness work to look at small bulk lot processing.

Variation between orchards, between families and between years for the same half-sib families, was evident in most variables. Large year-to-year variation was evident for seed size and dormancy which will add variability to family lots, if seed from the same half-sib collections is combined over several years. A final analysis of the data gathered over the past four processing seasons will be completed and distributed to interested parties. [OTIP 226]

Please contact Dave Kolotelo after March 31, 1999 for the complete report (Dave.Kolotelo@gems7.gov.bc.ca; (604) 541-1683 ext. 228).

6.3.5 Enhancement of Quality and Quantity of Seed in Lodgepole Pine Orchard #307

Michael Stoehr and Joe Webber

Progress/Results:

Pollination Trial:

Last year, insect protected cones yielded roughly three time as many filled seed per cone as unprotected cones. An insect predation effect was observed again, although the magnitude and overall seed yields were different from last year (9 filled seed cone vs. 27 filled seed cone). Currently, there are data available for four clones out of six (Table 10). The cone analysis for the remaining two clones is in progress and will be finished at the end of January, 1999.

Clone #	# of Ramets	Pollination Treatments No Insect Bag									
		1		2		3		4		5	
		fspc	%fspc	fspc	%fspc	fspc	%fspc	fspc	%fspc	fspc	%fspc
1505	3	3.33	12.54	0.75	4.72	0.50	3.19	1.88	9.38	0.85	4.56
1507	3	2.00	29.63	3.14	42.72	2.20	23.16	3.57	33.78	1.88	19.23
1512	3	0.92	6.18	2.45	15.08	1.33	6.90	2.71	11.18	1.57	9.48
1510	3	5.82	23.36	2.88	14.38	5.08	26.51	3.71	17.87	3.87	17.06
Mean:		3.02		2.31		2.28		2.97		2.04	
		Insect Bag									
		1		2		3		4		5	
		fspc	%fspc	fspc	%fspc	fspc	%fspc	fspc	%fspc	fspc	%fspc
1505	3	7.45	25.25	6.71	25.17	6.90	31.87	7.71	34.07	6.43	27.00
1507	3	8.24	58.82	8.50	52.58	8.89	53.69	11.83	60.94	12.06	50.23
1512	3	16.35	64.20	15.64	69.35	11.53	58.87	14.37	66.91	11.19	53.55
1510	3	11.09	50.21	3.63	20.42	5.24	24.59	5.14	26.09	7.67	35.17
Mean:		10.78		8.62		8.14		9.76		9.34	

Table 10: Cone analysis results.

Treatment Codes: 1= OP control; 2 = one application with Power Hitter; 3 = one application with Air Brush; 4 = one application with Power Hitter followed by misting; 5 = OP + misting.

Paternal Analysis:

This work is currently in progress by a University of Victoria coop student. Results will be available on March 31, 1999.

Cone Induction:

Cone induction was carried out in Weyerhaeuser's Grandview Orchard #311. Six clones with 12 ramets per clone (72 trees in all) were selected for induction treatments. Trees were selected on the basis of good vegetative vigor and reasonable uniform size. Two ramets per clone received one of the following treatments:

0 = Control (no treatment)
1 = $GA_{4/7}$ @ Half Dose
2 = $GA_{4/7}$ @ Full Dose
3 = Girdle (double overlapping stem)
4 = $GA_{4/7}$ @ Half Dose + Girdle
5 = $GA_{4/7}$ @ Full Dose + Girdle

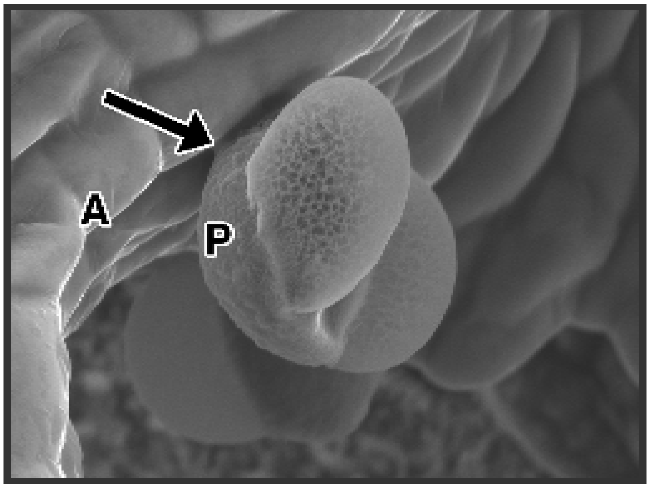
$GA_{4/7}$ efficacy will be evaluated during reproductive bud break in the spring of 1999.[OTIP 203]

6.3.6 Production of Rust Resistant Seed in Western White Pine Seed Orchards

John Owens and Glenda Catalano

Background:

All Canadian white pines are susceptible, or very susceptible, to white pine blister rust. About 20 years ago, the decision was made in BC to develop rust resistance through selection and breeding. During this time, six clonal or seedling seed orchards were established in BC from rust resistant material derived from the US and BC. These orchards are now reaching reproductive age, and there is a tremendous demand for rust resistant seed. Western white pine has a high seed potential per cone - about 150 seeds per cone, and young trees can produce many seed cone buds. However, the proportion of cones that reach maturity, and the seed efficiency of these cones, is often low. Commonly less than 50% of cones reach maturity and only about 30% of seeds are filled. The causes of these losses are many and varied. A study was begun in 1998, and will continue in 1999 to enhance cone and seed production in seed orchards in the Interior and on the Coast.



Western white pine pollen (P) adhering to the minute lipid drop (arrow) secreted from the micropylar arm (A) of the ovule at receptivity. Pollen is later scavenged by a large watery pollination drop.

Activities:

At the Saanich Seed Orchard and near Kalamalka (Bailey Rd), studies are underway to determine the time of seed cone initiation, the pollination mechanism, the receptive period of seed cones, the optimal time of pollination, the causes of seed cone loss (cone drop) and the causes of seed loss. First year results show that very young trees have a high potential for cone and seed production, but inadequate pollination is a major constraint. Seed cones have a long easily recognizable receptive period lasting four to seven days. The phenology of cones identifying the receptive stages has been photographed and described and made available to orchards for 1999. Controlled pollinations at all stages were done to determine the optimal time of pollination, and minimal amount of pollen required for cone survival and seed set. Ovules must be pollinated or they abort. If too many ovules abort, the cone aborts; but cone abortion also varies among clones. In some clones, regardless of the amount of pollen applied at the right time, 60% of cones abort, whereas in other clones, 40% abort. There seems to be an upper limit to cone survival, but the causes are not yet known. Seed loss is also high in many clones, and this may result from lack of pollination, selfing resulting in early embryo abortion, anomalies during development, insects or as yet unknown causes. The second year of this study will focus on specific causes of cone and seed losses and develop methods to enhance cone and seed production through more effective supplemental pollination and management of cone crops. Young orchards must be supplementally pollinated because, although most trees produce some to many seed cones, only a few trees produce pollen cones, hence almost all seed cones abort during the first summer. Pollen collection, extraction, storage and testing are not difficult, but a more efficient method of supplemental pollination must be developed. Results thus far, indicate that western white pine is an easy species to work with and should respond well to proper seed orchard management.[OTIP 162]

6.3.7 Control of Cone Beetles in a Coastal Seed Production Area of Blister-Resistant Western White Pine.

Robb Bennett

Project Description/Overview:

Cone beetles (*Conophthorus ponderosae*) are causing significant losses of cones and seeds in a Seed Production Area on Texada Island used for controlled breeding of blister-resistant western white pine. An integrated

Bow, arrow and fishing line technique for placing haul-up lines in trees.

program of pheromone-based, mass-trapping of beetles within this isolated stand, ground collections of beetle infested cones and cone bagging, will significantly reduce levels of damage.

Objectives:

Conduct a mass-trapping program against the cone beetle *Conophthorus ponderosae* in an isolated stand of blister-resistant western white pine, used for seed production from controlled breeding trials.

Activities:

In May 1998, insect traps were baited with cone beetle attractants and placed in the crowns of western white pine trees in the seed production area on Texada Island. A total of 2,630 cone beetles were captured, primarily during the period of 12 May to 10 June. In addition, several hundred live, young adult beetles were collected from attacked cones and used for continuing pheromone and molecular analyses. Although very significant numbers of beetles were killed, trapping efforts were not optimal, as the early part of the beetle flight was missed. Thus, numerous cones had already suffered cone beetle attack prior to the commencement of trapping. Trapping will continue in 1999, followed by an efficacy assessment at the end of the field season. [OTIP 216]

6.3.8 Establishment of Prince George Seed Planning Zone (PGSPZ), Interior Spruce, Somatic Embryogenesis (SE) Lines for Selection, and Demonstration of Growth and Spruce Leader Weevil Resistance

Chris Hawkins

Background:

Establishment of spruce SE candidacy test (CT) sites to screen for superior growth and potential spruce leader weevil tolerance, began in 1994, with material from BIOTIA crosses (PGSPZ, low, mid and high ranked families). Full sib seedlings from each family were planted as controls. This was followed in 1996 and 1997 with clones from families of the PGSPZ (PG95) and PG-ENA (PGSPZ x eastern North American parents), respectively, ranked high for both growth and weevil tolerance. Families and clones from previous years were also planted to provide benchmarks, and to estimate temporal effects. Open pollinated families ranked high for weevil tolerance, and growth from the old Quesnel Lakes (QL) SPZ (now PGSPZ) were planted in 1998, the final year of CT establishment. Starting in 1995, clonal blocks (CB), each about 0.1 ha, were established to demonstrate the growth of SE clones in comparison to seed orchard and wild stand seedlots. When possible, CB were established in conjunction with CT. CT and CB were established on as many BEC subzones as possible. 1998 was the last planned year for CB plantings. Proposed changes to the PGSPZ resulted in the 1998 program being nearly as large as all previous years combined.

Activities:

- Five, single tree plot, CT sites were established with 415B emblings and seedlings in May and June between 100 Mile House and the Missinka, about 400 km south to north (Table 11). The number in parenthesis indicates the total number of families and clones established (QL + BIOTIA + PG95 + PG-ENA).

Site Name	Cooperator	BEC	No. Families	No. Clones
CP 278-04	Weldwood, 100 Mile	ICHdk	18 (34)	452 (497)
Polley Lake	Riverside, Likely	ICHmk3	18 (37)	654 (705)
TFL 5, 200 Rd	Weldwood, Quesnel	SBSdw	18 (34)	513 (558)
Catfish Creek	Robson Valley FD	ICHwk3	18 (34)	436 (477)
Missinka	PAS, Bear Lake	SBSvk	18 (33)	485 (528)

Table 11: CT Sites Established in 1998 with QL, SE Clones and Half sib Seedlings

- About 24,000 SE clones and half sib seedling controls were planted on the five CT sites.
- Groundline stem diameter was recorded for all emblings and seedlings at planting.
- 12 CB were established from 100 Mile House in the south to Blackwater north of MacKenzie, using PG95, PG-ENA and QL clones (Table 12).

Site name	FD	Cooperator	BEC	Clones	SL	TOT
CP 104-05	100M	Weldwood, 100 Mile	CHdk	19	2	5200
Polley Lake	HF	Horsefly FD	CHmk3	19	2	4800
Maud Lake, 4900 Rd	QU	West Fraser, Quesnel	SBSmw	18	2	5900
TFL 5, 200 Rd	QU	Weldwood, Quesnel	SBSdw	17	2	4500
Catfish Creek	RV	Robson Valley FD	CHwk3	17	2	7500
England FSR	PG	CanFor, Netherlands	SBSwk1	15	1	5700
A Road	PG	CanFor, Clear Lake	SBSdw3	17	2	4900
Morilla Main	VAN	Slocan, Plateau	SBSdk	18	2	5100
Young FSR	FSJa	Fort St. James FD	SBSmc2	13	3	4000
Avril Lake	PG	Northwood	SBSwk1	20	1	4300
6800 Rd	PG	CanFor, Polar	SBSvk	18	2	5300
Finlay FSR 82Km	MAC	MacKenzie FD	SBSmk	16	1	4000

Table 12: CB sites established in 1998.

- The forest district (FD), cooperator, BEC, number of clones and registered seedlots (SL), and total number of emblings and seedlings planted (TOT), are indicated by site name.

- The TFL 5 and Catfish CB were established in conjunction with the CT on site.
- About 61,000 emblings and seedlings were planted in CB, and a 0.01 ha assessment plot was established in each of the 229 clone or full sib seedling blocks.[OTIP 207]

6.3.9 Testing, Selection, and Demonstration of Growth and Spruce Leader Weevil Resistance in Somatic Embryogenesis Lines of Prince George Seed Planning Zone (PGSPZ) Interior Spruce

Chris Hawkins

Background:

Eleven SE, candidacy tests (CT) were established between 1994 and 1997 (Table 13), using the parental sources described in Section 6.3.8. The number in parenthesis indicates the total number of families and clones established on a site (BIOTIA + PG95 + PG-ENA). About 25,000 emblings and full sib seedlings were planted on the 11 CT.

Site name	Cooperator	Planted	Stocktype	BEC	Families	Clones
Hungary Creek Km 4	Prince George FD	1994	1+0 313B	ICHvk	12	113
Hungary Creek Km 1	Prince George FD	1995	1+1 PBR	ICHvk	12	158
Huble Road	Northwood	1995	1+1 PBR	SBSwk1	12	206
Aleza Lake Wheel	Prince George FD	1996	1+0 415B	SBSwk1	15 (24)	268 (290)
Tumuch	Prince George FD	1996	1+0 415B	ICHvk	15 (24)	306 (329)
Indain Point	Prince George FD	1996	1+0 415B	SBSwk1	15 (23)	312 (334)
Aleza Lake Wheel	Prince George FD	1997	1+0 415B	SBSwk1	7 (29)	109 (278)
Hungary Creek Km 1.5	Prince George FD	1997	1+0 415B	ICHvk	6 (30)	97 (263)
Arctic Lake	PAS, Bear Lake	1997	1+0 415B	SBSvk	7 (28)	94 (268)
2700 Rd	West Fraser, Quesnel	1997	1+0 415B	SBSmw	7 (30)	64 (166)
Marie North	Fort St. James FD	1997	1+0 415B	SBSmc2	4 (14)	49 (87)

Table 13: CT established from 1994 to 1997 with SE clones and full sib seedlings.

Clonal blocks (CB) were established on 18 sites from 1995 to 1997 using BIOTIA, PG95, and PG-ENA clones and registered seedlots (Table 14). The Tumuch, Hungary Creek 1.5, 2700 Rd and Marie North CB were established in conjunction with the CT on site. About 95,000 emblings and seedlings were planted in CB over the three years. At the end of 1998, there were about 49,000 propagules in CT and 156,000 in CB.

Site Name	FD	Cooperator	Year	BEC	Clones	SL	TOT
Upper Fraser	PG	Northwood	1995	SBSwk1	6	2	3700
Bear Rd Km 46	PG	Northwood	1995	SBSwk1	5	2	3200
Longworth Rd	PG	Prince George FD	1995	SBSwk1	7	2	2800
300 Rd	QL	West Fraser, Quesnel	1996	SBSmw	17	3	6750
Tumuch	PG	Prince George FD	1996	ICHvk	7	3	8300
North Willow Rd	PG	Carrier, Prince George	1996	SBSmk1	10	2	5100
5300 Rd	PG	Dunkley, Strathnavor	1996	SBSwk1	9	2	3300
6900 Rd	PG	CanFor, Polar	1996	SBSwk1	8	2	4300
700 Rd	PG	CanFor, Polar	1996	SBSwk1	15	2	5300
TFL 5, 200 Rd	QL	Weldwood, Quesnel	1997	SBSmw	17	2	5350
Hungary Creek Km 1.5	PG	Prince George FD	1997	ICHvk	8	1	3000
Blackwater Rd	PG	CanFor, Clear Lake	1997	SBSdw3	15	1	5900
CP 92-01	PG	Dunkley, Strathnavor	1997	SBSwk1	20	2	7100
Government Lake	PG	CanFor, Netherlands	1997	SBSmk1	17	2	5400
200 Rd	PG	CanFor, Polar	1997	SBSmk1	19	2	7400
2700 Rd	QL	West Fraser, Quesnel	1997	SBSmw	11	1	6700
Marie North	FSJa	Fort St. James FD	1997	SBSmc2	19	2	8300
Manson 12000	MAC	Slocan, MacKenzie	1997	SBSmk1	10	1	2900

Table 14: CB sites established from 1995 to 1997.

Activities:

- CT established in 1996 and 1997 were assessed in May and June for over winter injury and mortality.
- All CT and CB sites were visited in the spring of 1998 to determine if any vegetation control was required. Vegetation control was planned but not implemented on several sites because the conifers were not adequately developed to withstand the herbicide.
- CT established in 1994 and 1995 were measured in the fall as were all the 1998 CT installations.
- CB established in 1996 and 1998 were also measured in the fall of 1998.
- A tour was conducted in July to sites established between 1995 and 1998, for about 25 people from the Forest Service, industry and academia.
- Drs Libby and Lester were taken to sites established in 1994, 1996, 1997 and 1998 as part of their SE review.
- A presentation on the testing program was made to the Western Forest and Conservation Nursery Association and a paper was submitted to the USDA Forest Service for publication in the conference proceedings.

Results from the CT have been presented at SIBC and AFMI.

Results:

Initially, it was thought clonal decisions based on growth could be made after five years. However, fifth year results suggest this probably is not the case. At Hungary Creek Km 4, year five data suggests:

- full sib seedlings are generally performing better than SE emblings from the same family but this may be due to the poor quality of the SE clones compared to full sib seedlings at the time of planting;
- parental breeding value is not a good predictor of SE clone performance;
- survival and vigor of emblings is excellent;
- clonal decisions based on growth will not be made before year seven; and
- it will take several more years before even a preliminary spruce leader weevil assessment can be done.

All CT established in 1996 have been affected with late June - early July frosts in 1996 and 1998. This has compromised the growth of all material on the three sites. It may take 10 years before any growth based clonal decisions can be made for the PG95 material. If this is the case, it will delay any SE operational deployment because of the large number of clones involved. Overall, the results reinforce the need for CT and CB.[OTIP 208]

6.4 Communications and Extension.

Projects under this section provide information on skills and knowledge, or that direct/enhance communication between tree improvement and its clients and/or that promote tree improvement in British Columbia.

6.4.1 Bowser Seed Orchards Realized Volume Genetic Gain Demonstration Plantations

Gordon Morrow

Project Description :

Growing stock and site maintenance of three Tree Improvement Program (TIP) genetic gain demonstration plantations. Annual maintenance of the following plots: Coastal Douglas-fir Realized Gain; a Sitka Spruce Weevil Resistance; and a Hybrid Black Cottonwood Demonstration has promoted an effective platform for the presentation and elaboration of TIP progress and goals.

There is a need for plantations of products of the Tree Improvement Program to demonstrate its goals and achievements to both the public at large and to reforestation personnel in the forest industry. Further, there is a need for such plantations to be distributed at convenient sites throughout the province, to enable TIP personnel to readily elaborate these goals and achievements.

Bowser Seed Orchards possess three such plantations: The Coastal Douglas-fir Realized Volume Gain Demonstration Plot, the Sitka Spruce Weevil Resistance Demonstration Plot and the Hybrid Black Cottonwood Volume Gain Demonstration Plot.

Results Report:

This project has maintained the three on-site demonstration plots in a clean, vigorous and healthy pest free condition, to enhance their usefulness in the promotion and presentation of TIP achievements and goals.[OTIP212]

6.4.2 Manual for Western Hemlock Seed Production.

Joe Webber

Project Description/Overview:

Western hemlock (*Tusga heterophylla* (Raf.) Sarg.) is an important orchard species ranking fourth among the tree improvement species in BC. Establishment of advanced generation seed orchards is occurring, and the need for intensive orchard management techniques has arrived. Current species plans show that future orchard production will rely heavily on supplemental pollination techniques to meet production goals. Field tested cone induction, and pollen management techniques for achieving these goals, are available. However, they are not easily attained for field managers. The objective of this proposal is to bring all material related to seed production in western hemlock into a comprehensive field manual.

Progress:

A contractor has been hired to assist in the compilation of all literature and data pertinent to the flowering, pollination and seed production of western hemlock. A draft form of the manual was completed by mid-January, with the completed manual slated for final printing in mid-March. The principal topics covered provide:

- an overview of western hemlock tree improvement;
- various approaches for orchard production (orchard design);
- orchard management (including cone induction, pollen management and crown management);
- orchard management strategies; and
- a summary of the reproductive biology of western hemlock.[OTIP 202]

6.4.3 Developing a Strategic Extension Plan for the Tree Improvement Council
Chal Landgren and Steve Stearns-Smith

Objectives:

Linking seed users with the informational tools they need to make decisions, is one of the goals for this project. To accomplish this, it was first necessary to examine the current situation with respect to tree improvement, and then determine where the gaps exist between knowledge and practice.

Activities:

Much of this analysis was conducted through face-to-face and telephone interviews with seed users and producers (Sept 97 - Mar 98). Most seed users indicated relatively few problems using improved seed at the current prices. However, the gains from using improved seed remain rather theoretical, for most seed users, since accelerated "green-up" and AAC boosts, depend on a wide range of external factors.

Based on the needs assessment, an extension plan was developed which maps out some alternative strategies for addressing the needs. The report can be obtained from the Forest Genetics Council web site.[OTIP 184]

6.4.4 Application of Seedlot Rating Protocols with Particular Reference to Interior Conifer Seed Orchards.
Michael Stoehr

Background:

This project is designed to assess the assumptions of the current seedlot rating protocol, and implement practices that optimize the genetic gain and diversity contained by orchard seed. Estimates of selfing (in clonal-row and conventional orchards), supplemental mass pollination (SMP) efficacy, and levels of pollen contamination, have or are being made, using isozymes and microsatellite DNA markers. We have concentrated on two spruce orchards: the Vernon Seed Orchard Company (VSOC) spruce seed orchard #214, which contains 43 clones in a random array, and the MoF seed orchard #620 at Kalamalka, which contains 36 clones arranged as a clonal row orchard with up to 20 ramets per clone.

Activities:

(SMP) (Michael Stoehr's Lab, Glyn Road Research Station):

A SMP study was conducted with 12 clones in VSOC orchard #214. Four, single parent pollen lots were applied to three female clones, using standard SMP techniques with and without a subsequent water misting. The effects of using insect bags on seed set was also evaluated (Table 15).

Results:

SMP drastically improved seed yield per cone, while the insect bags only slightly improved seed yields.

Wind Pollinated (no insect bag)					
Variable	N	Mean	Std Dev.	Minimum	Maximum
TSPC	96	149.3	24.1	95	207
FSPC	96	25.7	14.7	0	62
PFS	96	17.7	10.8	0	57.9
Wind Pollinated (with insect bag)					
Variable	N	Mean	Std Dev.	Minimum	Maximum
TSPC	92	150.1	25.6	77	195
FSPC	92	29.9	19.3	0	73
PFS	92	20	13.1	0	51.4
SMP (with insect bag)					
Variable	N	Mean	Std Dev.	Minimum	Maximum
TSPC	95	150.5	25.6	97	198
FSPC	95	64.2	28.8	2	131
PFS	95	42.4	17.2	1.9	81.8
SMP followed by misting (with insect bag)					
Variable	N	Mean	Std Dev.	Minimum	Maximum
TSPC	95	155.9	26.7	85	206
FSPC	95	78.4	32.2	2	143
PFS	95	50.4	18.8	1.7	82.7

Table 15: Seed Yields per Cone for SMP vs. Wind-pollinated Interior Spruce

Note:
TSPC = total seed per cone;
FSPC = filled seed per cone;
PFS = % filled seed;
N = number of cones analyzed.

Molecular Work (Kermit Ritland's Lab at UBC):

Efficiency of SMP will be evaluated via isozyme assay of seed (see above). All clones in both seed orchards (#214 and #620) will be genotyped, using highly informative microsatellite genetic markers. While microsatellite markers are extremely desirable, because of their hypervariability and ability to give information on paternity and pollen contamination, the large and repetitive nature of the conifer genomes makes "good" microsatellite loci difficult to find. We have germinated seed progenies from Seed Orchard #214 and pooled megametophytes. This allows us to directly assay for parent tree genotype at these "good" microsatellite loci. We are currently germinating seed progenies from Seed Orchard #620 using the same method for the same purpose.[OTIP 204]

Appendix 1

Tree Species Names and Abbreviations

CONIFERS

western redcedar	Thuja plicata	Cw
yellow-cedar	Chamaecyparis nootkatensis	Yc
Douglas-fir	Pseudotsuga menziesii	Fd
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 a

TIIP Matrix - Breeding and Testing

Priorities for 1998/99 Forest Renewal BC Operational Program proposals

Species	SPZ	Elevation band	Parent tree select.	Test establ.	Test maint.	Test meas.	Cntrl. cross	Wood assess.	Form assess.	Pest assess.	Breed orch./clbnk.	Clonal test stock
Fd	Maritime low (south)	0-700		1	1	3	1		1	2	1	
Cw	Maritime low (all lat.)	0-600		1	1		1			2	1	1
Sx	Prince George low	<1200			1	1	1	1		1	1	
Hw	Maritime south	0-600		1	1	1	1	1	1	2	1	
Pli	Prince George low	<1100			2		1			3	1	
Sx	Nelson high	>1400			1	1	1	2		2	1	
Pli	WK/SA low	<1400			2			1		3	1	
Ss	Maritime all	0-750		1	1	1	1	2	2	1	1	
Sx	Nelson low	<1400			1	1	1	2		3	1	
Pw	Coast (all)	0-1000			2	2	2			2	2	
Pli	Thompson/Okan. low	<1400			3		2	2		3	2	
Pli	Bulkley low	<1100			2		1			3	1	
Yc	Maritime	400-1200		2	2	2	2		2	2	2	2
Lw	W. Kootenay/SA	<1500			2						2	
Pli	Thompson/Okan. high	>1400			3			2		3	2	
Pli	Central Plateau low	<1000			3	3	2	3		3	2	
Pw	S. Interior (all)	0-750			2	2	2			2	2	
Pli	Prince George high	>1100	1								2	
Fdi	W. Kootenay/SA	<1000			2	2	2	2	2	2	2	
Sx	Alberta Plateau low	<1200			2	3	2	3		3	2	
Sx	Bulkley low	<1200			3	3	3	3		3	3	
Sx/Ss	SM/NST	all					3					
Fd	Submaritime	200-1000										
Pli	WK/SA high	>1400	3									
Sx	Prince George high	>1200			3	3	3	3		3	3	
Hw	Maritime high south	600+			3	3	3	3	3		3	
Fdi	W. Kootenay/SA	>1000			3	3	3	3	3	3	3	
Sx	Thomp./Okan. high	>1400			3	3					3	
Sx	Thomp./Okan. low	<1400			3	3					3	
Pli	Chilcotin low	<1100	3									
Pli	Finlay low	<1100										
Fdi	Maritime High	700+			2	3						
Fdi	Prince George	all			3	3		3	3	3		
Pli	E. Kootenay low	<1400	3	2							3	
Lw	East Kootenay	<1400			3						3	
Fdi	Quesnel Lakes	all			3	2	3	2	3	3	3	
Fdi	East Kootenay	all			3							
Fdi	Cariboo Trans.	all			3							
Fdi	Mt. Robson	all			3							
Ba	all	0-700										
Cw	Submaritime	200-1000										
Ba	Submaritime	200-1200										
Hwi	NST	0-800										
Cw	Maritime high	600+		3	3							
Bl	NST	all elev.										
Cw	S. Interior (all)	0-750										
Bn	Maritime south	600+										
Birch	all	all	2	2	2	2						
Aspen	all	all	3									
Poplar	all	all	3									

Priority Legend for TIIP Matrices		
1	=	High
2	=	Medium
3	=	Low
Blank	=	Not Needed
F	=	Funded

Appendix 2 b

TIIP Matrix - Seed and Vegetative Material Production

Priorities for 1998/99 Forest Renewal BC Operational Program proposals.

Species	SPZ	Elevation band	Orch. site dev.	Orch. establ.	orch. maint.	Graft/root orch.	Rogue orch.	Cont. cross	SMP	Pest mangmnt.	Cutting prod.	Somatic embryog.	SPA's	Cone harvest
Fd	Maritime low (south)	0-700		2	1	2	1	1	1	1	2			1
Cw	Maritime low (all lat.)	0-600	1	1	1	1	1	1	2	2	2			1
Sx	Prince George low	<1200			1	3	1	1	1	1	1	3		1
Hw	Maritime south	0-600			1	3	2	1	1	2	2			1
Pli	Prince George low	<1100	1	1	1	1	1	1	1	1				1
Sx	Nelson high	>1400	1	1	1	1	1	1	1	1	2	3		1
Pli	WK/SA low	<1400	2		2	1		3	1	1				1
Ss	Maritime all	0-750									2			
Sx	Nelson low	<1400			1		1	1	1	1	2			1
Pw	Coast (all)	0-1000		2	2	2			2	2				2
Pli	Thompson/Okan. low	<1400	2	2	2	2			3	1				2
Pli	Bulkley low	<1100			1		2	3	2	1				2
Yc	Maritime	400-1200	2	2	2	2	2			2	2			2
Lw	W. Kootenay/SA	<1500	2	2	2	2			2	2				2
Pli	Thompson/Okan. high	>1400	2	2	2	2		3		1				3
Pli	Central Plateau low	<1000			2	2	2	2	3	1				2
Pw	S. Interior (all)	0-750		2	2	2				2				2
Pli	Prince George high	>1100								2				
Fd	W. Kootenay/SA	<1000		2	2	2		3	3	2				2
Sx	Alberta Plateau low	<1200	2	2		2					3			
Sx	Bulkley low	<1200			3		3	3	3	3	3	3		3
Sx/Ss	SM/NST	all			2					3	3		3	2
Fd	Submaritime	200-1000			2	2	2		3	3				3
Pli	WK/SA high	>1400								2				
Sx	Prince George high	>1200			3		3	3	3	3	3			3
Hw	Maritime high south	600+			3		3			3				3
Fdi	W. Kootenay/SA	>1000	3	3		3								
Sx	Thomp./Okan. high	>1400			3					2				
Sx	Thomp./Okan. low	<1400			3					2				
Pli	Chilcotin low	<1100								2				
Pli	Finlay low	<1100								2				
Fdc	Maritime High	700+			2	3	3	3	2	3	3			2
Fdi	Prince George	all			2					3				
Pli	E. Kootenay low	<1400								2				
Lw	East Kootenay	<1400			3				3	3				3
Fdi	Quesnel Lakes	all			3					3				
Fdi	East Kootenay	all	3	3		3		3						
Fdi	Cariboo Trans.	all			3			3	3	3				3
Fdi	Mt. Robson	all	3	3		3		3						
Ba	all	0-700			1					3				
Cw	Submaritime	200-1000								3				
Ba	Submaritime	200-1200								3				
Hwi	NST	0-800								3			3	
Cw	Maritime high	600+								3				
Bl	NST	all elev.								3				
Cw	S. Interior (all)	0-750								3				
Bn	Maritime south	600+								3				
Birch	all	all												
Aspen	all	all												
Poplar	all	all												

Appendix 2 c

TIIP Matrix - Program Development, Support and Gene Conservation

Priorities for 1998/99 Forest Renewal BC Operational Program proposals.

Species	SPZ	Elevation band	Genecology	Orch. pest mgt.	Rooted cuttings	Somatic embryog.	Wood traits	Form traits	Variance comp.	Orch. mgt.	Cone induction	SMP	Contrl. crossing	Pollen mgt.	Breeding strat.	Inbreeding	Realzd.-gain trials	Pest resistance	Seed set	Gene conservation
Fd	Maritime low (south)	0-700	3	2	1F	3	1	1	2	1	1	1	1	1	2	3	1F	2		2
Cw	Maritime low (all lat.)	0-600	1F	3	2		2	2	1	1	2	2	1	1	2	1		2		2
Sx	Prince George low	<1200	2	2		3	2		2	2	2	1	1	1	2	2	1	1		2
Hw	Maritime south	0-600	1	3	1F		1	2	2	1	2	1	1	1	2	2	1F			2
Pli	Prince George low	<1100	2	1			3			2	1	2	2	1	2		1	2	1	3
Sx	Nelson high	>1400	3	2		3	3		3	2	3	2	2	2	2	2		2		2
Pli	WK/SA low	<1400	3	1			2		2	1	1	1		2				2	1	3
Ss	Maritime all	0-750	3	3	1F	2	1	2	1	1	1	1	1	1	1	2		1		1
Sx	Nelson low	<1400	3	2		3	3		3	2	3	2	2	2	2	2		2		2
Pw	Coast (all)	0-1000	2	3	2				2	2	2	2		2	2		2	1		2
Pli	Thompson/Okan. low	<1400	3	1			2		3	2	3	2	3	2	3				2	3
Pli	Bulkley low	<1100	3	1			3	3	3	2	2	2	3	2	3	3		3	1	2
Yc	Maritime	400-1200	2	3	3		2	2	2	3	3		3	3	3	3				2
Lw	W. Kootenay/SA	<1500	2	2						2	2	2		2	3	3				2
Pli	Thompson/Okan. high	>1400	2	1			3		2	2	3	2	3	2	2				2	3
Pli	Central Plateau low	<1000	3	1						3	3	3		3	3				1	3
Pw	S. Interior (all)	0-750	2	3	2				2	2	2			2	2		2	2		2
Pli	Prince George high	>1100	2	1							2	2		2	2					3
Fdi	W. Kootenay/SA	<1000	3	3	3		2	3	3	3	3	3	3	3				2		3
Sx	Alberta Plateau low	<1200	2	3		3	3		3						3					3
Sx	Bulkley low	<1200	3	3		3	3		3	3		3	3	3	3	3		3		3
Sx/Ss	SM/NST	all	2	3	3F	3	3											3		1
Fd	Submaritime	200-1000	2F	3						2	3	3		2						2
Pli	WK/SA high	>1400	3	2																3
Sx	Prince George high	>1200	2	3			3		3	3		3	3	3	3			3		3
Hw	Maritime high south	600+	3	3	3F		3	3	3	3	3	3	3	3		3				3
Fdi	W. Kootenay/SA	>1000	3	3			3	3	3									3		3
Sx	Thomp./Okan. high	>1400	3	3							3									3
Sx	Thomp./Okan. low	<1400	3	3							3									3
Pli	Chilcotin low	<1100	3																	3
Pli	Finlay low	<1100																		
Fd	Maritime High	700+	2			3				2	3	3	3	3						3
Fdi	Prince George	all	3				3	3	3	3	3									3
Pli	E. Kootenay low	<1400	3								3	3			3				3	3
Lw	East Kootenay	<1400	3							3	3			3						3
Fdi	Quesnel Lakes	all	3				2	3	3	3	3		3	3						3
Fdi	East Kootenay	all	3																	3
Fdi	Cariboo Trans.	all	3		3			3		3	3	3	3	3						3
Fdi	Mt. Robson	all	3					3												3
Ba	all	0-700	3							1	1			2				2		2
Cw	Submaritime	200-1000	3																	3
Ba	Submaritime	200-1200	3							3	3			3						3
Hwi	NST	0-800	3																	2
Cw	Maritime high	600+	3F																	3
Bl	NST	all elev.	3																	3
Cw	S. Interior (all)	0-750	3																	3
Bn	Maritime south	600+	3																	3
Birch	all	all	2																	
Aspen	all	all	2																	
Poplar	all	all	2																	

Appendix 3

Contact Phone List for Contributors

Contributor	Affiliation	Phone #
Bennett, Robb	MoF	250-652-6593
Bennett, Jordan	Uvic	250-721-7113
Berger, Vicky	MoF	250-260-4758
Binder, Wolfgang	MoF	250-952-4136
Bird, Keith	MoF	250-749-6811
Brown, Patti	CFP	604-885-5905
Browne-Clayton, Shane	Riverside	250-762-3411
Carlson, Michael	MoF	250-260-4767
Catalano, Glenda	Uvic	250-721-7113
Cartwright, Charles	MoF	250-387-6477
Chandler, Luke	Uvic	250-721-7113
Collison, Heidi	MoF	250-746-6701
Cox, Keith	MoF	250-835-4541
Crowder, Tim	TFL	250-652-4211
Draper, Dale	MoF	250-356-9276
Ekramoddoullah, Abul	For.Can.	250-363-0692
Fleetham, Carole	MoF	250-963-8416
Graham, Hilary	PRT	250-546-6713
Grossnickle, Steve	BCResearch	604-224-4331
Hak, Oldrich	WFP	250-479-4911
Hawkins, Chris	MoF	250-963-9651
Hewson, Clare	MoF	250-260-4776
Hunt, Rich	For.Can.	250-363-0640
Jaquish, Barry	MoF	250-260-4766
King, John	MoF	250-387-6476
Kolotelo, David	MoF	604-541-1683
Kope, Harry	C. Biol.	250-727-0514
Landgren, Chal	MoF	250-356-6207
Lane, Janet	WEYCO	250-546-8711
Lee, Tim	VSOC	250-542-0833
L'Hirondelle, Sylvia	MoF	250-952-4128
Morrow, Gordon	MoF	250-757-2015
Murphy, John	MoF	250-260-4754
Nicholson, George	Riverside	250-546-2293
Owens, John	Uvic	250-721-7113
Painter, Roger	MoF	250-356-9276
Piggott, Don	YPP	250-245-5935

Appendix 3 *(con't.)*

Contact Phone List for Contributors

Contributor	Affiliation	Phone #
Pomeroy, Norm	MoF	250-749-6811
Russell, John	MoF	250-749-6811
Ryrie, Lynette	MoF	250-260-4772
Stearns-Smith, Steve	MoF	250-953-3495
Stoehr, Michael	MoF	250-952-4120
Trotter, Dave	MoF	604-930-3302
Walsh, Chris	MoF	250-260-4777
Webber, Joe	MoF	250-952-4123
Woods, Jack	MoF	250-356-0888
Ying, Cheng	MoF	250-387-3976

Back Cover Photos Interpretations

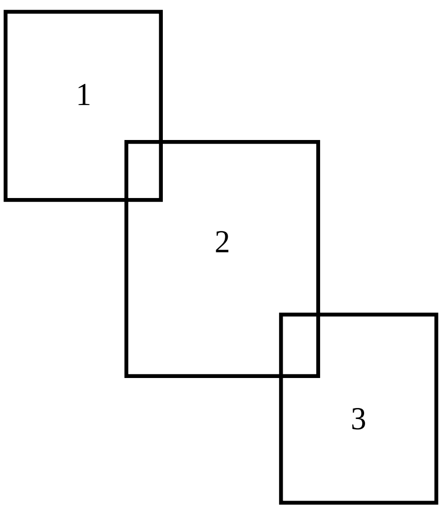
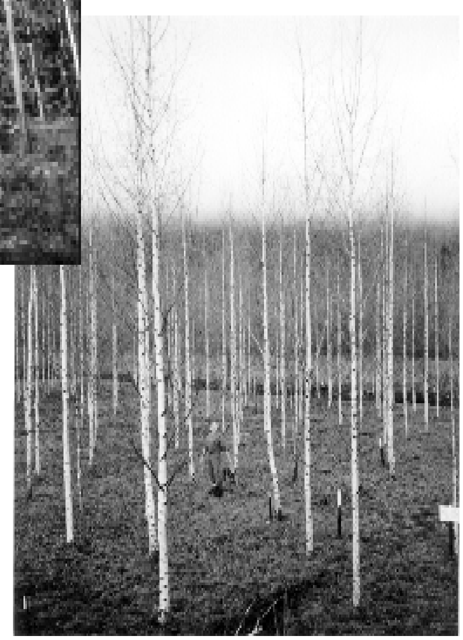


Photo #1 A winter 'skyview' in a stand of black cottonwood in the lower Fraser River with a helicopter hovering overhead. Research Branch is a member of the Poplar Molecular Genetics Cooperative based at the University of Washington, Seattle. Black cottonwood and balsam poplar trees from several BC river drainages were selected, with cutting wood and breeding branches collected via helicopter in the winters of 1995 and 1996. Several BC parents have been used in crosses with both black and eastern cottonwoods. Parent clones are archived in a breeding arboretum in Vernon.

Photo #2 Vicky Berger of Kalamalka Forestry Centre with a paper birch parent tree selected for stem form and volume growth rate near Duncan Lake. One hundred and ninety-five wind pollinated paper birch families, representing 19 stands from the Kamloops and Nelson Forest Regions, were planted on a Skimikin Seed Orchard site in spring 1998. This trial and a provenance test planted in 1996, (18 seed sources, 6 sites) will provide growth and adaptedness information needed for seed transfer guidelines and genetic improvement of this valuable broad-leafed species.

Photo #3 Michael Carlson (and 'Tanu') standing in a silver birch *(Betula pendula)* progeny trial, (planted in 1991 at the Skimikin seed orchard site) thinned to the best phenotypes for future seed production. A silver birch breeding program in Finland has been underway for more than 30 years. Ten improved silver birch families (selected for stem form and volume growth) from Finland and local paper birch control seedlots were planted at three BC sites in 1991. The Finnish silver birch far out-performed local unimproved paper birch seed sources, and may have a BC niche in the "aforestation" of abandoned/low value agricultural lands. This thinned trial stand should begin producing abundant seed in 1999/2000.



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