Forest Renewal BC Operational Tree Improvement Program

Project Report 1997/98

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Tree Improvement Program

British Columbia Ministry of Forests

Acknowledgements

This report marks the end of the first year of the Operational Tree Improvement Program (OTIP), funded by Forest Renewal BC (FRBC). It has been a busy year, with its initiation and the sorting out all the problems that go with a new program. The program did not begin until July 1997, but this did not deter the tree improvement industry from getting their projects underway and doing a lot of good work.

In this first year, everything has had to move quickly. The Call for Proposals and the review process was performed in a deliberate fashion to ensue funding would be out to the industry as soon as possible. Similarly, this report, which Mike Crown agreed to facilitate, has been another example of the year and the program; deliberate and paced. Many of you remember his recent work on the 1996 Tree Improvement Council Progress Report. Without his abilities, and the team of people that he works with, this report would not have happened. Thank you Mike for all your hard work in pulling it together.

To all of the Project Leaders who took the time to write their part of the Report, my sincere thanks. Many of you are already busy planning, or working on, the hectic spring activities that go with this business. That all project leaders have sent in a contribution, is a real indication of the type of people in our industry. Thanks for being patient with us, as we have gone through the teething pains of a new program this year.

A special thanks goes out to the editorial review team of Chal Landgren, Michael Stoehr, Joe Webber, and Jack Woods for tidying up our efforts. Thanks also to Bernadette Murphy, our communications and extension expert for her advice, and for supplying the material for the front cover. Bernadette is leaving Tree Improvement to take on other challenges in the provincial government. We will miss her work. Final thanks goes to Janet Gagne at FRBC who has worked hard on the OTIP, and given us strong support in initiating this program.

WELL DONE, everyone. We only had nine months of the program this year. Let's see what we can do with a full year.

Roger A. Painter
Tree Improvement Coordinator
Tree Improvement Council

Introduction

Dale Draper, and Shane Browne-Clayton, Co-Chairs, Tree Improvement Council of British Columbia

The Operational Tree Improvement Program (OTIP) was a great success in its first year of operation thanks to funding provided by Forest Renewal BC, and the efforts of participants from industry, government and universities,

The OTIP is designed to enhance existing tree improvement work, and move tree improvement in BC toward the goals articulated by the Tree Improvement Council (TIC). These goals include:

- 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
- supporting the long-term production capacity needed to meet the priorities of Council's business plan

Particular thanks are owed to members of the proposal review committees. Forest Renewal BC was able to fund this program in no small part because it could be assured that proposals would be fairly and objectively evaluated based on the council's goals for the provincial tree improvement program. Reviewing proposals was a difficult task and many people from industry and government generously contributed their time and energy to this part of the program. We thank you all.

Thanks are also owed to Roger Painter of the Ministry of Forests for overall administration of the program and for administering the contracts for industry projects. This program funded 66 projects for a total of $1.8 million dollars in its first year. The extent to which the program made progress toward the council's goals depended largely on the nature and quality of projects funded. The hard work of both the review committees in fairly and objectively evaluating proposals and the Ministry of Forests in managing contracts ensured that the right projects were funded and successfully completed.

In this first year, significant progress was made in some key areas of tree improvement, including cone induction activities, production of custom seed lots (e.g. controlled crosses, pollen collections), operational testing of research results, enhancing the genetic quality of orchards through roguing, support for ongoing operational breeding programs, pest management activities, and communications and extension projects. Due to limits on funding in the first year, proponents were asked to submit proposals of one year duration, and not to submit proposals for large capital acquisitions and investments, establishment of new orchards, or establishment of new breeding programs that have not been approved by TACs and the Council.

While this technical work was being implemented there were also significant advances being made in program planning by the Tree Improvement Council and Technical Advisory Committees. These include a province-wide *Tree Improvement Investment Priority (TIIP)* matrix supported by detailed *Species Plans*. The TIIP matrix enables council to base its investment decisions on an objective business-planning approach. It, in turn, is based upon the opportunities for advancing breeding work and enhancing production within important commercial species. These planning documents form the basis for next years' Call for Proposals for OTIP work.

We look forward to continuing success with the Operational Tree Improvement Program in next years' Call for Proposals. The Tree Improvement Council greatly appreciates Forest Renewal BC's ongoing support for the program, and for Janet Gagne's hard work and cooperation on FRBC's behalf.

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1.0 Goals and Priorities

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Roger Painter

The Operational Tree Improvement Program identifies four basic areas for investment:

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

These four areas are aimed at ensuring that the following goals set by the Tree Improvement Council (TIC) are met:

- increasing the genetic quality of reforested material from 6 to 12 % and,
- increasing the quantity of genetically improved material being used, from 25% to 75% within the next 10 years.

For this to happen, there will be a need to increase capacity in current orchards, as well as initiate new ones. In the first year, the general focus has been on improving existing orchards, and in enhancing existing breeding programs for the purpose of producing new material for current orchards and future orchards where capacity is lacking.

Tree Improvement, like most forestry activities, is a long term proposition. Development of breeding programs and subsequent orchard enhancement, takes careful planning. Concurrent with this first year of investment, the TIC, through its technical advisory committees (TACs), has been developing species plans to quantify and priorize specific genetic material needs. These have been developed to be included in the 1998/9 call for proposals. The process of setting specific goals for species will continue to be reviewed and modified as priorities become better defined.

2.0 The Call for Proposals

2.0 The Call for Proposals

Roger Painter

The 1997/8 Call for Proposals was issued on April 15, 1997. It identified approximately $2.5 million in available funding, and was distributed to a wide range of organizations and individuals, identified as being involved with tree improvement. This included both seed producers and seed users as well as breeders, and specialists in the tree improvement field. Proponents were asked to apply for funding by May 23 for activities that met the initial investment matrix developed for Forest Renewal BC (FRBC). A total of 89 proposals were received, with requested funding of $2.9 million. Review committees were struck for the Coastal and Interior Technical Advisory Committees, and proposals were divided up based on the location of the project and its scope. Proposals which had a provincial scope were reviewed by both committees. The committee members were sent copies of the proposals, given instructions and asked to rate the proposals according to the four criteria as listed.

Evaluation criteria	
Cost Effectiveness	30%
Impact and Value of the Product	40%
Feasibility or Chance of Success	20%
Capabilities and Assets of the Proponent	10%

The committees then met to review their ratings, discuss the merits in terms of the overall program and give each a final ranking and include recommendations. Each proposal was assigned a lead and co-lead reviewer, whose job was to look into the proposal in greater detail and lead discussion at the meeting. Where conflicts of interest existed, reviewers removed themselves from discussion of specific projects. Following the review meetings, the results from the two committees were combined and brought to the TIC for ratification. This package was then forwarded to FRBC for final approval, which was granted on June 16, 1997.

3.0 Evaluation Criteria

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Roger Painter

The evaluation criteria were designed to ensure that projects would:

- meet the priorities as stated in the Call,
- give good value for the investment,
- produce a product consistent with the need,
- be capable of being implemented, and,
- have personnel with the skills to carry out the project.

The following is a description of the evaluation criteria used to rate proposals.

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 - 40%:

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 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?

Capabilities and Assets of the Proponent - 10%:

Evaluation of the capabilities of the proponent for performing the work, and the assets that the proponent has or will need. Questions to be considered were:

- Is the proponent and/or team capable of implementing or directing the project?
- Does the proponent have sufficient assets available to perform the proposal without purchase or hiring of considerable additional resources?

4.0 Project Rating

4.0 Project Rating
Roger Painter

Rating of overall scores by the committees were gauged on the following scale for total potential score. This was used to give them a greater insight into the proposal's overall score.

90 to 100 points:-Excellent

Provides specific opportunities that meet investment priorities and provide 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.

80 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 and is geared to general benefits and long-term goals. In relationship to orchard capabilities, provides for improvements to general production and quality. Is both cost-effective and technically sound with a capable project team.

50 to 65% points:-Fair

Lacking some aspects of the key elements of criteria, or 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 First Year in Review

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Roger Painter

Final approval of the first year of the Operational Tree Improvement Program (OTIP) was given in late June 1997, and the Tree Improvement Council (TIC) approved a total of 66 of the 89 proposals submitted for funding. In financial terms, this worked out to a total of $2,900,000 in requests received with only $1,824,439 being funded. The Coast received a greater portion of the funded projects. Their programs have been underway for many years, and are considerably more advanced and diverse. The interior, however, did receive a substantial amount of funding. The breakdown by region follows:

Number of projects and funding by region

Interior projects	35	$590,695
Coastal projects	26	$965,885
Provincial related projects	5	$267,859
Overall Total	66	$1,824,439

Recognizing that the OTIP was initiated quickly and only started part way through the year, the figures are consistent with the needs for investment in tree improvement. A considerable amount of funding has been granted for projects in Breeding and Testing. This shows that tree improvement must expand into areas where seed capacity is low or not available, and thus increase seed production and quality overall. The early years of the OTIP will see considerable work in Breeding and Testing, as more genetic material is produced for deployment. This intensity of work will also be seen, but to a lesser extent, with Program Development as the industry works to develop better methods of operationally delivering its product. A project breakdown by areas of investment follows:

Number of projects and funding by area of investment

Breeding and Testing	23	$998,303
Seed and Vegetative Material Production	35	$424,171
Program Development	4	$274,427
Communications and Extension	4	$127,538

Considerable interest has been shown in the OTIP in its short existence. There were 33 separate proponents who put in requests in 1997/8. Although it was not possible to fund all of the projects, the quality of the submissions was excellent. The 1998/99 Call for Proposals and review is already in progress, and indications are that the tree improvement industry is reaching out to meet the challenges and opportunities that have been made available by Forest Renewal BC. The TIC has also moved to ensure that priorities and goals are better defined through development of species investment plans (Appendices 2a - 2c). These plans will ensure that the path for our industry is clear. As a long term investment, the future of tree improvement looks bright.

6.0 Project Descriptions

6.1 Breeding and Testing

6.1.1 Western Redcedar Genetic Tests for Identifying Elite Populations

John Russell

Project Description:

Field trials of western redcedar polycross families will be outplanted in the coastal WTM to determine breeding values of 1st-generation parents in TIC-approved seed orchards. Four field sites will be tested with approximately 150 families in the coastal WTM below 600 metres. This is the first of five series of testing.

End Product:

Up to 100% of the low elevation coastal WTM seed needs will be met with genetically improved material by the year 2005. Improved material from this program will provide up to 15% volume gain at rotation and reduced time to free-to-grow.[HQ98063]

6.1.2 Genetic Variation in Resistance to Keithia Leaf Blight in Western Redcedar

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

Project description:

Of the pathogens that occur on western redcedar, Keithia leafblight, a fungal pathogen endemic to North America, is the most important foliar fungal disease. In the 1991-1992 growing season, in container nurseries, 1 million seedlings were discarded due to Keithia leaf blight; a loss of approximately 10% of the total production (10 to 12 million) of western redcedar seedlings in BC nurseries. Should such high losses of western redcedar continue into the future, the cost to silvicultural and non-timber values will be economically unacceptable.

Objectives:

The objectives of this proposal are to examine open-pollinated and outcrossed populations of western redcedar, in established field sites, to determine a Keithia blight resistance pattern, and to apply these findings to seed transfer guidelines, and to a gene resource management strategy. It is known that western redcedar follows a generalist adaptation strategy. However, the occurrence and severity of Keithia leaf blight seems to be an exception. The occurrence and severity of Keithia leaf blight is thought to have a close adaptation to seed origin. Populations from coastal sites, when grown at a low elevation humid environment, were highly resistant to Keithia leaf blight; and populations from high elevation, drier interior sites, were very susceptible. Keithia leaf blight resistance is an example of population genetic change in response to environmental selection pressure that appears to be more adaptive than other fitness traits. There is a need to identify adaptable, disease resistant/tolerant, populations of western redcedar. By choosing seedlots and families that are the most suitable to a biogeoclimatic zone, nursery growers and district silviculturists can be assured of increased seedling performance and survival.

Results:

The results of this project will ensure adequate conservation of western redcedar gene resources, including management strategies for gene conservation, refining seed transfer guidelines, population improvement and support research. End-users will benefit from knowing that disease resistance correlates with seed origin. [HQ98093]

6.1.3 Maintenance and Measurement of Existing Redcedar and Yellow-cedar Family/Provenance Trials

John Russell

Project Description:

Six western redcedar and nine yellow-cedar provenance trials will be maintained, and five and seven year heights, respectively, will be measured. These trials are scattered throughout British Columbia.

End Product:

Analyses of height and survival data will provide information for revising existing operational seed movement and breeding zone delineation.[HQ98067]

6.1.4 Measurement and Maintenance of Red Alder Provenance Tests

Cheng Ying

Background:

Red alder is now a significant commercial species for high-value products, e.g. furniture and veneer, in Oregon and Washington. In recent years, management of hardwood resources in coastal BC has been increasing.

Objectives:

The primary objective of red alder provenance testing is intended to address two questions:

- Can we grow quality logs of red alder in managed plantation forests?
- Is there genetic potential for improvement?

Results:

Three test sites were planted in 1995. Early results indicate Gulf Islands provenances are fast growing.[HQ98074]

6.1.5 Wood Density Assessments for Selections in Coastal Douglas-fir Tests
Jack Woods

Overview:

Douglas-fir progeny testing for advanced generation populations began in 1975 with full-sib diallel tests. From 1975 to 1985, eight series of diallel tests were established. In the mid-eighties, results from provenance and progeny tests indicated some advantage to using parents from western Washington. Subsequently two open-pollinated test series of U.S. parents were established in 1987 and 1988 (EP513.90), with 75 and 85 families respectively. This project measured these tests.

Objectives:

1. Evaluate wood density on six EP513.90 progeny tests.
2. Measure height and diameter on series 2 of EP513.90.
3. Calculate wood density and stem volume breeding values for parents in test.
3. Select parents suitable for second generation breeding and production populations.

Activities:

Three of five sites were chosen from each of the two test series (EP513.90 and .91) based on heritibility for age 6 growth traits. On each site, wood density was measured using a pilodyn (assesses penetration depth of a steel rod under a consistent force). A total of 3,000 trees were measured on each site, for a total of 18,000 trees. In addition, total height and DBH were measured on the three sites from the second series (first series sites had been measured previously). Methods were similar to sampling procedures used on other Fdc progeny tests.

Data will be analyzed to estimate stem volume and wood density breeding values, using methods consistent with other Douglas-fir progeny tests. These breeding values will allow selection of best parents and/or best offspring within best families. Selected trees will form separate sublines in the advanced generation breeding program, and will be made available for orchard replacement and upgrading. Data analysis is expected to be completed by March 31, 1998.[HQ98064]

6.1.6 Maintenance of Existing Coastal Douglas-fir Progeny Test Sites
Jack Woods

Objectives:

1. Secure field identities on 60 progeny test sites in EP708 and EP513.
2. Remove competing non-test trees that have encroached on the sites.
3. Assess mortality.
4. Update access maps and notes.

Results:

1. As of February 15, 1998, 23 sites have been visited and objectives met.

Crews are currently working under contract to meet the above four objectives on an additional eight sites.

A total of 31 sites will have maintenance completed during the first year of this program; this will result in about half of the 60 sites proposed for the two-year project.

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 tree removal was needed within the sites, but some spacing had been done around site boundaries to make the sites easier to identify by forestry crews working in the area.

Output and Deliverables:

The Douglas-fir breeding program has a repository of permanent records that have been brought up-to-date for the 31 sites worked on. These records reside in Victoria and on computer files. The site records are available for age-correlation studies and for other tests that may be needed. This work puts a temporary closure on further work on these sites, and ensures these records and past investment will be protected.[HQ98065]]

6.1.7 Measurement and Maintenance of Coastal Douglas-fir Provenance Tests

Cheng Ying

Background:

Ministry of Forests' Coastal Douglas-fir provenance trial was designed for long-term monitoring of provenance performance in diverse environments to guide silvicultural selection of seed sources. It is the most comprehensive (80 seed sources tested at 35 locations throughout the species' coastal range in BC) and among the oldest (age 25-30), ever established in the Pacific Northwest.

Activities:

We have measured and maintained 12 tests in 1997-98. Since these tests are now at about half-rotation age, information derived from the data on tree growth and conditions (e.g. climate and pest related injuries) can be used to estimate the gain of superior provenances with high accuracy, to recommend the infusion of superior seed sources into breeding, and to model climate effect on growth and yield of managed forests.[HQ98073]

6.1.8 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. Information from the tests would be used to establish improved first-phase seed orchards, to rogue seed orchards to improve their genetic quality, and to construct advanced-generation breeding populations. In total, more than 250,000 test trees from 1,661 wind-pollinated families were established in the tests. First-phase seed orchards from the program are expected to provide sufficient quantities of improved seed to meet the projected planting needs of Interior Douglas-fir in B.C. (approximately seven million seedlings per year).

This first series of Interior Douglas-fir progeny tests represents a substantial investment, and is critical to the development of the species' breeding and seed orchard program. Fundamental decisions relating to seed orchard establishment and roguing, seed zone delineation, seed transfer, and advanced-generation breeding, will be based on results from the tests. Therefore, it is important that they be brushed, maintained and measured at regular intervals to maintain their integrity as breeding installations, and to build the data base required for decision making.

Objectives:

The objectives of this proposal are to brush, maintain and record tree height measurements on 15 Interior Douglas-fir progeny tests described in Table 1.

Seed Planning Zone	Plantation age	Number of test sites	Number of test trees per site
West Kootenay high	10	4	7,200
East Kootenay	6	5	8,192
Coast Interior Transition	6	3	3,440
Nass Skeena Transition	10	3	5,040
Total		15	

Table 1. Summary of Interior Douglas-fir progeny tests scheduled for brushing, maintenance and measurement: 1997/98.

Progress:

All 15 plantations were manually brushed, maintained and measured. Data analyses are complete for the West Kootenay high zone, and fast growing parents will be grafted in spring 1998. Data analyses for the remaining zones are in progress. [HQ98124]

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

Objectives:

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

Activities:

The outplanting of this trial will occur on five different sites in each of the partners' operating areas [(MacMillan Bloedel (MB), Western Forest Products Limited (WFP), TimberWest Forest Limited (TFL), Canadian Forest Products Ltd (CFP), and International Forest Products Ltd (Interfor)],in early March of 1998. To date, the stock has been tagged and lifted. The average cutting and seedling heights have been taken and are not significantly different. [HQ98095]

6.1.10 The Genetic Improvement of Western Hemlock
John King

Progress to date (January 31, 1998):

In 1997, the first 2 *F-1* progeny trials were established at Jordan River in Southern Vancouver Island and Kiyu near Woss, Northern Vancouver Island. These phase 1 progeny tests were somewhat incomplete, as they missed two of the CZ/Willamette diallel sets. The next phase will be to establish sites that have all the Hemlock Tree Improvement Co-operative (HEMTIC) material including the CZ/Willamette families from the mouth of the Columbia River. The most disappointing news of the year is the failure of the American sowing of the HEMTIC local diallels. In January 1997, at a meeting in Corvalis, all the local diallel sets 1/3:2/3 were split up between the contributors. We sowed our 1/3 material at the Sylvan Vale nursery and were quite happy with the results; unfortunately the Americans did not sow on time, and a hot spell in May killed the emerging seedlings. However Ron Haverlandt of Willamette feels there is still adequate seedlings for at least one site. We also have enough surplus that we can provide material for two sites and the Oregon Department of Forestry (ODF) and Rayonier are establishing sites with the surplus seedlings.

We have laid out trial sites at Jordan River and Rupert Main near Port McNeil that will provide two sites to be planted this spring with this second phase material. We have two others that can be planted with surplus stock. One is the Kettle Creek realised gain site that was destroyed by elk. This site, which is already laid out, is in a frost pocket and should provide good information on frost hardiness of American material. The last site, Raft Cove, is also a partial site that will permit comparison of material in the far North and West of Vancouver Island. This provides a total of two full *F-1* sites and four partial sites, and should be quite adequate as a local diallel testing phase.

At the HEMTIC meeting in January 1997 in Corvalis, Washington, it was decided to delay sowing the elite portion of the HEMTIC breeding plan, because only 70% of it was complete. With the 1997 crossings complete, the seed count as of December 31 is nearly 90%, and the elite crosses will be sown this year. The American partners have delayed sowing their elites in order to complete more crosses.

The activities planned this year essentially finish the work outlined in the original hemlock breeding plan proposal (King and Cress 1991). The original plan had up to 12 test sites established for BC, starting in 1996. By the end of this year, approximately 10 test sites will have been established. Once this year's activities are complete, the hemlock program will essentially be in the ground, and activities will be mainly in documentation, maintenance and some small scale GCA testing. [HQ98108]

6.1.11 Brushing, Maintenance and Measurement of Western Larch Progeny Tests in the Nelson Forest Region
Barry Jaquish

Background:

The first-generation breeding population for western larch in B.C. consists of 608 parents selected in natural stands in the East and West Kootenay seed planning zones. Grafts of these trees have been established in breeding orchards and holding beds at Kalamalka. In 1989, two first-generation seed orchards, containing more than 100 parents each, 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 ITIC cooperated in establishing 17 western larch progeny tests in 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, to refine western larch seed transfer rules and seed planning zones, and to construct advanced-generation breeding populations. In total, more than 115,000 test trees from 607 wind-pollinated families were established in the tests.

This first series of western larch progeny tests represents a substantial investment, and is critical to the development of the species' breeding and seed orchard program. Fundamental decisions relating to seed orchard management and roguing, seed zone delineation, seed transfer, and advanced generation breeding will be based on results from the tests. Therefore, it is important that they be brushed, maintained and measured at regular intervals, to protect their integrity as research installations, and to generate the data base required for decision making.

Objectives:

The objective of this proposal is to brush, maintain and record three-year tree height measurements on four western larch progeny tests in the second series of progeny tests for the East Kootenay seed planning zone.

Progress:

All four plantations were manually brushed, maintained and measured. Data analyses are complete and recommendations for seed orchard roguing have been forwarded to the East Kootenay seed orchard manager.[HQ98125]

6.1.12 Maintenance and Protection of Lodgepole Pine Provenance Tests

Cheng Ying

Background:

Our lodgepole pine provenance research has generated enormous amount of valuable information. Productive seed sources include, Larch Hill and Inonoaklin in Shuswap-Adams, Marl Creek, Settlers' Road and Cartwright Lake along Rocky Mt. Trench, etc. These provenances have become target seed sources in reforestation.

Activities:

With FRBC funding, we have surveyed pest damages of these tests in the past five years, and have identified provenances highly resistant to foliar disease (e.g. Larch Hill and Inonoaklin), and western gall rust (e.g. Swan Hills. and Mt. Watt, Alberta). These resistant provenances can be used as the primary seed sources in reforestation at sites with high incidence of pests. Growth and pest data are also being used to model the effect of climate change on distribution of native lodgepole pine forests.

In addition to generating valuable genetic information helping silviculture, tree improvement and gene conservation, the network of lodgepole pine test represents the only presence of tree improvement (forest genetics) activities in many districts in the interior. Road construction and forest operation damaged some of the tests, and caused the complete loss of one test on Alaska Highway in recent years. To avoid these incidents, these tests must be both physically (maintenance for easy recognition by field crew) and legally (accurate document of site location and description in district land management system) protected. We have completed the physical maintenance of 20 test sites in 1987-88. We are updating the documents.[HQ98075]

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

Michael Carlson and John Murphy

Introduction:

British Columbia has made substantial investments over the past 25 years in genecological research and selective breeding with our major commercial species. We are starting to realize the benefits of this research and breeding with biologically based seed transfer guidelines, and genetically improved seed from seed orchards.

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:

Prompt establishment of realized gain trials for two of our breeding zones (seed orchard planning zones) will provide area based productivity gain information soon after our orchards reach full production, and will allow for accurate adjustment of growth and timber supply models.

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

- Develop generalized predictions of unit-area volume gains for a range of genetic levels (three) from individual-tree progeny tests.
- 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.
- 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:

This spring, approximately 2,800 lodgepole pine strobili were control pollinated at Kalamalka Forestry Centre, and another 2,100 at the Red Rock Research Station. These crosses were made to ensure sufficient seed for the realized genetic gain trials for the Thompson - Okanagan and the Willow Bowron breeding zones. Cone and seed cleaning is complete for 1996 crossing, and we will proceed with the Thompson-Okanagan trial in 1998. Small numbers of R.G. family seedlings were grown for demonstrations at six Southern Interior seed orchard and administration sites, to be planted in 1998.[HQ98122]

6.1.14 Improvement of Rust Resistance in Western White Pine Stocks - Evaluation of Field Trials
Rich Hunt

Objectives:

To determine blister rust resistance, half-sib families have been inoculated annually from 1986 through 1995.

Activities:

Stock excess to these needs from 1992 to 1995 has been planted in several test plantations. These were evaluated to determine early blister rust incidence, and determine if plantations needed maintenance. Eight plantations were examined at the Coast, and four in the Interior. Four of these plantations had a high incidence of blister rust infection. In these, families were ranked for blister rust incidence and correlations were made to the incidence of two resistance traits as determined from inoculations.

Results:

There were no correlations between field resistance and the trait reduced-needle-lesion-frequency in any plantation. All four plantations had weak positive correlations between field resistance and the trait slow-canker-growth. Two of the younger plantations need considerable maintenance; these and others are expected to have a high incidence of blister rust within 2 years. The current early data should be regarded as preliminary. They suggest that slow-canker-growth is a superior trait to reduced-needle-lesion-frequency. Therefore, parent trees possessing the trait slow-canker-growth would currently be the best recommended sources of resistant seed and pollen. [HQ98109]

Western White Pine Displaying the Blister Rust Resistance Trait Slow-canker-growth.

6.1.15 Realized Genetic Gain Trial to Quantify White Pine Blister Rust Tolerance Increases from Genetic Selection

Michael Carlson and Lynette Ryrie

Introduction:

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 (Washington, Oregon, Idaho, Montana) with partially rust tolerant seedling stock derived from co-operatively managed seed orchards in Idaho and Oregon. The U.S. Forest Service long term breeding effort (1960 to present) has produced seed orchard seedlots with estimate 60% plus tolerance to white pine blister rust.

A breeding program in BC began in 1980, a co-operative effort of the BC Ministry of Forests and the Canadian Forest Service. In a relatively short period of time, 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 Ministry of Forests in Vernon. Eighty percent of the trees in this orchard are from the U.S. program with the remainder coming from BC selection and screening efforts. Full production of approximately two million seed per year is expected by 2004.

Estimates of blister rust tolerance are needed from seedling crops from our Ministry of Forests, 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:

1. 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.
2. 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 seedlots, were grown in styroblocks at the Kalamalka Forestry Centre in 1996/97. Most of these seedlots will display blister rust tolerance levels, similar to the seed that will be produced by our Bailey Site Seed Orchard starting in approximately 2006. Seven seedlots are wild-collected from throughout the Pw range in the Southern Interior, and serve as non-rust tolerant ‘controls’. Also represented, is 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 for planting in Spring 1998. Between 2,200 and 2,700 trees will be planted at each site. Interpretive signs are being designed for display at each of the test sites, explaining objectives, materials and project design.[HQ98127]

6.1.16 Weevil Resistance Genetic Improvement in Spruce Populations

John King

Progress to date: (January 31, 1998):

Last year (1997), we started a detailed look at the data in preparation for writing up the report (Phase 1). Results from the two year assessment at the Jordan River site were very interesting and were presented at the Canadian Tree Improvement Association (CTIA) meeting in Quebec City. Instead of a broadly based resistance throughout the dry Douglas-fir zone as expected, the resistance on East Vancouver Island is centred on the Qualicum area, going from Nanoose to Courteney. A collection of 20 families was made in this area, which, together with collections from the Fraser Valley, Oregon, and Washington (made by the ODF and Washington Department of Natural Resources), will be sown in 1998. We are currently planning to sow the test material in 1998. Besides the collections, last years activities included assessments for a third year of testing at Jordan River, assessments on clonal sites at Sayward and Zeballos, and infestation of another series of family trials at Port Renfrew. Dr Alfaro and his team at the CFS have given considerable help in the assessments and infestations.[HQ98069]

6.1.17 Testing, Selection, and Demonstration of Growth and Spruce Leader Weevil Resistance in Somatic Embryogenesis (SE) Lines of Interior Spruce

Chris Hawkins

Activities:

Five, single tree plot, candidacy trial (CT) sites were established in May and June (Table 2). The number of clones, including full sib seedlings, planted for each family are indicated by site. Plantings included two registered seedlots, repeat clones of 12 families from previous CT, and stecklings from 10 of the families grown at two different nurseries. About 8,000 emblings, seedlings and stecklings were planted. Clonal block (CB) demonstrations were established on nine sites in May and June with about 49,000 emblings,

	Sites and BEC unit				
	Aleza Lake	Arctic Lake	Hungary Creek	Marie North	Quesnel 2700 Rd
Family	SBSwk1	SBSvk	ICHvk	SBSmc2	SBSmw
1 (G1*G21)	11	11	11		9
3 (R63*E866)	8	6	10		4
4 (E872*G145)	25	22	23	9	18
5 (G1*G87)	5	5	7		4
6 (E663*R63)	21	15	18	9	11
7 (E1659*E1649)	14	12	11	7	10
8 (G173*E866)	5	4	3		3
10 (G1*G167)	9	9	11	1	8
23 (G167*G161)	25	21	23	10	9
73 (G87*G161)	16	15	15	6	6
77 (G87*E1645)	30	31	33	12	16
107 (G87*G138)	6	6	4		3
119 (G21*G29)	13	10	11	8	6
125 (G21*G161)	9	10	12	7	8
143 (G29*G167)	35	36	33	8	18
186 (G161*G29)	20	19	18	8	9
Seedlots	2	2	2		2
Repeats (12)	16	15	15		14
Stecklings (10)	20	20	10	20	20
Total planted	2320	2152	1620	525	1432

Table 2 Candidacy trial site plantings in 1997. (G = Prince George; R = Prince Rupert; and E = Eastern North American sources).

seedlings and stecklings. All prior year's CT were assessed in June. Vegetation control was done as required on all CT and CB plantations. Survival plots were established in the 1997 CB, and survival assessments were done on all CB plantations. About 25,000 embling/seedlings from all CT were measured or assessed in the fall. A tour was conducted in September for about 25 people from the BCFS and the forest industry. At Aleza Lake, weevil survey trees were tagged during the spring and surveyed in the late summer. 24,500 emblings were lifted, packaged and placed in storage at Green Timbers in November for planting on five CT sites from 100 Mile House to Bear Lake.

Results:

Preliminary analysis of three BIOTIA sites, planted in 1994 and 1995, indicates that generally, for a given family, full sib seedlings perform better than most, if not all clones.[HQ98078]

6.1.18 Interior Spruce Progeny Test Establishment and Maintenance

Barry Jaquish

Background:

The progeny testing program for Interior spruce in B.C., represents a substantial 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 obtain information on parental breeding values to establish and rogue first-generation seed orchards, 2) to provide estimates of genetic gain, and 3) guide advanced-generation breeding. By spring 1997, more than 100,000 second-generation seedlings, derived through controlled crossing among select first-generation parents, will 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 B.C. They will serve as test populations from which to select parents for second-generation seed orchards and third-generation breeding.

These tests are critical to the development of the Interior spruce breeding and seed orchard program. Fundamental decisions relating to breeding strategies, seed orchard establishment and roguing, seed zone delineation, seed transfer, and advanced-generation breeding, will be based on results from the tests.

Therefore, it is important that they be brushed, maintained and measured at regular intervals to maintain their integrity as research installations.

Objectives:

The objectives of this proposal are to brush, maintain and, if necessary, irrigate eight Interior spruce progeny tests, to locate sites in the Prince Rupert Forest Region and to establish second-generation tests for the Buckley Valley seed planning zone.

Progress:

All eight sites were brushed and maintained. Three test sites were located in the Prince Rupert Forest Region. These sites will be site prepared for planting in 1999.[HQ98126]

6.1.19 Maintenance of West Kootenay Progeny Test Field Plantations
Clare Hewson

Objectives:

The objective of this project was to ensure competing vegetation would not interfere with the growth and development of the seedlings established in the West Kootenay progeny test. Data collected from this progeny test will identify the superior families to retain in the existing West Kootenay seed orchard. The current estimate of genetic gain for this orchard is 2%, but by retaining only superior families based on three, six and ten year measurements, future genetic gains are predicted to be 8% (A. Yanchuk, 1996). It is predicted that this gain will be realized on approximately 6,500 ha of land annually (production of 7.1 million seedlings/year).[HQ98112]

6.1.20 Yellow-cedar Genetic Tests for Identifying Elite Populations
John Russell

Project Description:

Field trials of yellow-cedar clones from pedigreed material will be outplanted in the coastal WTM to determine 1) breeding values of 1st-generation parents in TIC-approved seed orchards, and 2) clonal values of 2nd-generation progeny. One-year old seedlings grown from seed, from six 8-clone partial diallels, will be used as donor-stock for producing 1+0 rooted cuttings. Approximately 1,800 clones from 96 full-sib families will be planted at three sites in a randomized, incomplete block design. This is the first of three series of testing.

End Product:

Up to 100% of the yellow-cedar seed and cutting needs will be with genetically-improved material by the year 2007. Improved clones from this project and WFP clonal trials will provide 20% volume gain at rotation and reduced time to free-to-grow. [HQ98066]

6.1.21 Propagation and Maintenance of Stoolbed of Native Black Cottonwood
Cheng Ying

Objectives:

The phenomenal growth rate of hybrid poplar clones (mean annual increment over 30 m^3 per hectare per year) has attracted industrial interest in short rotation intensive silviculture for fibre production. However, high-yield hybrid clones will, sooner or later for perhaps evolutionary reasons, succumb to insects and to diseases. New hybrid clones will have to be developed to replace the old ones, in order to sustain the viability of this high-yield clonal forestry. Lack of background genetic information about our native black cottonwood constitutes the major knowledge gap in breeding high-yield and pest resistant hybrid clones. This genetic testing of native black cottonwood was initiated primarily to fill this knowledge gap.

Activities:

About 800 clones have been gathered from all major river drainages on the coast. We are now propagating these collections to produce physiologically uniform cuttings for testing. [HQ98072]

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

Background:

The Barnes Creek Clone Bank was established by the Ministry of Forests in 1977 to serve as the long-term reserve for important tree breeding materials. The 35 ha reserve contains grafted trees from most of the parent trees in the provincial Interior spruce, Douglas-fir and western larch tree breeding programs, and several important tree improvement and growth and yield research installations. The reserve was established with four goals: 1) long-term preservation of important breeding material, 2) *ex situ* gene conservation, 3) to provide male and female flowers for advanced-generation breeding, and 4) to provide scionwood to establish seed orchards. 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. The western larch clone bank is presently about 30 percent complete.

The reserve represents a substantial investment and contains a large source of material that is vital to the Interior tree breeding and seed orchard programs. It is important that the site be maintained to ensure that grafts survive and grow, and are adequately protected.

Objectives:

The objectives of this proposal are to:

Transplant 100 young grafted Douglas-fir trees from the Kalamalka Forestry Centre to Barnes Ck.

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.

Weed, water and maintain the area's recently established grafting bed.

Progress:

About 110 grafted Douglas-fir trees were planted on the site. All routine site maintenance and graft maintenance was completed. The grafting bed was maintained, and grafting will commence in spring 1998. Mature Douglas-fir grafts in the clone bank were used to complete about 80 controlled crosses for second-generation selection [HQ98123].

6.2 Seed and Vegetative Material Production.

6.2.1 Clone Bank Planting at the Prince George Tree Improvement Station

Carole Fleetham

Objectives:

The objective was to establish two to three healthy ramets per clone.

Activities:

Approximately 400 grafts were planted in the Interior spruce clone bank at the Prince George Tree Improvement Station in August of 1997. Planting took approximately three weeks to complete. Ramets representing BLK, CP, CT, EK, FIN, HH, MGR, MIC, FN, QL, SA, TO and WK planning zones, were planted. [HQ98103]

6.2.2 Controlled Cross Douglas-fir Seed Production

Tim Crowder

Background:

Currently, there is a limited supply of seed coming from advanced generation seed orchards of Douglas-fir that has a genetic rating of +10%. Harvesting is increasing on highly productive low elevation second growth Douglas-fir sites, on East Vancouver Island, creating an increased demand for the best material available.

Objectives:

This project is designed to fill this need by producing a seed lot from only the best clones within the orchard that will have a breeding value of +15%, and this seed can then be used to produce enough material for 2.7 million rooted cuttings.

Results:

Controlled pollinations were carried out on 45 trees from eight clones with high breeding values in orchard #154. Pollen from 12 different clones was collected, extracted and applied to the bags. Cones will be harvested in the summer of 1998, and will yield an estimated 1.76 kg seed that will yield 514,000 seedlings with a potential gain of +15%.[HQ98083]

6.2.3 Flower Stimulation on Seed Orchards #134, #140 and #154

Tim Crowder

Objectives:

In seed production, as in most other crops, different environmental conditions from year to year cause fluctuations in the quality and quantity of production. This project is an effort to enhance production and increase the genetic quality of the seed produced from these orchards. In years of low seed production, some clones do not produce any seed, which leads to a reduction of the number of parents contributing to the seedlot, thereby reducing the level of diversity. When low amounts of pollen are produced within the orchard there is a greater influence from contaminating pollen from surrounding stands.

Activities:

To combat these problems, 156 western redcedar trees in orchard #140 were sprayed with GA3 twice, and 518 Douglas-fir trees in orchard #134 and #154 were stem injected with GA 4/7 to stimulate a crop of male and female flowers. [HQ98086]

6.2.4 Establishment and Maintenance of an Interior Douglas-fir Propagation Bed

Chris Walsh

Outline of Project:

There was a documented demand for Fdi seedlings in seed planning zones for which no orchards existed (MIC, SA high, WK low, EK, BSH). Progeny testing of interior Douglas-fir parent trees had demonstrated that significant genetic improvement could be realized through orchard seed production. Data existed to allow orchard trees to be selected from the breeding populations and grafted. The establishment of the propagation bed will allow grafting for the orchards to proceed (without prejudicing any decision regarding the location for the orchard).

Work Completed:

Approximately 3,000 graft-compatible interior Douglas-fir (Fdi) seedling rootstocks were established and maintained in a propagation bed at the Bailey Road Site of Kalamalka Seed Orchards.

Product:

Graft-compatible rootstock for the production of interior Douglas-fir orchard trees. [HQ98119]

6.2.5 Upgrading Western Hemlock Orchard #130 with Superior Clones

Tim Crowder

Background:

TimberWest Forest Limited is a founding member of HEMTIC, which includes governments and industrial co-operators in BC, Washington and Oregon. We have been actively involved in the breeding, testing and selection of this species. Orchard #130 was established before any test data was available and although it has produced well in the past (we have a 15 year inventory of seed), there are better clones now available.

Objectives;

This project will replace some of the existing trees with better quality clones. This will raise the genetic gain of seed from this orchard from 2% to 13.5%.

Results:

To date 259 producing trees from this orchard were removed and replaced with trees that have an average breeding value of +13.5%.[HQ98084]

6.2.6 Delivering High-gain Western Hemlock Reforestation Material to Fulfil All of our Coastal Requirements Between 0 and 800 Metres

Patti Brown

Objective:

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

Work Completed:

70 litres of cones were obtained from the 1997 controlled crosses, and the seed from this collection is in the process of being registered as SL60624 with a genetic worth of 14.5.

Product:

This will produce approximately 150,000 single sown seedlings for both operational usage and for bulking up future cuttings. 50,000 cuttings from 5,000 donors from the 1996 controlled crosses at 3 different nurseries are being taken in January 1997, to produce plantable stock for the spring of 1999.[HQ98096]

6.2.7 Replace Mortality and Increase Size of Orchard #179

Patti Brown

Objectives:

To meet all of our needs for western hemlock seedling requirement for under 600m, with seed of genetic value greater than 15, from Orchard #179, by the year 2005 in the most cost efficient manner.

Work Completed:

61 ramets from 10 clones were added to Orchard #179 in October 1997. The irrigation system was extended to include these additional ramets. The B.C. and Grays Harbour components of this orchard are now complete.

Result:

This will increase the orchard capability by 50,000 seedlings annually, beginning 2005. [HQ98098]

6.2.8 Western Hemlock Elite Crossing Program
Diane Medves

Work Completed:

This project carried out cone induction and control pollinations for the creation of an "elite" seedlot of Western Hemlock. In May 1996, six of the top 28 clones identified by the HEMTIC as having the best Breeding Value, were induced with GA injection. Pollen from six different clones of the top 28 (BV > 9) was collected and used in a pollen mix for control pollinations in the spring 1997. Seed was harvested (34,000 seed) in the fall 1998, and will be used on crown lands, managed by MB.[HQ98081]

6.2.9 Collection of Western Larch Pollen from Natural Stands for Use to Enhance Seed Production through Supplemental Mass Pollination in Two Larch Seed Orchards
Clare Hewson

Background:

Seed supply for Western Larch (Lw) is a limiting factor for establishing this species in reforestation programs. To combat this shortage, two genetically improved Lw seed orchards have been established at Kalamalka Forestry Center with the expectation to produce the projected requirement of 6 million genetically improved seedlings annually. As with most immature seed orchards, a shortage of pollen produced in the orchards is the limiting factor in achieving significant seed production.

Objectives:

This project proposes to collect a minimum 15 litres of pollen (equivalent to 75 litres of mature pollen buds) from superior natural stands, as identified from progeny/provenance tests, and make it available for application on these developing seed orchard trees to increase seed yield.

Progress:

The program is scheduled to commence in March with the selection of stands, and will be completed prior to May, 1998. It is anticipated this project will be continued in 1999.[HQ98113]

6.2.10 Larch Cone Adelgid Effect on Seed Production
Chris Walsh

Outline of Project:

The project was designed to determine whether the larch cone adelgid (*Adelges lariciatus*) is causing a significant reduction in the quantity or quality of seed produced in larch orchards.

Work Completed:

Larch trees bearing cones in both larch orchards at Kalamalka were surveyed in June, and rated for the density of adelgids on their cones. Samples of cones from each tree were collected at cone maturity in early August. These cones were analyzed for numbers of filled seed per cone, and the seed will be tested for germination behaviour. Seed results will be correlated with adelgid density.

Product:

The results of this project will show whether adelgid control in larch orchards is warranted.[HQ98121]

6.2.11 Orchard Tree Crown Management
Chris Walsh

Outline of Project:

Crowns of orchard trees were managed in such a way to increase economic efficiency of orchard seed production. Trees are topped to reduce cone harvest costs, and pruned to encourage future cone production and allow efficient access.

Work Completed:

Basal pruning and topping were completed in two lodgepole pine orchards, 230 and 307. Trees were topped at 2.5 metres.

Product:

Sustainable delivery of improved lodgepole pine seed at reasonable costs.[HQ98117]

6.2.12 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:

- 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.
- 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.[HQ98114]

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 pollination and reducing pollination by undesirable parents. The result will be an increase in both the quantity and genetic quality of seed produced.

Work Completed:

Due to late approval, no pollen collection or application was possible in 1997. However, funding has been used to test the viability of existing stored, high-value pollen and to refurbish pollen management equipment.

Product:

Greater quantities of higher genetic worth Interior spruce, Interior lodgepole pine and western larch seed will be produced in future years.[HQ98118]

6.2.14 Grafting to Upgrade Orchards at Kalamalka Seed Orchards
Chris Walsh

Outline of Project:

The Lw orchards and some Sx orchards at Kalamalka Seed Orchards were initially established without reference to progeny test data. As test data became available, the orchards have been rogued. To sustain orchard target production, trees must be added to the orchards to replace those rogued. By using new grafts of the top-ranked clones, genetic gains will increase.

Work Completed:

For Orchard 209 (QL Sx), approximately 200 grafts were made (at 90% success) from high breeding value (volume) and weevil resistant QL zone selections. When these trees begin contributing to orchard seedlots (expected within seven years), estimated genetic worth will increase significantly.

For Orchard 333 (EK Lw), approximately 390 grafts were made (at 92% success) using both seedlings and existing orchard ramets for rootstock. These existing orchard ramets used for rootstock were from clones chosen for roguing. Rogued and grafted trees were selected based on six year progeny test data. Projected genetic gain for Orchard 333 increased significantly.

Product:

Greater quantities of higher genetic gain Sx seed will be produced for the new Prince George seed planning zone. Greater quantities of higher genetic gain Lw seed will be produced for the EK seed planning zone.[HQ98116]

6.2.15 Pollen Collection and Supplemental Mass Pollination. (SMP) - Bulkley Valley #219 and Willow Bowron #222

Tim Lee

Background:

The Bulkley Valley and Willow Bowron Orchards were started in 1992 with the first phase of planting. The development stage is nearly complete, and the first planted ramets are beginning initial production. Commonly most orchards' initial production requires that the pollen be managed to ensure what little pollen is produced, is placed at or near the female flowers as they become receptive. As the orchards mature and the natural pollen cloud develops, the need for pollen management changes to elite pollen collections.

Activities:

In both orchards the activities were identical:

- Pollen surveys were taken to ensure the inclusion of all clones in the pollen mix for SMP, and the best pollen sources were identified.
- Pollen was hand picked and dried to 6 - 8% moisture content, and was re-applied to receptive flowers, making use of SMP methods .
- SMP applications using a pollen application wand occurred three times to ensure pollen was present for each clone as its receptive period progressed.

In total, five litres of pollen were applied to the orchards.

Product:

Cones will be harvested from these orchards in the fall of 1998. This will begin the initial production of genetically improved Class A seed. The production will provide seed for the following planning zones: Bulkley Valley, McGregor, Quesnel Lake, Mount Robson, Cariboo Transition, and Nechako (east of the Fraser river). Between 1.5 and 2 million seeds are expected from these projects.[HQ98087 & 088]

6.2.16 Roguing of Lodgepole Pine Seed Orchards #203 and #204 at the Prince George Tree Improvement Station

Carole Fleetham

Objectives:

Breeding values for parents of two interior lodgepole pine 1.0 generation orchards, Willow Bowron #203 and Smithers #204, are now available. The future management of these orchards can now take parental genetic worth into consideration, by roguing clones of low gain. The result will be seedlots of higher genetic worth. In March 1998, approximately 35% of the lower ranked clones in each of the two orchards will be rogued. [HQ98094]

6.2.17 Flowering Phenology in Advanced Generation Lodgepole Pine Seed Orchards #228 (Bulkley) and #220 (Willow Bowron) at the Prince George Tree Improvement Station

Carole Fleetham

Background:

Knowledge of both female and male flowering phenology in a seed orchard is necessary in order to maximize the effectiveness of supplemental mass pollination (SMP).

SMP is used:

- to increase filled seed production when there is insufficient within orchard pollen to produce filled seed,
- when there is a potential for pollen contamination from outside genetically inferior pollen,
- to improve panmixis when there are early or late flowering clone. By applying pollen from trees with high breeding values, the overall seedlot genetic worth is increased.

Activities:

Reproductive phenologies were carried out in two lodgepole pine seed orchards (#220 and 228) at the Prince George Tree Improvement Station in May and June of 1997. [HQ98104]

6.2.18 Crown Management in Three Advanced Generation Lodgepole Pine Seed Orchards

Carole Fleetham

Objectives:

Three advanced generation lodgepole pine seed orchards at the Prince George Tree Improvement Station were designed to produce 25% of the seedling needs in eight seed planning zones in central and northern BC.

To meet these demands, crown pruning of the trees is required. Pruning increases the number of flowering sites by increasing the number of intra-fascicular buds.

Results:

In June 1997, first and second order shoots exceeding 20 cm in length on approximately 3000 trees in seed orchards #220,223 and 228, were pruned. The results indicate a noticeable increase in the number of intra-fascicular buds formed in the summer. [HQ98106]

6.2.19 Inadequate Root Development of Lodgepole Pine Ramets - Bulkley Valley #219 and Willow Bowron #222

Tim Lee

Background:

In the spring of 1997, a number of grafts began to lean or completely fell over in the wind. The roots were found to be insufficient to anchor the ramets. The affected ramets were immediately anchored using a wooden stake and tree rope. It was felt that if the ramets were anchored and remained undisturbed by the wind, better roots systems would form. As initial seed production is about to begin, the need to find an immediate solution to the problem was required. The planning zones affected are Bulkley Valley, McGregor, Mount Robson, Quesnel Lake, Cariboo Transition, and Nechako.

Activities:

Approximately 4000 ramets were anchored in this fashion. Checking the ties and re-staking a number of the ramets was required as the year progressed.

Product:

The root deficiency problem will require a number of years to correct itself and target production levels are not far off. [HQ98089]

6.2.20 Graft Maintenance – VSOC Holding Area

Tim Lee

Objectives:

This provides cost effective and quality care for the development of new grafts (ramets) prior to outplanting into the orchard position, and will expedite the establishments of VSOC orchards for the production of genetically improved seed.

Activities:

- Care and maintenance of grafts takes place on a weekly basis.
- The holding area is maintained free of weeds.
- Grafts receive fertilizer and irrigation as required for proper development.
- Grafts are pruned to promote scion growth and after two growing seasons they are lifted and planted out into the orchard position.
- All grafts are tied and staked to prevent snow damage and a snow fence is erected to help minimize wind desiccation for the winter months.

Product:

The above practices provide healthier grafts ready for transferring into the orchard. [HQ98090]

6.2.21 Western White Pine Resistant Seed Production for Operational Usage

Patti Brown

Objectives:

- To produce a small operational crop from Orchard #174 by: collecting and processing pollen, applying individually to cones to conserve pollen, and bag to protect from *Leptoglossus*.
- To increase the surface area available for future cone production through crown pruning techniques.
- To increase the resistance value of the orchard by adding clones that have recently been identified as having a slow canker growth mechanism.

Activities:

- 643 cones remain from the 1047 1997 pollinations and will be collected in August of 1998.
- An average of 70 filled seeds/cone was obtained from 1996 pollinations. This would provide a potential 40,000 seedlings based on 1997 germination success rates.
- All ramets were pruned in August to enhance flowering branches.
- 291 scions were collected from in the orchard to replace mortality over the last 3 years.
- An additional 100 scions (4 parents) were collected from original parent trees selected in the top 15

parents for slow growth and/or low spotting traits.

Grafting is completed at Cowichan Lake Research Station and these ramets will be incorporated into the orchard in the fall of 1998.[HQ98097]

6.2.22 Sitka Spruce Donor Establishment
Diane Medves

Background:

This project developed 350 Sitka Spruce donor plants for setting rooted cuttings. These donors were from the top 15 O.P. families from the Qualicum provenance. These families have demonstrated superior weevil resistance after two inoculation tests.

Activities:

In May 1997, 350 Ss plugs were transplanted into pots and put onto an accelerated growth regime to promote shoots. Terminals were pruned back. In January 1998, these plants were sent to Cairnpark Nursery to take the cuttings and set them for use in operational planting programs in 1999.

Product:

Each plant will yield approximately 50 cuttings, totaling approx. 18,000 cuttings. [HQ98080]

6.2.23 Operational Deployment of Highly Weevil Tolerant Sitka Spruce Somatic Seedlings.
Dan Polonenko

Background:

Sitka spruce is an extremely important commercial forestry species in coastal British Columbia. However, this species is particularly susceptible to terminal leader damage by the white pine weevil (*Pissodes strobi* Peck) and consequently, annual reforestation plantings of Sitka spruce during the past decade have decreased by 90% to about 1 million seedlings. Currently, high-weevil-risk reforestation sites are being replanted with lower-value and slower-growing species, e.g. western redcedar.

Considerable research efforts have been placed during the past decade, on breeding and selecting weevil-resistant Sitka spruce. Data collected from the Ministry's provenance trials at Fair Harbour (FRDA Report 226, pp 134-149) and Jordan River, suggested that the use of selected weevil-resistant Sitka spruce provenances would reduce weevil damage to 15% or less (CFS Report on Project # E2-6602). In addition, recent BC. research initiatives have been organized to accelerate the delivery of highly weevil-resistant Sitka spruce for commercial reforestation, through the development of somatic embryogenesis technology for this species (Technology BC award #141, 1994-97). Successful completion of that initiative enabled the establishment and on-going field-testing of a clone bank, prepared from proven weevil-resistant open-pollinated Sitka spruce families (FRBC grant # FR-96/97-356). Currently, the collective output from these initiatives includes approximately 300 embryogenic lines from 23 proven highly weevil-resistant Sitka spruce open-pollinated families, which are currently being assessed in nursery and research field trials.

Objectives:

The main objective for this FRBC-funded project is to deliver 100,000 1+0 spring Sitka spruce somatic seedlings for planting in operational field trials by five forestry companies in spring 1999. The deliverables for the first year (i.e., 1997-98) were to produce and germinate Sitka spruce somatic embryos (SE) at a pilot scale, and then transplant the germinants into styroblocks for production of somatic seedlings in an operational forestry nursery setting.

Results:

As of January/1998, nearly 230,000 Sitka spruce SE were produced from 53 lines selected from nine open-pollinated weevil-resistant families. Approximately 200,000 SE were germinated in February 1998, and are scheduled for transplanting in March 1998. Based on SE germination and transplant performance in a small scale-up study conducted in early 1997, we anticipate that approximately 128,000 Sitka spruce somatic seedlings will be lifted in November 1998.[HQ98110]

6.2.24 Upgrading Interior Spruce Orchard #210 with Superior Clones
Tim Crowder

Objectives:

This orchard was designed to get an early start in producing improved seed for the Finlay seed planning zone.

Activities:

Selection of the parents was made when the first measurements were taken at age six. Subsequent measurements at age 10 identified some rank changes in the tested parents.

Results:

This project is designed to remove 15 clones with low breeding values, and plant 252 trees with better breeding values. An additional 603 trees were field grafted on to rootstock in orchard positions. Further trees will be added as they become available.[HQ98085]

6.2.25 Alternate Cone Rust Host Removal.

Keith Cox

Objectives:

This project was targeted at reducing the amount of seed loss to spruce cone rust in the Skimikin seed orchards, through removal of the alternate host plants (Pyrola arifolia) and decreasing the amount of pesticides used to control the cone rust.

Activities:

- Pyrola plants were removed from about one half of the area to be treated by hand-digging in May. Less rust infection was found in the orchard where the most plants were removed from the perimeter.
- Ten plots were established to quantify the effectiveness of removing the Pyrolas.
- Five were established where plants had been removed in previous years (“old” plots) and five were established where infected plants were removed in 1997 (”new” plots).
- Data from the “old” plots showed that where 61 infected plants had been dug out in previous years, only 8 infected plants were found. In other words, 87% of the infected plants that were removed had not regrown. The “new” plots had a total of 93 infected plants identified and removed.

These plots will be monitored in 1998 for regrowth.

Results:

A sample of 199 cones on one tree each of ten different clones was taken in the Central Plateau (CP) Low and a similar sample of 200 cones was taken in the Central Plateau High. There was a 4% rust infection in the CP Low sample and 10.5% in the CP High sample. The difference in infection rate between the two orchards may be due to the perimeter of the CP Low having had more Pyrolas removed, or there may be a difference in rust susceptibility between the clones, in the two samples. Samples will be taken again in 1998, with the same clones where possible. The plot and sample data are available upon request.

The effectiveness of this work is based on meeting a biological window. After that time it is not possible to identify the infected plants. As approval for the project did not arrive until after this period, the project had to be scaled back. The impact of this was that only half of the proposed work was accomplished. [HQ98091]

6.2.26 Roguing the Central Plateau Spruce Seed Orchards.

Keith Cox

Activities:

- In September and October a total of 323 low genetically ranked trees were removed from the Central Plateau (CP) Low and High Elevation spruce seed orchards at Skimikin Seed Orchards.
- The trees were cut down, and limbs and tops were left in the orchard and mulched into chips with the flail mower.
- The stems were large enough that most were skidded to the edge of the orchard where they await disposal.
- The stumps were removed with a backhoe to reduce the risk of rootrot, which was already apparent in two of the cut stumps.
- Removal of the stumps will also enhance safety and prevent hazards when orchard manlifts are used.[HQ98092]

6.2.27 Clonal Roguing of Orchard #303

George Nicholson

Background:

The Interior spruce orchard #303 is a first generation orchard with 240 families. Orchard #303 supplies seed for the Thompson Okanagan seed planning zone. Progeny from this orchard have been planted in field test sites, and six year tree height measurements have been completed. The clones have been ranked for growth potential, based on this six year data. There are also 30 clones in this orchard that are not in the progeny tests due to the lack of seed production for testing. The current genetic value of this orchard is four percent at the present level of family participation.

Objectives:

The specific objective of this project is to reduce the number of families of poor genetic value, increasing the overall genetic gain to eight percent from four percent. The orchard has been separated into high and low elevation operational blocks, with the elevational division being 1,300 metres. The bottom 16 percent from each elevational block will be physically removed from the orchard configuration, increasing the value of the seed production from the remaining families.

Results:

The roguing of these families has been completed and the improved seed produced from this orchard in 1998 will reflect the genetic gain, by the removal of these poor quality clones. A total of 78 clones has been removed from the orchard design.

The direct benefits from this proposal will flow through to the clients using the improved seed from this orchard. These clients will be the Licensees and those participating in the Ministry of Forests Small Business Program, who will be operating in the Thompson Okanagan seed planning zone. [HQ98101]

6.2.28 GA Treatment for Interior Spruce Orchard #303

George Nicholson

Background:

The Interior spruce orchard #303 is designed to supply improved seed for the Thompson Okanagan seed planning zone. This orchard is a rogued first generation orchard, producing seed with an improved gain nearing eight percent. The seedling requirements for the Thompson Okanagan zone are estimated at 4.2 million seedlings annually. The orchard is currently producing approximately 2.0 million potential seedlings annually.

Objectives:

The objective of this project is to increase the seed production from this orchard by using cone induction techniques with GA4/7 to increase flower production within the orchard.

Activities:

There were a total of 557 ramets treated in the spring of 1997. The GA was mixed with absolute alcohol and injected into the stem of each ramet selected. The results of this treatment will show in the increased flower production for the 1998 seed crop.

Results:

There were 557 ramets treated in the spring of 1997 with GA4/7. This cone induction treatment will produce a projected 10 thousand additional grams of improved seed, yielding an additional 1.5 million potential seedlings for reforestation in the seed planning zone. The increase in seed production will benefit all of the forest licensees, and the participants in the Ministry of Forests Small Business program in the seed planning zone. [HQ98102]

6.2.29 Consolidation of Orchard #209

Chris Walsh

Outline of Project:

Kalamalka Seed Orchards Orchard #209 was heavily rogued in 1996. The remaining trees were at too low a density for wind pollination to be effective. This project involved transplanting the trees to a part of the old orchard area, creating a tree density adequate for effective wind pollination.

Work Completed:

The trees remaining after the 1996 roguing were transplanted by a contractor with a 44 inch treespade from their original widely spaced locations (average density 120 trees per hectare) to one end of the old orchard, resulting in an average density of 260 trees per hectare. Distribution of clone locations met randomized clonal distribution restrictions. A new tree tag was required for each tree. All stumps remaining from the roguing were removed with a stump-grinder.

Product:

Orchard #209 now has trees at a high enough density for wind pollination to be effective in producing acceptable numbers of seed per cone. As a result, greater quantities of improved Sx seed will be produced for the QL and CT zones.[HQ98115]

6.2.30 Grafting of Interior Spruce for the Spruce Clone Bank at the Prince George Tree Improvement Station

Carole Fleetham

Background:

The Prince George Tree Improvement Station is the location for the Interior spruce clone bank. The clone bank was designed to preserve all parent tree selections made in the province. The clone bank is important as it serves as both a source of material for grafting new genetically improved orchards, as well as a gene archive for the species.

Activities:

Approximately 1,700 Interior spruce trees were grafted in May 1997, representing material primarily from the Fort Nelson planning zone and the Mica (# 304), Shuswap Adams (#305 and #306), Quesnel Lakes (# 209) and Central Plateau (#205 and #206) seed orchards. Post graft care included watering, fertilizing and pruning. The grafts were planted in the holding area in July 1997.

Results:

Once the seed orchard material is established in the clone bank, roguing to increase genetic gain can occur in the orchards.[HQ98105]

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

Clare Hewson

Background:

The management of 'high density' clonal row orchards and conventional seed orchards, consisting of rapid growing species such as western larch, pose major crop management problems to the orchard manager with regard to excessive height growth. This was the first year of a long term crown management program and treatments were applied to over 2100 ramets.

Objectives:

The objectives of this program is to determine which techniques are superior in controlling vegetative growth, while at the same time ensuring cone and seed production are not jeopardized. The results will identify the effects of the various treatments on enhancing cone production, and which contribute to more effective orchard and crown management practices (pesticide application, pollination, row access, cone collection, scion collection etc.). As information becomes available as to the cost effectiveness of a particular treatment, this treatment may be initiated in other developing orchards or may be discontinued.

Results:

The effects of these initial management treatments will be assessed early this spring. As this project is being conducted on developing (not producing) orchards, effects of the various treatments on enhancing cone production will not be available for several years. However, the treatments have definitely contributed to more effective orchard and crown management. These operational treatments will be continued to assess their effect on orchard and crop management and crop enhancement in the future.[HQ98111]

6.2.32 Bulking up Yellow-cedar Elite Clones by Means of Vegetative Reproduction

Oldrich Hak

Objectives:

- To select approximately 50 elite clones from 940 clones established in the first three phases of field trials, and locate these clones either in the orchard or in the field trials.
- Collect cuttings and establish greenhouse culture to reproduce and rejuvenate the elite clones, to produce a total of 100 ramets per clone within two years.
- Establish a holding area to accommodate and protect about 5,000 ramets until ready to be established in the future high gain orchard.

Activities:

- Selection of 47 elite clones from first three phases of field trials was completed. Initial selection of about 58 elite clones was based on data analyses for growth performance in the field. Additional evaluation of the selected clones for form, reduced the number to 47. Twenty-five of these clones were located in the hedge orchard, and the remaining 22 clones were located in the field.
- Cuttings from the selected clones were collected in November and December and established at CairnPark Nursery in Duncan, for rooting and rejuvenation.
- Holding area for the clonal material was established. [HQ98071]

6.2.33 Yellow-cedar Hedge Program
Diane Medves

Objectives:

This project selected Yc families identified in the early stages of the Yc breeding program as good performers in the nursery beds. (No gain figures attached). From these families, clones were taken and selected over the past five years for rootability and plagiotropism.

Results:

This project helped produce a yellow-Cedar hedge orchard that will supply nurseries with better yield potential cutting materials and faster field establishment. The hedges were planted in the field in the fall of 1997 and cutting production was taken in January, 1998. Cuttings were sent to Sylvan Vale Nursery and to Cairnpark Nursery for production and operational planting programs. [HQ98079]

6.2.34 Maintenance of Demonstration and Realized-gain Field Plantations
Clare Hewson

Objectives:

The objectives of this project were to ensure competing vegetation would not interfere with the growth and development of the seedlings established in these plantations, and to ensure that any data obtained, would not be compounded by the effects of competing vegetation.

The long term objectives of this program are to:

- visually compare the performance of seedlings derived from various sources, including control crosses, seed orchards, and adjacent planning zones with local seedlots,
- demonstrate, through height, diameter, volume and quality parameters, the value of seedlings derived from current seed orchard seed, when compared to currently used natural stand seedlots, and,
- provide additional information concerning seed transfer and seedling performance.

Results:

The contractor successfully removed all competing brush and re-established stakes and ID labels where necessary. The competing vegetation was reduced to a level where it no longer interferes with the growth and development of the seedlings established in these plantations; thereby ensuring that data obtained in future is not compounded by the effects of competing vegetation.[HQ98107]

6.3 Program Development, Support and Gene Conservation.

6.3.1 Full-Sibling Douglas-fir Production from a Crown-Pruned, Clonal Row Orchard
Joe Webber and Michael Stoehr

Background:

Two options being seriously considered for delivery of high gain material include smaller breeding style orchards with associated vegetative bulking techniques and intensively managed seed orchards. While the more cost effective delivery tool for high-gain propagules is seed production, the potential for mass deployment of high gain crosses through vegetative amplification (stecklings and emblings) is attractive. If we are not prepared to pay the extra cost of vegetative amplification (between 2-5 times), then we must change our concepts of orchard design and management. It is our long term goal to demonstrate that crown pruned, clonal row orchards are a cost effective tool for operational production of elite, full-sibling seed.

Activities:

- In 1991, we established a clonal-row, crowned-pruned Douglas-fir orchard incorporating some of the concepts developed by New Zealand (i.e., hedge and meadow orchards).
- Ramets are spaced 2.5 metres within and 4 metres between rows.
- Two pruning regimes are being evaluated: conventionally (toping to 3m with some inter-nodal branches removed) and radical (most of the center bole is removed at 2m height creating a bowl-like shape).

Before operational production is considered, several questions need to be answered:

- Can a pruned 2 metre tree produce or be induced to produce seed and pollen cones?
- Will a clonal row orchard suffer from excessive selfing?

- Will easier access to the flowering crop facilitate SMP efficacy and crop protection?
- What is the effect of competing pollen cloud density (including within and contaminating pollen) on SMP efficacy?

Results:

Half of the orchard is induced annually, using a combination of girdling and gibberellin $A_{4/7}$ treatments on top of summer drought. Because of the high vigour of the ramets, we use a full circle girdle. Girdling is completed three weeks before vegetative bud flush. GA is applied as a single dose stem injection when the vegetative bud flush reaches 10-20% . Table 3 shows the flowering and seed yield data for the last three induction years. Pollen production data has been good for all clones on both pruning regimes.

	1995		1996		1997	
	2m	3m	2m	3m	2m	3m
% Flowering Ramets	54.2	62.5	71.2	54.2	70.8	75.8
Number of Cones/Ramet	22.8	25.6	37.4	14.6	33.4	23
Number of Seed/Ramet	825	897	1352	478	*	*
Filled Seed/Cone	36.2	34.9	36.2	32.7	*	*

* data not available at printing

Table 3 Average flowering and seed yield data for two pruning regimes in a Douglas-fir clonal row seed orchard.

Flower response to induction has been consistent during the last three years (considered to be poor flowering years). Flowering response on our most severe pruning regime is as good or better than the less severe pruning regime with twice the crown volume. Using DNA paternity analyses, Stoehr et al. (1998) found selfing rates to average 6% (range 0-19%) and SMP efficacy averaged 55% (range 33-73%). The selfing rates are comparable to a conventional, randomly designed orchard, and the SMP efficacy rates were greater than twice the currently accepted value of 20%. The improved SMP efficacy was a direct result of improved access to the crop, allowing better timing and application of elite pollen parents. We are continuing to test SMP under various pollen cloud density, and to screen the results using routine DNA paternity analyses. [HQ98099]

6.3.2 Successful Continuation of the Interior Cone & Seed Pest Management Service

Robb Bennett

Background:

In 1997, Operational Tree Improvement Program funding allowed the continuation of the Ministry of Forests' very successful and popular Interior Cone and Seed Pest Management Program. Following, is a brief outline of the achievements of the Program (led by Dr. Ward Strong).

The Interior Seed Pest Management Biologist made approximately 150 seed orchard site surveys (with pest identifications, reports, and management recommendations) for spruce, larch, pine, and Douglas-fir adelgids; bud-, seed-, and coneworms; spruce cone borers; gall midges; seed chalcids; leader weevils; spider mites; pine needle sheath miners; cone spittlebugs; aphids; pitch moths; larch casebearers; cone cochylids; seed bugs; white pine blister rust; western gall rust; and needle casts. An additional 35 site visits were made at the request of various orchard managers.

Results:

Sixteen projects (in-house or in collaboration with Simon Fraser University, University of New Brunswick, University of Northern BC, Canadian Forest Service, and Research Branch) were initiated or continued in 1997. The following projects showed significant progress:

- Spruce gall adelgid monitoring program. Quantitative monitoring program has been developed and is operational.
- Correlation of Leptoglossus seed bug feeding to low seedset in Pli seed orchards. For the first time in BC, the presence of Leptoglossus has been quantitatively correlated with low seedset in a conifer seed orchard.

Activities:

- Presentation of adelgid monitoring program at the Annual General Meetings of the Entomological Societies of Canada and British Columbia and the BC Seed Orchard Staff Group
- Adelgid monitoring paper prepared for submission to peer-reviewed journal The Canadian Entomologist.
- Two adelgid monitoring and one seed bug seed damage articles published in "Seed and Seedling Extension Topics" – Vol 9(2):11-16, Vol 10(1) (in press).
- Seed bug management presentation to BC seed orchard staff group annual general meeting.
- Year end Pest Monitoring and Status reports to all

Interior seed orchard managers.[HQ98070]

6.3.3 Enhancement of Seed Quality Through Family Processing

David Kolotelo

Objectives:

Processing of cones and seeds separately by individual family is being investigated as a means of increasing forest productivity and maximizing options for gene resource management.

Activities:

Family processing is being performed on interior spruce, interior lodgepole pine and coastal Douglas-fir. Detailed measurements of cone production, cone moisture content, cone size and condition, proportion of productive cone scales and filled seeds, seed efficiency, extraction efficiency, volumes at each processing stage, final seed weight, processing yield (Kg of seed per Hl of cones), purity, moisture content, seed size, germination capacity and rate and degree of dormancy have been quantified for 70 families and an additional seven bulked lots derived from the same parents in each orchard. An additional 30 families collected in 1997 and three bulk lots will be completely processed and tested prior to the end of this fiscal year. Processing costs and family field performance in progeny tests are being used to evaluate the cost effectiveness of family processing.

Results:

Variation between orchards, between years for the same half-sib families and between families was present for most variables. Family seedlot characteristics such as seed size and degree of dormancy showed large year-to-year variation, indicating that combining seed from the same family over multiple years, does not seem to be practical as it would add a great deal of ‘non-genetic’ variation to each seedlot. The differences in efficiency by processing families was negligible in lodgepole pine, but for Douglas-fir and one orchard of interior spruce, gains were equal to or greater than one gram of seed per litre of cones by family processing.

Initial results of Dr. Lester’s work on cost effectiveness, indicated that seed processing by family was far less cost effective than processing seed from the same families in a bulked sample. Initial work on the sensitivity of cost effectiveness to site index, processing cost, number of seedlings and expected genetic gain, indicated site index is the most influential variable. The effects of site index were non-linear, indicating cost effectiveness of family processing needs to be examined within a specific range of sites. Due to long rotations and relatively low harvest yields, family processing is extremely expensive in Sx and Pli; but costs are much lower for Fdc, due to the shorter rotations and greater harvest yields. [HQ98082]

6.3.4 Application of Seedlot Rating Protocols with Particular Reference to Interior Conifer Seed Orchards

Michael Stoehr

Objectives:

The first objective addresses deficiencies in our knowledge about genetic efficiency of Interior spruce and pine orchards (both Industry and Ministry), while the second develops general methodology for seed orchards which will be specifically applied to the Interior orchards.

The overall objectives of this study are divided into two areas:

1) Orchard specific studies, involving designed experiments to elucidate factors affecting seed genetic quality. These include studies of selfing rates in clonal row seed orchards, pollen contamination under supplemental mass pollination, and inequalities of male gametic contributions.

2) An evaluation and possible revision of the protocols for rating seed orchards seedlots in British Columbia, and the development of new marker methods for rating genetic quality using bulk seedlots.

Achievements:

Clonal Row Orchard at Kalamalka Seed Orchards (#620). Open-pollinated seed were collected from all clones (with the exception of two), and processed in clonal lots. These seeds are currently being assayed, using isozyme markers to estimate selfing and outcrossing rates. This work is done under contract to Western Forest Products under the supervision of Dr. El-Kassaby. The final contract deliverables are due on March 31, 1998.

Vernon Seed Orchard Company (#214): Open-pollinated family (clonal) lots have been collected and processed. As above, these seeds are being assayed for isozyme variation to estimate the level of selfing and outcrossing under contract to Western Forest Products. The results will be available on March 31, 1998.

Lodgepole pine orchard at Kalamalka (#307). Open-pollinated clonal lots have been harvested and processed. Outcrossing and selfing will be determined, using chloroplast DNA inheritance patterns. This work is contracted to BC Research Inc., and the results are due on March 31, 1998.

Output and Deliverables:

A workshop to introduce interior seed orchard managers to the existing coastal seedlot rating protocol, was given. During this workshop, the implications of having a seedlot rating protocol were discussed.[HQ98100]

6.4 Communications and Extension.

6.4.1 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 end goal for this project. To accomplish this task, it is first necessary to examine the current situation with respect to tree improvement, and then determine where gaps exist between knowledge and practice.

Activities:

Much of this analysis has begun through face-to-face and telephone interviews with seed users and producers (Sept 97- March 98). To date, most seed users suggest relatively few “problems” using improved seed at current seed prices. The rewards from using improved seed, for many users, remain rather theoretical, as gains from “green up” and boosts in allowable cuts depend on a wide range of external factors.

Following the needs assessment, an extension plan will be drafted for the Tree Improvement Council to review. Time permitting, selected Extension projects will be implemented from the strategic plan.[HQ98077]

6.4.2 Improve and Augment Public Communication Programs at the Kalamalka Forestry Centre

Chris Walsh

Outline of Project:

Improvement of public communication programs promoting tree improvement at the Kalamalka Forestry Centre. Existing signs and displays were refurbished.

Work Completed:

The highway sign and a twelve-board information kiosk were repaired and refinished.

Product:

Improved public education and perception regarding tree improvement in B.C.[HQ98120]

6.4.3 Development and Initiation of an Internet Web Site, Bulletin Board and Promotional Material for the Tree Improvement Council

Roger Painter

Objectives:

Effective communications within the tree improvement industry and to the forest industry, will be an essential part our future business. Over the past year the Council has been carrying out a strategic review, and identifying alternative models for delivering tree improvement. Communications is the key to ensuring that our industry is updated on proposed changes, and at the same time is provided with an opportunity to give input. Due to the wide spread geographical nature of the Council and it’s Technical Advisory Committees, it is difficult to meet more than a few times in a year. It is important that discussion and communications between meetings be improved There is a need to have a method of communicating technical information, current publications, information on people and organizations involved with the Council, and newsletters. Current technology exists, using the Internet, to provide the communications network that is needed.

Activities:

This project has established electronic Bulletin Boards for the Tree Improvement Council and the Coastal and Interior Technical Advisory Committees to provide a method of communications and discussion. This project is also directed at the process of enhancing the image of tree improvement within the forest industry. This project has purchased a display panel and developed information that will be shown in the coming year to promote tree improvement at forestry and associated conventions and meetings. Initiation of a web-page, also originally planned for this project, is scheduled for 1998.[HQ98076]

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
Fdc	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					
Fdc	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
Fdc	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
Fdc	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
Fdc	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
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