TIC*talk*

FGC Forest Genetics Council of British Columbia

Information for and from the tree improvement community of British Columbia

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Eighth Edition

TIC*talk* is an on-line extension newsletter produced annually by the Forest Genetics Council of British Columbia (FGC) – a multi-stakeholder business planning and advisory body appointed by the Province's chief forester – to inform persons of recent activities and topical issues associated with the conservation and management of BC's forest genetic resources.

This newsletter's name is derived from the predecessor of the FGC: the Tree Improvement Council (TIC) of BC and was later referenced as Tree Improvement Community. The objectives of Genetic Resource Management (GRM) activities, however, are broader than just increasing timber value. Maintaining the genetic diversity and resilience of our forested ecosystems in a changing climate are equally important. We invite you to submit ideas for renaming this publication to Diane Douglas (diane.l.douglas@gov.bc.ca) by April 1, 2008. The winner will receive a Texan-sized California pine cone to display prominently in their home or office. We also welcome your comments on this newsletter and suggestions for its improvement.

This issue contains a variety of articles submitted by members of BC's GRM community of practice, which we hope you will find informative.

The Ministry of Forests and Range's (MFR) Tree Seed Centre (TSC) celebrates 50 years of excellence in cone and seed services in 2008. Heather Rooke describes the TSC's history and its pivotal role in forest stewardship. David Kolotelo further describes some of the features and test results of the TSC's quality assurance program.

Jim Corrigan, Ward Strong, and Babita Bains et al. describe their respective efforts to understand and thwart the insect armies – and now air forces! – that attack BC's seed orchards. Thanks to their efforts, and those of orchard managers, these valuable trees and their seed crops are being protected. For example, despite heavy attacks by the mountain pine beetle (and other bark beetles) over the past two years, mortality in active lodgepole pine orchards has been minimal due to the health and vigour of the orchard trees and pro-active spray programs.

If you want to know about differentiation between male, female and vegetative meristematic tissues, *the buds* described by Patrick von Aderkas, Lishen Kong and Michael Carlson *are for you*. Sally John and Richard Reich also describe screening for *Comandra* blister rust resistance in lodgepole pine (for trees that survive MPB!).

Finally, for travel bugs, Alvin Yanchuk shares stories of his recent trip to New Zealand and the follies of privatizing that nation's national forests. David Reid also highlights his recent trip to Sweden and reports the formation of a new IUFRO Working Party for Seed Orchards – for which David is one of the deputy directors. Excursions such as these, to learn what others are doing and to share our knowledge, are important in this era of globalization and environmental change.

In consideration of these and other emerging issues, Alvin Yanchuk, Dale Draper, John Elmslie (CEO Winton Global & FGC Industry Co-chair), Jack Woods (FGC program manager), Keith Jones and Associates, and I have been reviewing the components, assumptions, and objectives of GRM in BC. Over the past two years, we have engaged the GRM community of practice, stakeholders, and interested members of the public in a dialogue to develop a forward-looking strategy for GRM in BC. Our final report is available at http://www.for.gov.bc.ca/hti/grm/grm_dialogue.htm.

INSIDE

Please let us know if we hit or missed the mark on the vision and objectives proposed in this report.

In other news, Dale Draper, Director, Tree Improvement Branch, MFR, was recently asked to lead the MFR's strategic unit for Climate Change and Forest Carbon. Dale was instrumental in establishing the FGC, which now serves as a management model for other forestry programs. He will now serve to prepare the MFR's response to climate change, which includes examining the role of forests in mitigating greenhouse gas emissions. We wish him well with this formidable task. We can also assist Dale and our planet by exploring ways and means of reducing our own carbon footprint – in our business practices and personal lives.

Over the next several years, the MFR aims to adapt BC's forest and range management framework to a changing climate. In support of the chief forester's Future Forest Ecosystems Initiative (FFEI), the MFR and FGC will be developing genetic conservation strategies and transfer guidelines to facilitate the migration of species and seed. More on these initiatives in the coming months and next edition – so stay tuned.

For more information about the Forest Genetics Council of BC please visit http://www.fgcouncil.bc.ca/.

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Tree Seed Centre Turns 50!

submitted by Heather Rooke

As part of the Ministry's Forest Stewardship Division, Tree Improvement Branch, the Tree Seed Centre (TSC) is located in south Surrey, BC. Fifty years ago, the British Columbia Forest Service began operating a provincial TSC in Duncan on Vancouver Island. By the late 1970s, operations at the Duncan location were significantly constrained as a result of infrastructure age, size, production capabilities, capacity to handle various species and seedlot sizes, and physical proximity to clients and service providers. In the mid-1980s, design and construction of a new facility specifically designed for the delivery of cone and seed services was completed in 1986, operations were closed in Duncan and resumed in Surrey.

The TSC carries out a wide range of quality assured stewardship services including seed testing, registration, storage and distribution for Crown land reforestation and other purposes. In addition, the TSC plays a key role in cone and seed evaluations, cone and seed processing, information management, cone-seed research, extension, training and communication. The variety of services provided by the TSC, often referred to as the Seed Handling System, form a chain of custody and integral link in a complex genetic resource management system. Seedlot diversity, identity and quality must be ensured, maintained and carefully tracked during and after a seedlot's active life. Best scientific and technical information guide and inform decision making and continuous improvement.

Services are provided to a large and diverse group of clients including forest licensees, Ministry of Forests and Range, seed orchards, forest nurseries, Tree Seed Dealers, First Nations, researchers, educators and the public. TSC staff, AKA "Coneheads," include 14 full-time and six to eight seasonal, supplemented by a variety of professional, technical and trades contractors.

As a result of MPB and increasing orchard production, cone-seed service levels are currently three times that of the past 10-year average. In order to meet these increasing production levels, cone and seed processing operations run continuously (seven days per week) throughout the year, at times on a more than one shift basis. Staff at the TSC are also seeing an increase in requests for expedited processing and service complexity, particularly for those production, family and research lots originating from seed orchards.

In 2008, the TSC will celebrate its 50th anniversary. Although timing and event planning is in very early stages and details have yet to be confirmed, we'd like to extend an early invitation to our colleagues and clients – we hope that you'll be able to join us in 2008!

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One Bud, Two Bud, Three Bud, Four: Making lodgepole pine buds count

submitted by Patrick von Aderkas, Lisheng Kong and Michael Carlson

Newly formed buds located along a long shoot can be of four types – male, female, short shoot, and lateral shoot buds.

Formation of buds is quite ordered – females are always produced last.

In theory, seed orchards of lodgepole pine produce cones in abundance; in practice, there is both seasonal and genotypic variation. Buds are produced in the summer. There are guides to the location and development of buds. Unfortunately, as everyone who has split a leader with a sharp grafting knife knows, it is hard to tell buds apart. For someone who wants to count female buds, it's a headache: one bud, two buds, three buds, four?

The reason for this difficulty lies in the diversity of buds that are formed. Newly formed buds located along a long shoot can be of four types – male, female, short shoot, and lateral shoot buds. At early stages they appear remarkably similar. Every orchard manager and breeder would like to have an idea of whether it's going to be a good year or bad year. Many managers would also like to know when to apply treatments to induce more cones: there's hardly any point in applying such a treatment if the female buds have already formed. Add to this the unknown of whether female bud development varies by genotype, and counting female buds is more like a migraine headache.

To answer these questions, two French Master's exchange students (Samir Demdoum and Sébastien Bonthoux) and a UVic co-op student (Genoa Barchet) helped us collect and section five genotypes (1506, 1524, 1540, 1531, and 1539) from Kalamalka Forestry Centre over the course of one summer. The buds were killed, processed into plastic, and then cut on a sledge microtome. This method is labour-intensive but allows easier orientation of sections. Sectioning was also done according to a randomized design to avoid bias in the interpretation.

Genotypes show obvious differences. By the end of the summer, clones characteristically differ in the size of their long shoots (Fig. 1).

Formation of buds is quite ordered – females are always produced last (Fig. 2). For this reason, they are still early in development when other buds are more developed. Female buds cannot be confused with males, which are morphologically quite distinct and clustered at the base of the long shoot bud, nor with short shoot buds which are smaller. They are very easily confused with lateral shoot buds. These are found in the apical half of the long shoot – the same location where females are formed. Microscopically, meristems of early female buds are hemispheric (Fig. 3), whereas those of lateral shoot buds are not. We sectioned until we had definitive identification of females (Table 1).

Figure 1. Comparison of clones 1531 and 1539 on October 3, 2006. Bar = 1 cm.

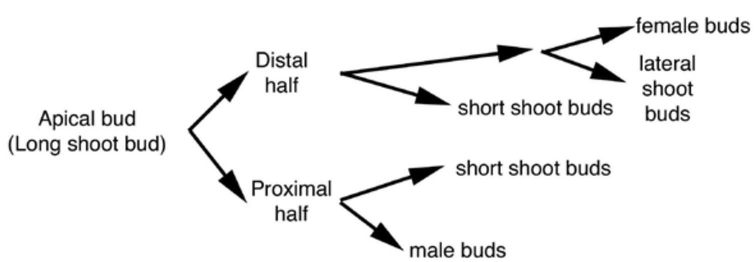

Figure 2. Schematic of bud development in long shoot buds.

Figure 3. Longitudinal section of female bud of lodgepole pine from clone 1524, 3 October, 2006.

The five clone sample used consisted of two with low cone production histories and three with relatively high annual production figures. Because of the small number of clones sampled, the apparent inverse relationship observed between long shoot length and fecundity may be due to sampling error alone. In order to test this proposition, additional clones were selected based on historical cone production records from the 307 orchard. Three clones with high, three with low and three with intermediate cone production numbers were chosen for additional study. Average annual cones per orchard ramet production histories ranged from less than 100 to over 700 for these nine clones.

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Table 1. Female bud presence (shaded) in five genotypes over the growing season

	Date of collection						
Clone	5-Jul	18-Jul	1-Aug	15-Aug	31-Aug	15-Sep	3-Oct
1506			■	■	■	■	■
1524				■	■	■	■
1531		■	■	■	■	■	■
1539						■	■
1540		■	■	■	■	■	■

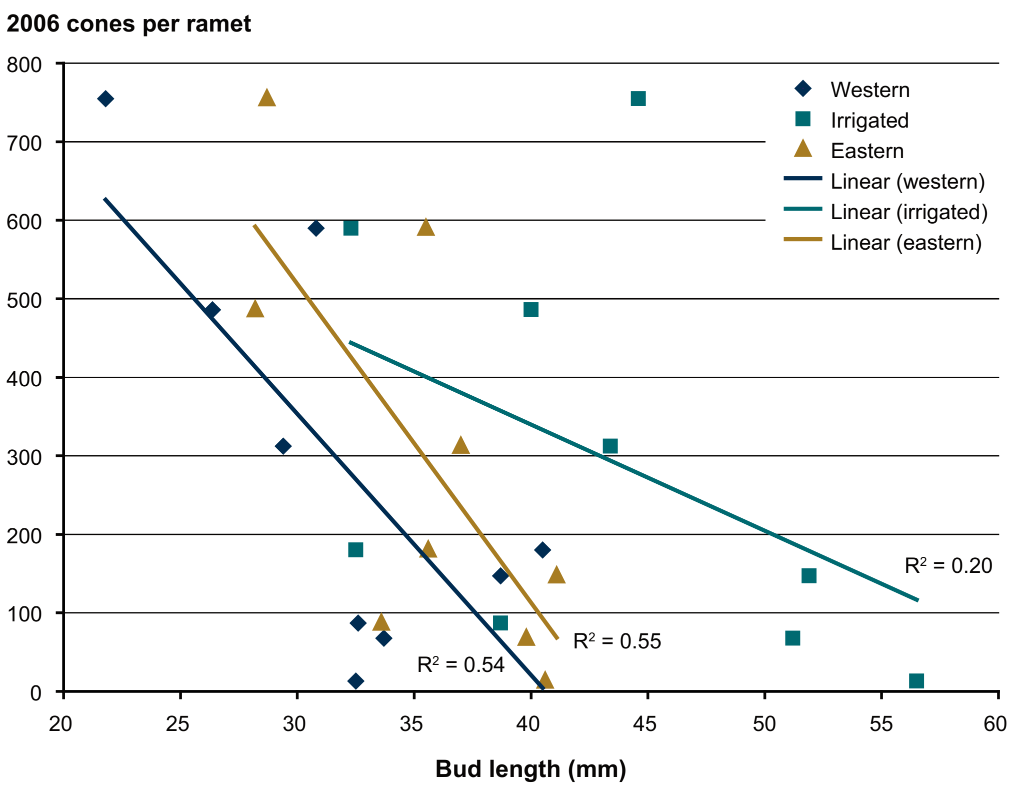

Figure 4. Averages of cones per ramet in 2006 for nine clones plotted against average ramet shoot-bud lengths. Three geographic areas sampled in orchard 307.

The date of 1 August is important, as initiation is well underway in most clones.

This means that induction treatments should be implemented in early July if they are to maximize female bud formation.

Three ramets per clone were chosen, one each from three different geographic areas within the 307 orchard. Ten first-order lateral shoots in the upper south-facing crown of each tree were measured from the most distal needle fascicle to the bud tip in January of 2007. Clonal cone production averages in 2006 were plotted against average ramet shoot bud lengths for each of the three geographic area samples (Fig. 4). Relatively high R2 values for two of the three plots supports the hypothesis that long-shoot bud lengths are inversely proportional to clonal female fecundity. The relationships between long-shoot bud lengths, male and female fecundities and clonal breeding values (for tree stem volumes at rotation age) is unknown in lodgepole pine. We do not have individual clonal breeding values for orchard 307 parents, but several progeny tested orchards in the Vernon area do. Managers of these orchards have cone production records for their clones so that the relationships amongst fecundity, shoot bud lengths and breeding values could be easily studied in the future.

Female differentiation showed genotypic variation. Two of the lines (1531 and 1540) were early initiators of female cone buds and two of the lines were late initiators (1524 and 1539). Overall female development was earlier by two to three weeks than previously reported for BC.

There were other measures that could be operationally useful. One that we encountered by accident was the usefulness of halving long shoot buds and inspecting the buds in the field. Historically high cone-producing genotypes were easily discernible because they had smaller long shoot buds: female buds and lateral shoot buds were quite obvious to the naked eye by early September. In contrast, the historically lowest cone producers had quite elongated long shoot buds by the first of August: they had very few female buds. This implied that the investment in vegetative growth was much heavier in these genotypes. This observation fits with the "vegetative vigour hypothesis" set out by Meehan (cited in Ross and Pharis, 1987) which stated that a continuum in physiological fitness exists in conifers, and the level of fitness will affect the reproductive structures produced. At varying nutrient status, the tree will produce short shoot buds, male buds, female buds, and lateral shoot buds in an increasing order of fitness.

The date of 1 August is important, as initiation is well underway in most clones. Initiation of females (and lateral shoot) bud would appear to be in mid-July. Female bud differentiation likely begins in late July for some genotypes, because female buds could be observed by August 1, 2006. Based on this observation, female bud initiation is more highly variable than was previously suspected. This means that induction treatments should be implemented in early July if they are to maximize female bud formation.

Paper Birch Makes the Team

submitted by Michael Carlson, Vicky Berger, Nicholas Ukrainetz

Betula papyrifera (paper birch) has long been considered more of a nuisance than an asset by foresters in the BC Interior. It can be an aggressive competitor for light and space in young conifer plantations on rich sites. Its principal use, until recently, has been firewood. Today, in some locales, harvested birch is still credited against the conifer quota which provides a disincentive for its recovery by licensees. Attitudes seem to be changing, however, as we better understand its ecological contributions in *Armillaria* root rot resistance and nitrogen fixation, its nurse cropping and wildlife attributes, and its potential commercial values.

In addition to working birch for firewood, several small operators throughout the Interior are cutting flooring, cabinet and countertop stocks and, recently, veneers for plywood manufacture. The Swedish giant IKEA has expressed interest in our interior birch resources. The most innovative use to date is for disposable wooden cutlery. "Aspenware" is cut out of laminated veneer sheets of paper birch peeled on modified chopsticks peeling machines in a plant near Lumby. Aspenware hopes to capture one-tenth of one percent of the north American disposable cutlery market, which is 160 billion pieces… of plastic used and discarded annually.

The standing volume of paper birch (50 million cubic metres) represents 0.65% of British Columbia's total timber inventory (approx. 7.5 billion cubic metres). Two-thirds of that volume is in birch-leading stands north of Williams Lake, with the Fort Nelson District having one-forth of the total provincial volume. More than 100 000 cubic metres are harvested annually from public and private lands, but it is estimated that a sustainable annual harvest of more than twice that is possible in the BC interior.

Paper birch genecology work began in BC more than 10 years ago, with our 18 Seed Source trial. Results from that trial suggest that paper birch is quite movable geographically and that certain seed sources from the north coastal-interior transition perform well over a very wide portion of the central and Southern Interior. In the mid 1990s, 19 paper birch stands were selected in the former Kamloops and Nelson forest regions (see Fig. 1).

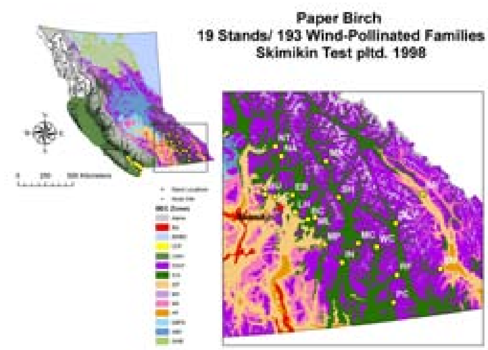

Figure 1. Paper birch Skimikin test seed sources.

A total of 193 phenotypically superior trees were selected in these stands and the seed collected. In 1998 a single progeny test site was planted at the Skimikin Nursery northwest of Salmon Arm. Thirty-two seedlings per selected parent were planted in a randomized complete-block design with four-tree row plots (see Fig. 2).

Figure 2. Skimikin paper birch progeny trial S' 2006.

Tree height and stem diameter measurements were made three times over the next nine years. Using 10-year stem volume measurements (D2×Ht), an "index score" was used to rank all trees on site. The score was composed of a deviation of a tree's family from the plantation mean plus the deviation of a tree from its family mean, both adjusted for block effects and multiplied by family and within family heritability estimates respectively. Thirty-six of the top 100 index-scored trees were selected, with additional consideration given to stem straightness and absence of insect, disease, and frost origin damages.

"Aspenware" is cut out of laminated veneer sheets of paper birch peeled on modified chopsticks peeling machines in a plant near Lumby.

Paper birch genecology work began in BC more than 10 years ago, with our 18 Seed Source trial.

Seed from these orchards will come with an estimated genetic gain in the range of 16 to 19% for rotation age (40 years) stem volume.

Paper birch, now with a progeny-test based seed orchard, has finally made "the team"!

In March of 2007, scion were collected from these 36 trees (see Fig. 3).

Figure 3. Vicky Berger and Nick Ukrainetz collecting scion W' 2006/07.

Grafting was done at the KFC site on one-year-old potted paper birch rootstock. Graft take was 83%. The resulting 150 grafts were evenly divided between the Skimikin and Kalamalka seed orchard sites. Orchard configurations and management regimes are under discussion using the Finnish and Swedish program's methodologies as models. Grafted parent meristems are 10 years from germination, which is about the onset of reproductive activity in the wild, so we might anticipate orchard seed production to begin in the next two to four years. Seed from these orchards will come with an estimated genetic gain in the range of 16 to 19% for rotation age (40 years) stem volume. Areas of use will include the Southern Interior and much of the central interior, within an elevation band as yet to be determined.

Paper birch, along with other interior broadleaved species, have heretofore been categorized in the Forest Genetics Council Business Plan as a "Genecology" species, that is, seed source (provenance) testing research only. Paper birch, now with a progeny-test based seed orchard, has finally made "the team"!

Responding to Climate Change: Assisting seedlot migration to maximize adaptation of future forest plantations

submitted by Greg O'Neill, Michael Carlson, Vicky Berger and Alvin Yanchuk

Summary

Little is currently known regarding the adaptive responses of breeding populations of BC's commercially important tree species. To ensure that each reforestation site receives the Class A seedlots that are best adapted and most productive for its current and future climate, each breeding/production population must be tested across a broad range of climatic and latitudinal environments.

The Assisted Migration Adaptation Trial (AMAT) intends to test the 35 breeding/production populations (i.e., Class A seed orchard seedlots for which seed is available, from BC and western States) across 48 test sites. Twelve field tests per year for each of four years will be established throughout BC and neighbouring states, beginning in spring 2009. Use of local control (wild stand) seedlots and a block plot layout will enable realized genetic gains to be estimated for each population. Productivity of each population will be described as a function of the climate and latitude of the test sites, enabling development of a deployment system that will maximize forest productivity while ensuring the widest deployability of every orchard seedlot.

Background

Identifying the seedlots that are best adapted to a reforestation site can be one of the most important reforestation decisions (Zobel and Talbert 1984). However, in many areas of the province, seedlots that are adapted today will be rendered maladapted toward the end of their rotation by climate change, resulting in decreased pest resistance, growth and wood quality. Planting seedlots adapted to a longer portion of their rotation (i.e., assisted migration) is recognized as a cornerstone strategy to mitigate negative impacts associated with climate change (Ledig and Kitzmiller 1992; Carter 1996; Rehfeldt et al. 2001; Rehfeldt 2004; Sonesson 2004; Wang et al. 2006), and in some cases may enhance a site's productivity in a warmer climate (Rehfeldt et al. 2001).

Approximately 50% of all seed planted in the province originates from seed orchards (i.e., Class A seed). By 2013, approximately 75% of planted seed is expected to be Class A seed (see Business Plan of the Forest Genetics Council of BC at http://www.fgcouncil.bc.ca/). The majority of the progeny tests used to evaluate orchard parent trees were established when climate change was not perceived as a significant issue, and the need to move seed large geographic distances to ensure adaptation of planted seed was not envisaged. Consequently, the vast majority of orchard parent trees have been tested only within a narrow climatic and latitudinal range and only within the breeding zone from which they originated.

Heightened calls for assisted migration and increased species diversity associated with climate change and replanting beetle-infested areas are creating a demand for Class A seed outside of each seedlot's tested environment. Testing of species outside of their current range shows that populations of some species perform remarkably well where they are not currently native, as evidenced by multi-species testing in the Bulkley Valley (Barry Jaquish, pers. comm.) and in the Cariboo (Koot 2007) (see http://www.for.gov.bc.ca/hfd/library/FIA/2007/LBIPI_4638002a.pdf). Without better understanding of their productivity, wood quality, and health responses across a wide climatic and latitudinal range, it is difficult to predict which class A seedlots are most suitable for current or future climates (Fig. 1).

Project focus

Climate change inserts a new dimension into seedlot selection because the best adapted species and seedlots for a site will likely change during the rotation. Identifying the best adapted seedlots will therefore involve maximizing adaptation (the seedlot–climate match) over the course of the rotation.

The primary focus of this project, therefore, will be **to develop an understanding of the adaptation of each breeding population**, as

The Assisted Migration Adaptation Trial (AMAT) intends to test the 35 breeding/production populations…across 48 test sites.

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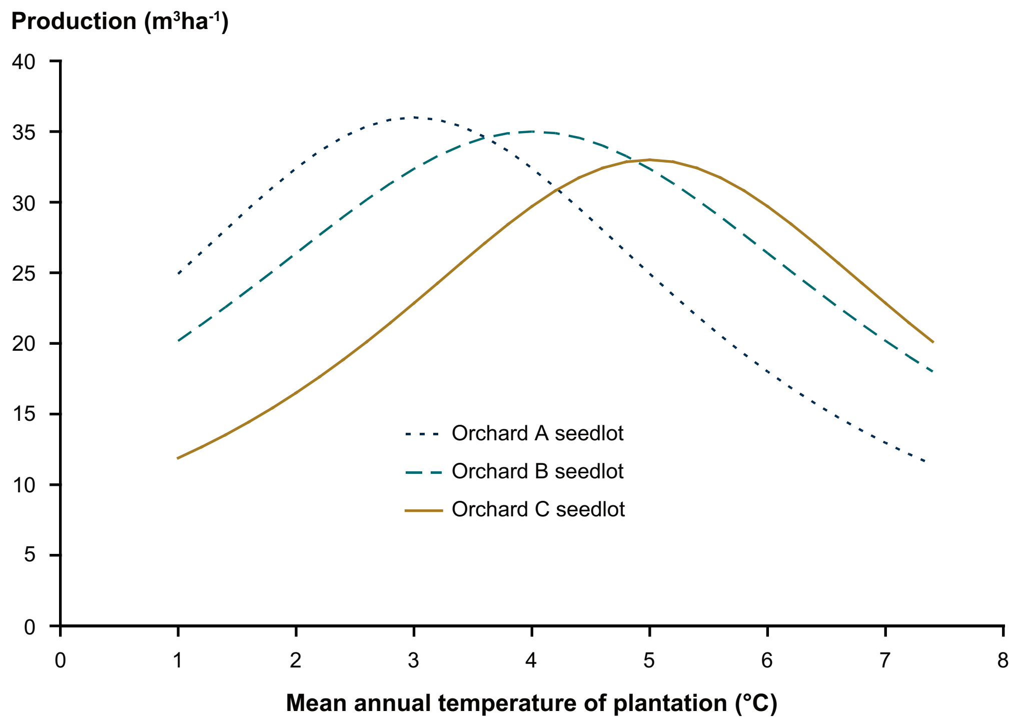

Figure 1. This schematic shows possible response functions of three seed orchard seedlots. Knowledge of response functions such as these could help identify seedlots expected to be best adapted and most productive in each climate.

The primary focus of this project, therefore, will be to develop an understanding of the adaptation of each breeding population, as represented by class A seedlots or seed from elite families, across a range of climatic and latitudinal environments in BC and adjacent states.

Second, local wild-stand controls planted at each test site will enable the growth of each breeding/ production population to be compared to that of wildstand seed, and a realized genetic gain to be calculated for each breeding/ production population, and estimated for all climates.

represented by class A seedlots or seed from elite families, across a range of climatic and latitudinal environments in BC and adjacent states. Knowledge of the adaptive response of each seedlot to a range key climatic variables and photoperiod (latitude) will form the foundation of a system of assisted migration of seed that will help mitigate maladaptive responses in some areas, while potentially enhancing forest productivity in other areas (Wang et al. 2006), and ensure that the gains achieved through four decades of tree breeding in BC will be realized in a future climate.

Second, local wildstand controls planted at each test site will enable the growth of each breeding/production population to be compared to that of wildstand seed, and a **realized genetic gain to be calculated for each breeding/production population, and estimated for all climates**. Use of large block plots will minimize competition among plots of each population, thereby minimizing inter-seedlot competition and improving the accuracy of the realized gain estimates.

An extensive set of Class A seedlot tests is required across a diverse array of climatic and latitudinal environments. By relating test site climate and latitude to productivity, wood quality and health of each Class A seedlot (Fig. 2), those species and seedlots that will maximize these attributes of BC's forests across the climates of a future rotation can be identified, and this information incorporated into species and seedlot selection systems.

The proposed project addresses critical knowledge gaps in our understanding of the growth of genetically improved seedlots across a range of climates and latitudes. Specifically, the experiment seeks to:

1. quantify the productivity of BC's genetically improved populations across a wide climatic and latitudinal range in order to estimate their performance in current and new environments (i.e., develop response functions);
2. compare productivity of A and B class seed and calculate realized genetic gain; and
3. incorporate knowledge of class A seedlot (breeding population) productivity into species and seedlot selection systems.

Project design and implementation

For each of the 35 Seed Planning Units that currently have orchard seedlots, one seedlot will be solicited from seedlot owners. These seedlots, along with local controls consisting of pooled wildstand seedlots, will be tested in an incomplete design at 48 locations, with each orchard seedlot planted at approximately 30 locations. The large number of locations, relative to typical progeny tests, and their careful selection is required in order to adequately sample the climate space of each species' fundamental niche and to develop growth response equations using multiple site climate variables.

To ensure that the test sites sample the range of climates found in BC, the 192 forested biogeoclimatic variants were clustered into 48 groups, with each group representing somewhat similar climates. Twelve field tests per year for each of four years will be established throughout BC and neighbouring states, beginning in spring 2009. Research Branch staff will be contacting licencees in central and Southern Interior BC (the location of the first 12 sites) to request assistance identifying candidate field test sites and donating seed to this important project.

Height, diameter and survival will be measured on all trees at five-year intervals. Seedlot growth statistics will be input into TASS, and expected volume at rotation estimated for each seedlot at each site. Volume at rotation of each species will also be expressed as a percent of the local control seedlot to calculate realized gain of each seedlot. Response functions will be developed relating rotation-age volume of each seedlot to the climate and latitude of test sites, and maps developed to identify the most productive seedlots for each climate.

Numerous individuals have provided input on the design of this project. Anyone wishing to receive the complete project proposal should contact Greg O'Neill (greg.oneill@gov.bc.ca) or Michael Carlson (michael.carlson@gov.bc.ca). Continued feedback is appreciated.

Start-up funding for this project was received from the Forest Genetics Council. This project has been identified as a key project of the Future Forest Ecosystem Initiative.

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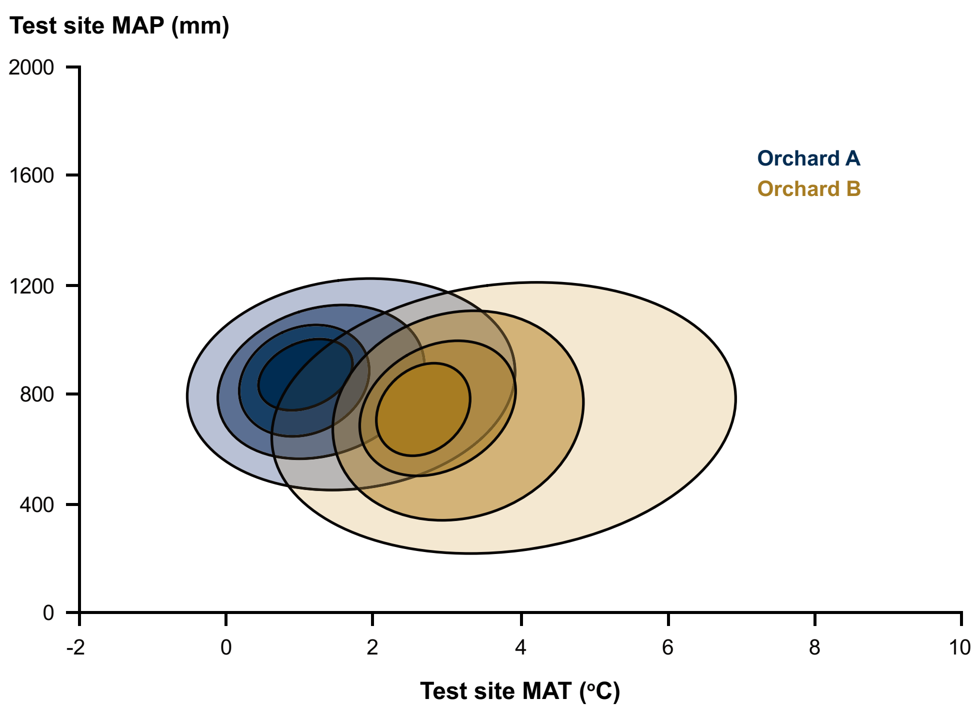

Figure 2. Example of possible genetic worth clines of two seed orchards seedlots based on two climate variables. Knowledge of such GW clines could alter seedlot selection decisions and improve adaptation and productivity of plantations. In addition, GW clines would greatly improve the ability to make informed decisions regarding assisted migration of species and seedlots.

References

Carter, K.K. 1996. Provenance tests as indicators of growth response to climate change in 10 north temperate tree species. Can. J. For. Res. 26: 1089–1095.

Koot, C. 2007. Performance of ponderosa pine and western larch planted north of natural ranges. Technical Report, RP #05-03 Summary Following the First and Second Growing Seasons. Vancouver, BC. Forestry Investment Account Land Base Investment Program.

Ledig, F.T. and Kitzmiller, J.H. 1992. Genetic strategies for reforestation in the face of global climate change. For. Ecol. Manage. 50: 153–169.

Rehfeldt, G.E. 2004. Interspecific and intraspecific variation in *Picea engelmannii* and its congeneric cohorts: biosystematics, genecology and climate change. General Technical Report RMRS-GTR-134. USDA Forest Service. pp. 1–32.

Rehfeldt, G.E., Wykoff, W.R., and Ying, C.C. 2001. Physiological plasticity, evolution, and impacts of a changing climate on *Pinus contorta*. Climatic Change 50: 355–376.

Sonesson, J. 2004. Climate change and forestry in Sweden. Kungl. Skogs-och Lantbruksakademiens 143: 1–40.

Wang, T., Hamann, A., Yanchuk, A., O'Neill, G.A., and Aitken, S.A. 2006. Use of response functions in selecting lodgepole pine populations for future climates. Global Change Biology 12: 2404–2416.

Zobel, B.J. and Talbert, J.T. 1984. Applied Tree Improvement. John Wiley and Sons, New York.

Tree Seed Centre Quality Assurance Program

submitted by Dave Kolotelo

This article reviews part of the Tree Seed Centre's (TSC) Quality Assurance (QA) program, which is dedicated to ensuring quality seed for reforestation.

Moisture Content and Germination Falldowns

Estimates of stratification moisture content and germination falldowns have traditionally been an output of our QA program (see http://www.for.gov.bc.ca/hti/treeseedcentre/tsc/csio3-sowingrequestshtm.htm). This year we are combining the five-year estimates for these assessments into one table and providing a more comprehensive comparison between A (orchard-produced) and B (natural stand) seed, including the statistical significance (t-test, two-way, ∝ =0.05) of the difference between these variables for A-class and B-class seed. The table also presents results of lab testing, QA sampling in seed preparation prior to shipping, and feedback from nurseries on the actual nursery germination (see Table 1).

Table 1 provides an indication of average stratification moisture content [mc] by species and genetic class. Significant genetic class differences for mc are observed in Fdi,

Table 1. Five-year averages (2003–2007) for stratification moisture content, germination capacity (gc) and germination falldowns [samples sizes in brackets]. Shaded cells represent statistically significant * differences between A and B class seed. Green values indicate no significant difference.

		Lab		Seed preparation		Nursery	
Species	Genetic class	Moisture content % [n]	GC % [n]	GC % falldown [n]	GC % [n]	GC % [n]	GC % falldown [n]
Ba	B	33.6 [13]	73.1 [16]	78.0 [16]	4.9 [16]	74.9 [8]	-3.1 [8]
Bg	B	33.5 [18]	77.6 [19]	78.7 [19]	1.1 [19]	71.6 [13]	-4.1 [13]
Bl	B	37.3 [52]	65.4 [56]	64.8 [56]	-0.6 [56]	58.0 [29]	-10.5 [29]
Cw	A	NA – pelleted	85.5 [89]	82.3 [85]	-3.6 [85]	80.1 [58]	-5.1 [58]
Cw	B	NA – pelleted	79.5 [94]	76.7 [91]	-2.4 [91]	77.5 [66]	-3.2 [66]
Dr	B	NA – pelleted	70.3 [19]	67.7 [19]	-2.6 [19]	65.1 [14]	-7.6 [14]
Fdc	A	32.2 [60]	93.0 [74]	92.9 [59]	0.1 [59]	92.4 [53]	-1.2 [53]
Fdc	B	32.7 [34]	88.1 [35]	89.5 [35]	1.3 [35]	84.7 [21]	-1.1 [21]
Fdi	A	32.2 [14] *	93.0 [16]	94.7 [13]	1.5 [13]	80.0 [9]	-3.4 [8]
Fdi	B	34.1 [81]	88.4 [85]	91.1 [82]	2.3 [82]	87.8 [74]	-0.2 [74]
Hm	B	33.6 [20]	83.1 [20]	88.0 [20]	4.9 [20]	79.3 [19]	-5.0 [19]
Hw	A	26.2 [38] *	89.9 [41]	89.4 [41]	-0.5 [41]	87.8 [33]	-2.6 [33] *
Hw	B	29.1 [31]	82.3 [32]	83.7 [32]	1.4 [32]	84.7 [29]	3.3 [29]
Lw	A	34.2 [36] *	90.0 [37]	90.0 [37]	0.0 [37]	89.9 [30]	-0.1 [30]
Lw	B	35.5 [50]	83.4 [51]	86.0 [51]	2.6 [51]	83.9 [44]	0.3 [44]
Plc	B	28.3 [17]	94.0 [17]	93.8 [17]	-0.2 [17]	91.8 [9]	-0.7 [9]
Pli	A	29.5 [43]	96.4 [55]	95.3 [43]	-1.1 [43]	93.8 [39]	-2.7 [39]
Pli	B	30.1 [94]	94.0 [115]	93.4 [93]	-0.3 [93]	92.0 [87]	-1.3 [86]
Pw	A	36.8 [107]	91.4 [95]	85.8 [88]	-5.5 [88] *	85.5 [79]	-5.6 [78] *
Pw	B	37.1 [13]	81.8 [12]	69.6 [11]	-11.4 [11]	67.0 [10]	-14.8 [10]
Py	B	27.5 [55]	90.4 [57]	87.8 [56]	-2.5 [56]	88.8 [35]	-2.0 [35]
Sb	B	32.4 [8]	72.8 [8]	72.0 [8]	-0.8 [8]	75.8 [7]	3.2 [7]
SS	A	22.3 [12] *	96.6 [12]	92.3 [12]	-4.3 [12] *	91.6 [9]	-4.8 [9]
SS	B	27.2 [30]	91.1 [31]	91.2 [31]	0.2 [31]	90.1 [25]	-1.5 [25]
Sx	A	26.5 [78] *	92.0 [94]	94.1 [80]	2.5 [80]	92.1 [74]	0.2 [74]
Sx	B	31.3 [53]	85.3 [55]	86.4 [54]	1.1 [54]	84.5 [46]	-0.2 [46]
SxS	B	30.2 [24]	87.0 [24]	89.2 [24]	2.2 [24]	84.9 [17]	-3.2 [17]
Yc	B	44.8 [7]	50.3 [7]	58.0 [7]	7.7 [7]	76.0 [3]	23.7 [3]
Total Sample Sizes (N)		**988**	**1266**	**1170**	**1170**	**940**	**937**

Significant genetic class differences for moisture content are observed in Fdi, Hw, Lw, Ss and Sx, but only in HW is there also a significant difference in germination at the nursery.

The largest nursery germination falldowns (>5%) were experienced with Pw, Bl, Dr, Hm and A-class Cw.

Test results indicate very high efficiencies for the pelletting process.

Hw, Lw, Ss and Sx, but only in Hw is there also a significant difference in germination at the nursery. These mc differences have been observed for several years and are an indication that differences due to the genetic material or production site exist, but generally these differences have little or no impact on seed quality or seedling production. These mc differences may simply be a result of the larger seeds we see from Pinaceae seed orchards. Growers should pay extra attention to small sowing requests of species exhibiting relatively low moisture contents (Hw and SS in particular) to ensure that these seeds do not dry out during the sowing phase.

Falldowns in seed preparation and at the nursery are quantified relative to the latest lab germination (a negative number is a decrease relative to lab germination). The largest seed preparation falldowns are with Pw and A-class SS. At the nursery large (>5% difference), falldowns were experienced with Pw, Bl, Dr, A class Cw and Hm. Note for Pw that greater falldowns are being experienced with B-class seed and it appears that our stratification protocols are optimized to overcoming dormancy in our seed orchard crops, which account for over 95% of the Pw sown over the past five years.

Thank you to all nurseries for providing data for this assessment. Your contributions greatly assist us in quantifying lab tests with actual nursery results and identifying testing priorities.

Pelleted Species

Pelleting (covering seed with a coating for ease of handling and use in sowing equipment) is performed on all redcedar (Cw) requests and most red alder (Dr) seedlots. In addition to germination testing, we perform assessments on the efficiency of pelleting. The variable estimated is the proportion of pellets containing one seed per pellet. The test is based on eight replicates of 25 seeds and each pellet is dissolved and classified as having one seed/pellet, empty, containing debris, or having more than one seed per pellet. See Table 2 for testing results over the past five years.

Test results indicate very high efficiencies for the pelleting process. We have had virtually no complaints on pellet quality over the past two years and Carl Happel, the contractor who performs this service, is commended for his efforts and diligence.

Returned Seed

Returned seed was again used operationally in 2007 and we requested nursery feedback on the germination of all returned-seed sowing requests. We received nursery feedback on 84% (64/76 seedlots) of these requests, providing a good indication of the operational performance of this type of seed at the nursery. The returned seed program, for 2007, involved only the following species in the following seedlot proportions: Pli (53%); Sx (20%); Fdc (20%); Fdi (4%); Cw (3%); and SS (1%). Table 3 presents the returned seed (QAR) results separately for A-class (62000 series) and B-class (52000 series) seedlots in comparison to regular seedlots (QA) of the same species (sample sizes enclosed in brackets).

The nursery falldowns on the seed are quite small, at -1.3 for returned orchard seed and -0.1 for returned natural stand seed. The nursery results have a lot of 'background noise' (e.g., extended stratification, upgrading, sanitation treatments etc.), which

Table 2. The results of the pelleting assessment 2003–2007. Figures indicate the percentage of pellets with one seed per pellet with sample sizes in brackets.

Species	2007	2006	2005	2004	2003
Cw	99.0 [30]	98.7 [35]	96.9 [33]	98.0 [26]	96.0 [24]
Dr	97.9 [4]	95.9 [5]	93.7 [6]		

Table 3. A comparison between sowing requests (QA-SRQ) and returned seed (QAR-SRQ) sowing requests in terms of lab germination capacity (GC), QA GC at shipping, and GC at the nursery (Nurs) with falldowns indicated relative to the lab germination.

	Lab GC (#)	QA GC (#)	QA Falldown	Nurs GC (#)	Nurs Falldown
QA – SRQ	89.2 (110)	89.8 (97)	0.3 (97)	85.2 (90)	-2.5 (89)
QAR – SRQ – A	94.2 (47)	94.3 (7)	-0.4 (7)	93.2 (41)	-1.3 (41)
QAR – SRQ – B	93.5 (29)	95.2 (5)	-0.2 (5)	92.8 (23)	-0.1 (23)

is beyond our control. I am not concerned about the difference between -1.3 and -0.1, but very pleased that the results were generally quite good for returned seed. The nursery falldown for our primary QA-SRQ program is slightly larger and I think the best explanation is that we “generally” only attempt to re-use seedlots that perform well but, in our primary QA-SRQ activities, there is more of an emphasis on sampling the range of seedlots being used, especially those that may exhibit problems. Our QA program is continuing to evolve and we appreciate any feedback you may have.

The nursery germination falldowns through the use of returned seed is quite small.

Reforestation with "A" Class Seed

submitted by Peter Forsythe

Introduction

There are several things that can be either directly or indirectly related to "A" class seed. Some are positive while others are negative. Fortunately, the positives outnumber the negatives. I would like to address those positives first.

Before I get started, I should describe what a silviculturist is starting out with in the form of planting sites. The forest site is not a cultivated farmer's field but an area with lots of slash (logging debris), brush, duff and sometimes poor soils. You could clean up the site and pile and burn most of the slash, or broadcast burn the site. This would yield a cleaner site, with fewer obstacles to compete with the trees for space and nutrients. The risks of broadcast burning has almost eliminated its use because of potential escapes. Piling and other types of MSP can be very expensive and will also slow down the growth and spread of the brush, but will not eliminate it. The duff layer can be anywhere from a few centimetres to 30 cm or more in wetter ecosystems. The duff layer also contains a large portion of the available site nutrients and, therefore, it should be left in place whenever possible. Soils can be very dry to very wet and very nutrient poor or nutrient rich. Take into account slopes, aspects, water tables, exposed rock etc. and you can be left with a less than ideal planting site to grow a tender young seedling. Trees in this environment need to be able to rise above the competition and elbow their way in becoming the dominant vegetation on the landscape.

Seedlings from "A" class seed are generally stronger and better able to recover from these abuses, often with very little help from the silviculturist.

Hopefully, this will give you some appreciation for the environment that the tree faces when it is planted on a cutblock.

"A" Class Seed Benefits

1. Fast-growing seedlings are what every silviculturist likes to have in their reforestation arsenal. There are several advantages to this including: early establishment, head start on brush competition, reduced time to free growing and, ultimately, shorter time to the next harvest.
   - Young trees endure a lot of abuse within the first few years of growth. They need to grow roots fast and effectively in order to find both water and nutrients. Seedlings planted in the middle of a slash pile or where there is competition from other vegetation may end up horizontal after the shifting snow loads of winter. Much of this vegetation (e.g., twinberry, fireweed) will lie down over the seedlings in the fall and then snow will push everything to the ground with the seedling on the bottom. This often leads to a very horizontal looking tree the following spring (Fig. 1). After several years of this abuse the tree will become weaker and eventually die. Seedlings from "A" class seed are generally stronger and better able to recover from these abuses, often with very little help from the silviculturist.

Figure 1. "Horizontal" seedling.

   - Even if the tree is not pushed to the ground, the surrounding brush will be competing with the young seedling for light, water and nutrients. The taller and sturdier the tree, the better able it is to withstand the forces of the brush and snow. For the first few years (five years) the brush is also establishing and becoming larger, stronger and spreading every year. A seedling that is able to compete with the brush will not only survive, but will also grow at a better rate than the tree that is barely able to recover from the past winter before the next winter begins (Fig. 2). I've seen sites where trees are barely growing one centimetre per year. The amount of brushing required has been greatly reduced with the use of seedlings grown from "A" class seed. These trees have been able to compete successfully with other vegetation on the site.

The amount of brushing required has been greatly reduced with the use of seedlings grown from "A" class seed.

Figure 2. One year after planting SBS wk1.

- Of course, all of this early growth has some political benefits, like reaching the very important free-growing milestone. This is when the company's obligation to re-establish a new forest is reached. It is hard to put an exact figure on the time savings to reach free-growing, but it is probably about five years (Fig. 3). This would mean that what used to take about 15 years has been reduced to about 10 years. This reduction is shared with improved nursery practices, better stock handling and better planting techniques.

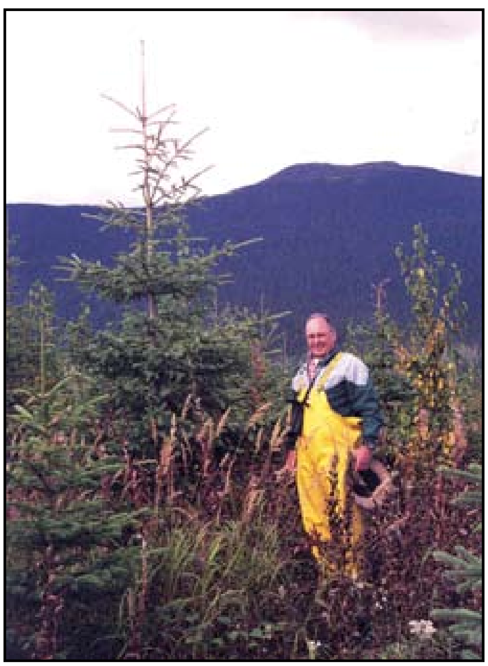

Figure 3. Seven years after planting SBS vk.

- Let's say that the current forest attained a good merchantable size when it was about 100 years old. Forests are renewed under several scenarios, but for the sake of simplicity, we will say that the renewal was after a fire and the entire forest was replaced at one time. Originally, the forest started from seed either remaining on the site or from survivors. The vegetation also started in the same way and everything struggled to grow. The brush in many areas would out-compete the trees and there would be dead trees or reduced growth. This would lengthen the establishment period to 20 or 30 years while the trees repeatedly struggled to dominate the site. These trees had a Site Index of 18 (meaning it had reached 18 metres tall in 50 years). Currently, with use of "A" class seed, we are seeing the growth pattern accelerated and the Site Index is often at 25 or more on the same site. This would indicate that the stand is growing faster both from early deliberate establishment and predominately fast-growing trees. This means that we have reduced the time to rotation by 25% and, with seed that can maintain at least 15% faster growth, we have a reasonable chance of reaching the rotation by 80 years.

2. Since 1995 we have been using improved seed and there are a couple of things that I have noticed – trees planted in slash and overall survival.
   - We gave up broadcast burning in the early '90s for several reasons. This left the slash on the site for the silviculturist to work around. At first, we piled a lot of it and burned the piles in late fall when risk of escape was minimal. This was expensive, time consuming, sometimes damaging the site, and we started leaving more areas without any form of site preparation. At first we ended up with many replants after the first attempt failed. Then came along the "A" class seed and better nursery practices, which lead to better survival in slash areas.
   - Overall survival has grown over the past few years and is probably largely attributable to the stronger trees that we get from improved seed. This doesn't mean that there isn't any mortality, but it does mean that we will, on average, have more survivors with better growth.
3. Of notable interest with the development of seed orchards and monitoring trees from improved seed, is the identification of certain traits of various families. In particular is the Sx that are resistant to white pine leader weevil. I'm currently testing this seed to determine if it is

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The seed orchard provides a good, stable environment and we consistently receive good quality seed and the elimination of "dud" seedlots that were poor performers in the forest.

If we want to have a forest industry in the future as well as all the other land uses, we're going to have to grow more on less land. The supply of class "A" seed is a large part of this cycle.

as good as some of the early testing suggested. We lost a large part (42 ha) of a plantation to a combination of leader weevil and frost, so we planted the area with mostly Pli, but I couldn't resist planting part of the hardest hit area with resistant Sx. We are going into the sixth year since planting, and the hard clay soils are having an effect on tree growth but the leader weevil has so far left the trees alone. Surprisingly, I'm not seeing the amount of frost damage that I thought we would experience. The poor growing conditions should have made the trees more susceptible to attack. This resistant seed was made possible from observation and may only be the tip of the iceberg for the control of other seedling problems.

4. There are a few things that have made life a little easier for the silviculturist.
   - In the past, we would wait for a crop to develop and then we had to keep our fingers crossed that the weather held and that the insects didn't find the cones before we picked them.
   - The seed orchard provides a good, stable environment and we consistently receive good quality seed and the elimination of "dud" seedlots that were poor performers in the forest.
   - Catching a good cone crop out of a high elevation stand can be even more difficult with only a good crop every 10 years or so. By exerting some control on orchard growth, we are able to attain good seed on a steadier basis.

"A" Class Seed Negatives

1. "A" class seed is very expensive compared to wild stand costs. Even helicopter picking in a good crop with short turnarounds for the helicopter are relatively inexpensive.
2. Since "A" class seed is larger than "B" class, we require more kilograms of seed to produce the same number of seedlings. The difference in seed size per gram is about 20% and does have an affect on the final cost of seedlings.
3. The supply of some of the "A" class seed is limited at the present time, leading to a short supply of "A" class Pli seed. With the current Mountain Pine Beetle epidemic, the supply of seed for reforestation is stretched to the limit and our systems were not designed to oversupply for an extended period.

Over the past few decades we have learned a lot about establishing a new conifer forest after harvesting. However, I sometimes wonder if we are taking full advantage of what we have learned. For example, we learned long ago that proper site preparation made a big difference in seedling survival and growth, but we have stopped completing site preparation and rely more heavily on stronger seedlings to take up the shortcomings. A lot of work had been completed during the 1980s on determining the best types of site preparation. I sometimes wonder what the results would be if we were to take all the accumulated knowledge and apply it on a good forest site? Like a farmer, we know how to prepare our site, select the best species and stock type, and how to tend the young crop. Would this yield be significantly more than what we are seeing in our present plantations? I think I've had a glimpse of this a few times and it wouldn't surprise me if we could even compete with manufacturers growing trees in much warmer environments. We have seen what our neighbours to the east have accomplished with poplars in the north, and I think we are very close to accomplishing this with our conifers. The commercial forest is shrinking and making way for other uses. If we want to have a forest industry in the future as well as all the other land uses, we're going to have to grow more on less land. The supply of class "A" seed is a large part of this cycle.

Confronting the Mountain Pine Beetle in the Interior Seed Orchards in 2007

submitted by Jim Corrigan, Keith Cox, Hilary Graham, Judy Murphy, George Nicholson, Greg Pieper, Karen Turner, Tia Wagner

Despite earlier hopes that seed orchard pine trees might not be favoured for attack by the mountain pine beetle (MPB), *Dendroctonus ponderosae*, the beetles became a serious pest problem at several Interior seed orchard locations in 2006. Four semi-retired lodgepole pine orchards (ca. 4200 ramets) were lost to MPB at the Prince George Tree Improvement Station (PGTIS) in that year. No seed orchard trees were hit at the Skimikin Seed Orchards in 2006, but most of the pine trees surrounding this property were killed by the bark beetles. A few lodgepole pines were attacked in seed orchards at both Pacific Regeneration Technologies (PRT) and Vernon Seed Orchard Company (VSOC) in the north Okanagan. However, the most dramatic 2006 attacks in the Okanagan occurred at the Kalamalka Forestry Centre in Vernon (KFC), where more than 800 seed orchard lodgepole pines were hit by MPB (Corrigan et al., 2006). By the end of 2006, it was clear that seed orchard pines were not immune to the devastation caused by MPB in British Columbia. However, several critical questions did remain about MPB attacks in the Interior seed orchards:

- What proportion of the 800+ pine trees attacked by MPB in the Kalamalka seed orchards would die through the 2007 growing season?
- Would the blue stain fungus kill the trees that had repelled the beetle attacks on them?
- Could a program be developed to protect Interior pine seed orchards from MPB attacks in 2007?

How many mpb-attacked seed orchard trees would die at Kalamalka in 2007?

One of the first symptoms of a successful attack by MPB is the accumulation of sawdust on the ground around its root crown. This occurs as the adults excavate their brood galleries under the bark. It had been observed in September of 2006 that very few of the attacked trees in Kalamalka Orchards 230 and 307 had sawdust piles developing at their bases. In the late fall of 2006, Judy Murphy examined all of the attacked trees in both KFC pine orchards. Of 801 trees hit by the beetles, Judy detected successful brood production in only two trees. The trees which had failed to support brood development appeared to be healthy and gave no symptomatic indications that they had been fatally attacked.

In order to learn more about the 2006 MPB attacks at the KFC, the bark was stripped from the boles of a number of pine trees that had been rogued as part of another research trial. Judy Murphy removed the bark from the boles of 18 MPB-attacked trees from Orchard 307. All of these trees appeared healthy when they were felled and it was thought that none of them had produced beetle brood. As well, she removed the bark from three trees that were known to have hosted successful development of beetle brood in 2006. These three trees would have been killed by MPB if they had not been cut down.

On the 18 'healthy' trees, bark removal revealed that the MPB brood galleries had been walled off completely and there was absolutely no evidence of larval brood development in any of these boles (Fig. 1). This defensive response to attack by the beetles is called a hypersensitive reaction and it was seen at every MPB attack site on the boles of the 18 'healthy' trees. On the three trees that would have succumbed to the beetle attacks, the hypersensitive defensive

Figure 1. Bole of a felled pine tree from Kalamalka Orchard 307 from which the bark was removed in the late fall of 2006. The tree was attacked by MPB in the late summer of that year. All of the MPB brood galleries were walled off by the tree (the darkly stained wood around the pitch-filled beetle excavations). No beetle progeny were produced from this bole. Photograph by Jim Corrigan.

By the end of 2006, it was clear that seed orchard pines were not immune to the devastation caused by MPB in British Columbia.

This defensive response to attack by the beetles is called a hypersensitive reaction and it was seen at every MPB attack site on the boles of the 18 'healthy' trees.

It was apparent that, in the trees that successfully defended themselves, the beetles had been rejected and/or killed very shortly after getting under the bark.

These results allowed us to conclude that healthy seed orchard pine trees could survive moderate levels of MPB attack.

reaction was never seen in association with successful brood galleries. The length of each brood gallery was measured on all of the peeled boles. The mean length of these galleries from the 18 trees that had successfully repelled the beetles was 3.8 cm (N=524 galleries) while the mean length of brood galleries in the three trees that been attacked successfully was 11.6 cm (N=257 galleries). It was apparent that, in the trees that successfully defended themselves, the beetles had been rejected and/or killed very shortly after getting under the bark.

We concluded that the attacked trees in Orchards 230 and 307, which did not have any appreciable amount of sawdust accumulated at their bases, had successfully prevented MPB brood development under their bark. While this was very good news, we were still concerned that the blue stain fungus might kill some of these trees in 2007, even if beetle brood had failed to develop in them.

Would the blue stain fungus affect trees that did not support the development of beetle brood?

Several boles examined in the bark peels were split longitudinally, revealing their heartwood to the core. As well, the cross section of all of the peeled boles could be seen where they had been cut down. There was absolutely no blue stain found anywhere on the boles of the 18 trees that had no brood development (Fig. 2a). Two of the three trees that had produced MPB brood showed blue staining around the entire outer circumference of their boles, and these stains extended well into the heartwood. The third tree that had supported brood production had a most interesting reaction. Tree KK11 had been strip attacked, meaning that one side of the tree had parental galleries that had produced brood, while the galleries on the other side had been walled off by the hypersensitive reaction of the tree without brood production. An examination of the cross section of this bole showed that the blue stain had developed under those galleries that had produced beetle brood, but had failed to develop under those areas where the tree had successfully walled off the brood galleries (Fig. 2b).

Neither beetle brood nor blue stain fungi had established in any of the 18 'healthy' trees examined by Judy Murphy. These observations increased our optimism that most of the attacked trees in the two KFC pine seed orchards would survive the MPB attacks they sustained in 2006. Observations made through 2007 have borne this out, as only one additional tree succumbed to the 2006 MPB attacks in Orchards 230 and 307 during the past growing season. So, of 801 trees attacked in Kalamalka seed orchards in 2006, only three of them were killed by the MPB attacks on them. These results allowed us to conclude that healthy seed orchard pine trees could survive moderate levels of MPB attack.

Could the Interior pine seed orchards be protected from MPB attack in 2007?

After detecting mass attacks by MPB in several Interior pine seed orchards in 2006, emergency bole sprays (2% Sevin solution) had been applied at both PGTIS and at several seed orchards in the Okanagan Valley. These sprays had appeared to protect most treated trees from further MPB attack late in the 2006 growing season. Based on these results, it was decided that protective bole sprays would form the basis of the 2007 integrated management program for MPB in Interior seed orchards. Table 1 shows the components of the MPB protection program instituted in 2007.

2a) 2b)

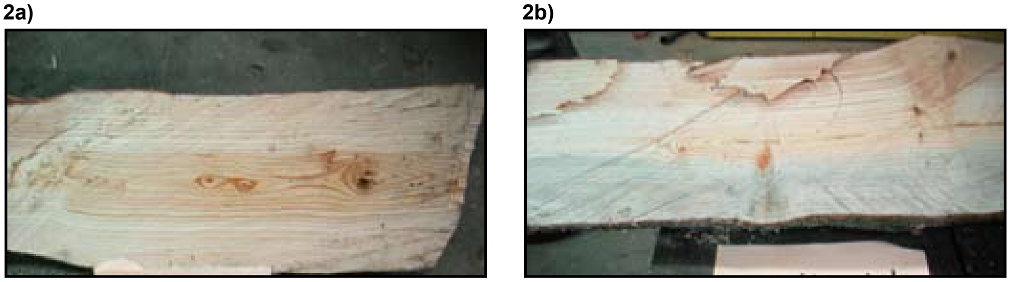

Figure 2. 2a) Cross section of the bole of tree L31. All of the galleries on this bole had failed to produce brood and were walled off by the hypersensitive reaction of the tree. There was no blue stain found anywhere on this bole. 2b) Cross section of the bole of tree KK11. This tree was strip attacked. The blue stain appeared under the area of successful brood production on the bole. Attacks on the other side of the tree were walled off, and there was no blue stain found under the failed brood galleries. Photographs by Judy Murphy.

Table 1. Recommendations for MPB control in Interior seed orchards for 2007

1. **Sevin bole sprays.** Sprays of a 2% suspension of the contact insecticide Sevin were to be applied to the boles of seed orchard pine trees in the pre-flight period for MPB (late April to early June). These treatments were a prophylactic measure; trees would be treated without waiting for the detection of new MPB attacks or spikes in pheromone trap catches. If monitoring through the growing season showed that MPB attacks were increasing in number and, therefore, protection from the first spray was breaking down, it was recommended to apply a second Sevin bole spray as soon the breakdown in tree protection was detected.
2. **Hydration/irrigation.** We believe that good hydration was the principal factor that allowed so many KFC seed orchard trees to survive being attacked by MPB in 2006. Orchard managers were advised to keep trees in optimal condition with respect to their hydration state throughout the growing season.
3. **Monitoring for new attacks.** Regularly scheduled monitoring of trees for new MPB attacks was recommended for all pine seed orchards in 2007 to assure that the spray treatments continued to protect trees from attack by MPB throughout the growing season.
4. **Pheromone trap monitoring.** Installation and regular monitoring of MPB pheromone traps was recommended for Interior seed orchards for the entire 2007 growing season. This would allow managers to respond to large inflights of beetles with increased monitoring of their plantations to look for new attacks.
5. **Sanitary removal.** Timely sanitary removal was recommended for trees that were dead or were clearly going to die from MPB attack, as these killed trees would become local sources for MPB adults.

In 2007, all of the Interior operations with mature pine plantations instituted versions of the recommended protective measures against MPB in their pine orchards. Sorrento and Kettle River Seed Orchards were not involved in 2007 program as their lodgepole pine trees were too small to be the targets of attacks by MPB. With the exception of PGTIS, all seed orchards reported summaries of their 2007 MPB control programs to the Interior Seed and Cone Pest Management Biologist in the fall of the year. These results are summarized below.

In Table 2, the bi-weekly pheromone trap catch totals are shown for the Interior seed orchard operations on a 'per trap' basis. This was done by dividing the total bi-weekly catch of beetles at each location by the number of pheromone traps that had been put out at that site. Although all traps did not catch equal numbers of beetles at any site, the 'per trap' numbers are given to facilitate comparisons of MPB population levels at different locations around the Interior.

In 2007, all of the Interior operations with mature pine plantations instituted versions of the recommended protective measures against MPB in their pine orchards.

Table 2. Bi-weekly pheromone trap catch totals (on a per trap basis) for Interior seed orchards in 2007

Period ending…	Bailey Road, MFR	Eagle Rock, Tolko	Kalamalka, MFR	Pacific Regeneration Technologies (PRT)	Skimikin, MFR	Vernon Seed Orchard Co., (VSOC)
May 31	0	191	1	83.5	75.2	9
June 15	3.5	–	2.3	103.5	134.7	31.8
June 30	3.5	–	3	179.8	736.7	27
July 15	3	410.5	4	257.8	3 803.4	822.5
July 31	1	5 572.5	8	214	4 325.2	598
Aug. 15	12.5	5 100	26.3	129	2 285.5	1 398.5
Aug. 31	6.5	1 013.8	14.3	211	1 023.6	1 362.8
Sept. 15	6.5	235	11.3	133	545.8	423.3
Sept. 30	0	–	0	4.3	7.5	196.5
Oct. 15	0	–	0	–	0	1.3

Adult MPB specimens were caught around all mature Interior pine seed orchards in the summer of 2007.

There were large discrepancies in the number of beetles trapped at different locations. At least some of the large catches at Tolko Eagle Rock in Armstrong were thought to be coming from the nearby lumber mill, where huge numbers of MPB-infested pine logs were being stored prior to processing. At Skimikin, the large trap catch totals were reflective of the enormous MPB populations that have invaded the Kamloops/Salmon Arm area in the past few years. Since 2005, nearly all of the wild pines have been killed in the forests around the Skimikin Seed Orchards. The discrepancies between totals for VSOC, KFC and Bailey Rd. were less easy to explain. Through the peak flight period (July 1–Sept. 15), VSOC trap catch totals were 20 to several hundred times higher than totals for traps located just a few kilometres away at Bailey Rd. and KFC. Pheromone lures and killing agents were changed in mid-summer in the KFC and Bailey Rd. traps, but this did not appear to affect their catch levels to any extent. These discrepancies may be due to patchy dispersal patterns from nearby infested areas, but no definitive reason could be identified for the differences in trap catches for the three locations around the Vernon area.

Adult MPB specimens were caught around all mature Interior pine seed orchards in the summer of 2007. It could be argued that population levels were too low at Bailey Rd. or KFC to constitute a real threat. However, about 100 unprotected pine trees were attacked on the KFC grounds in 2007. We concluded that all mature Interior pine seed orchards were exposed to potentially harmful population levels of MPB in the summer of 2007.

Table 3 shows the results of the 2007 MPB protection programs for most of the mature pine seed orchards around the Interior. Over 32 000 seed orchard pine trees were treated in 2007. Most operations needed to apply only a single spray treatment to protect their trees through the 2007 growing season. A total of five trees were attacked by MPB in all treated plantations, and four of these trees were killed or removed because of the MPB attacks on them. Given the pheromone trap catch results from these locations, and with numerous observations of MPB attacks on untreated trees in the vicinity of these orchards, we concluded that the 2007 MPB management strategies were very effective at protecting the pine trees in the Interior seed orchards.

Given the pheromone trap catch results from these locations, and with numerous observations of MPB attacks on untreated trees in the vicinity of these orchards, we concluded that the 2007 MPB management strategies were very effective at protecting the pine trees in the Interior seed orchards.

Table 3. Results from the 2007 MPB control programs in Interior seed orchards

Period ending...	Bailey Road, MFR	Eagle Rock, Tolko	Kalamalka, MFR	Pacific Regeneration Technologies (PRT)	Skimikin, MFR	Vernon Seed Orchard Co., (VSOC)
Seed orchards (ramets-species) treated	1 (ca. 2300-Pw)	2 (ca. 3500-Pli)	2 (ca. 3400-Pli)	3 (ca. 3000-Pli)	2 (ca. 400-Pw, 400-Py)	5 (ca. 19 000-Pli)
No. bole treatments per orchard	1	1	1	1	1	2 young orchards – 1 spray; 3 mature orchards – 3 sprays
No. pheromone traps main-tained	2	4	4	4	14* (*only 6 traps out until June 11)	4
Protected trees attacked	0	0	2	1	0	2
Protected trees killed	0	0	2	0	0	2 removed after attacks
Unprotected trees attacked	0	Some attacks in area around orchards	About 50 in area around orchards	9 around site	Four Py trees hit before being sprayed	–
Unprotected trees killed	0	Some mortality in area around orchards	About 30 in area around orchards	9 around site	None on orchard grounds	–

Conclusions

There are few good-news stories associated with the current MPB epidemic in BC. A recent report by the Ministry of Forests and Range states that 13 million hectares of Crown forest have been killed by MPB to date and predicts that 78% of the pine wood volume in the province will be killed by 2015 (BC Ministry of Forests and Range, 2007). However, the story of MPB in the Interior pine seed orchards is a bright light in this larger picture of devastation. Unlike most trees in wild stands, seed orchard pines have demonstrated that they can survive a certain number of MPB attacks on them. More importantly, results from the 2007 MPB protection program give us a very strong indication that seed orchard pine trees can be protected from attack by the bark beetles. While protection programs in Interior seed orchards will probably need to be carried out at most locations for the next three to 10 years, we are confident that the sources of seed needed to replant the pine forests of the province can be preserved until the ultimate collapse of the MPB populations around BC.

Acknowledgements

The authors sincerely thank the Forest Genetics Council of the Province of British Columbia for supporting the MPB protection programs undertaken in the Interior Seed Orchards in 2007.

References

British Columbia Ministry of Forests and Range. 2007. Timber Supply and the Mountain Pine Beetle Infestation in British Columbia – 2007 Update. Forest Analysis Branch, Victoria, BC.

Corrigan, J., M. Carlson, G. Giampa, V. Berger, C. Walsh, and W. Strong. 2006. They're Heeeere! – Observations of the First Mountain Pine Beetle Attacks Recorded at the Kalamalka Forestry Centre. TIC*talk* Vol. 7, pp. 4–8.

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More importantly, results from the 2007 MPB protection program give us a very strong indication that seed orchard pine trees can be protected from attack by the bark beetles.

Cone and Seed Pest Research Report

submitted by Ward B. Strong

The *Dioryctria* pheromone was discovered only two years ago, opening the way for monitoring of adult male moths.

The objective was to determine when adults start to fly, whether there are distinct flight periods or times of no flight, and whether the timing of flights is similar between the Coast and Interior regions.

The first full year of the Cone and Seed Pest Research program was marked by a very busy lab, the start of several research projects, and the continuation or completion of others. In my lab at Kalamalka Forestry Centre, there were two graduate students, a summer technician, and a summer student. We had many small and large projects on the go; the main ones are summarized below.

1. *Dioryctria abietivorella* pheromone lures and adult flight phenology (in-house).

The *Dioryctria* pheromone was discovered only two years ago, opening the way for monitoring of adult male moths. However, the formulations have not been thoroughly tested, nor had commercial supplies been developed. I arranged for a commercial manufacturer, ChemTica of Costa Rica, to supply lures commercially. They formulated the pheromone in a standard rubber septum lure (Fig. 1), and also a new polymer material. We compared these with the previous supplies from University of California-Riverside (UCR) by running traps side-by-side in a single Douglas-fir orchard at Kalamalka Forestry Centre. Seven replicates were set out June 21; lures were replaced August 2, and traps were removed Sept 19. Traps were re-randomized weekly within the same orchard. Results showed that the UCR septa were the most attractive lures (Fig. 2), catching an average of 2.15 males per week, significantly higher than the ChemTica septa (1.14 males/week) or the ChemTica polymer (0.79 males/week) ($P < 0.001$). I am currently in discussion with ChemTica and UCR to try to figure out why there is such a large difference. Even so, the ChemTica lure, which will continue to be available in the future, is a usable lure for monitoring purposes.

The third year of flight phenology monitoring in British Columbia was 2007, with traps sprinkled throughout the interior and coastal BC seed orchards and outlying areas. The objective was to determine when adults start to fly, whether there are distinct flight periods or times of no flight, and whether the timing of flights is similar between the Coast and Interior regions. Traps were baited with UCR septa lures and placed in orchards or wild areas in late April. Males caught were counted weekly and lures replaced every four weeks. Males were first caught in late April or early May, and numbers caught increased until July or August, after which they declined – the last moths being caught in mid-October (Fig. 3).

Figure 1. Diamond trap hanging on spruce limb. Insert: *Dioryctria* pheromone lure diamond trap.

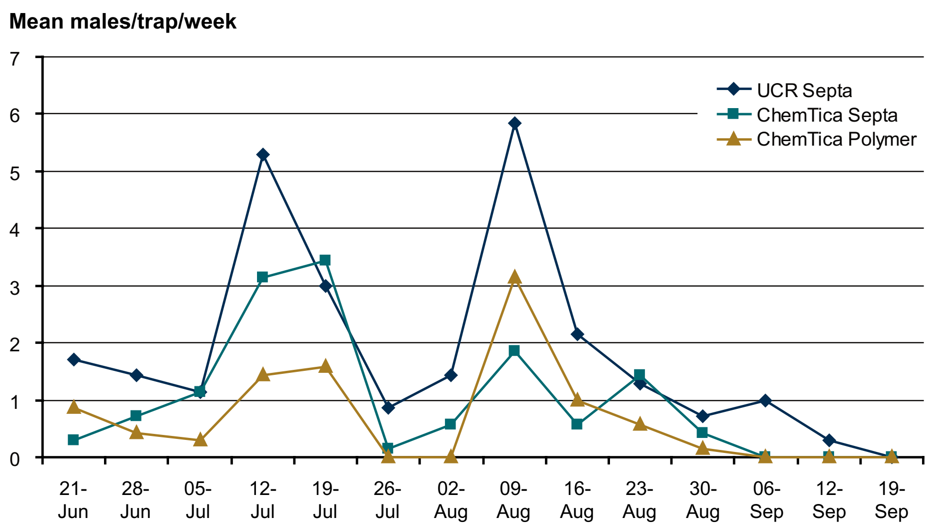

Figure 2. Pheromone traps baited with 3 different lures and installed in one orchard at Kalamalka Forestry Centre.

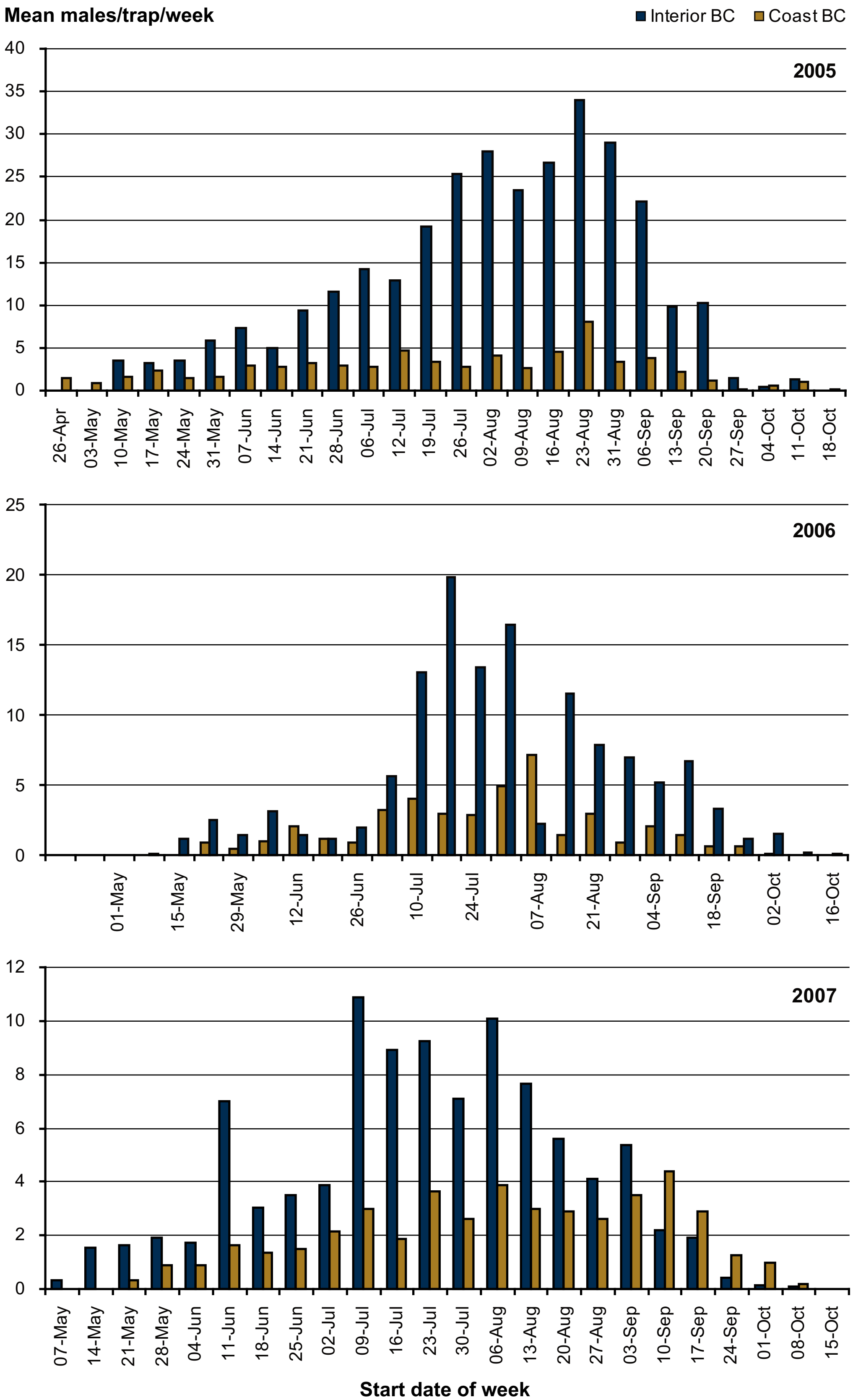

Figure 3. Seasonal pheromone trap catches of *Dioryctria abietivorella* in 2005, 2006, and 2007.

Males probably emerge before females. In the Interior, the first cone damage due to newly hatched larvae was observed one to three weeks after the first males were caught. Pheromone traps can, therefore, be used to time monitoring for first damage, and possibly to time spray applications. Trap catches continued throughout the summer, suggesting that there is more than one generation, and that generations overlap. The flights into September and October indicate that stages other than late-instar larvae might overwinter – adult females, eggs, or young larvae.

2. *Dioryctria abietivorella* life history and reproductive behaviour (Caroline Whitehouse, University of Alberta).

This project was in the hands of a Master's student funded by the Forest Genetics Council, working during the summer in my lab. In this start-up year, she discovered how to trap *Dioryctria* in light traps, learned how to tell species apart by dissection, learned how to determine mating status of females, and established a live colony to continue her research in Edmonton through the winter. As she was not a registered grad student until September, this year was a "bonus" year to get Caroline going on this three-year project. Objectives are to determine at what stages *Dioryctria* overwinter, when and where eggs are laid, if there are novel windows for control, and whether the pheromone can be used to control the pest through either mating disruption or attract-and-kill methods.

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3. *Synanthedon sequoiae* surveys and damage potential (in-house).

Orchards in the Interior have been plagued with Sequoia pitch moths for a long time. Trees attacked at a young age are susceptible to breakage, limbs can break off older trees, and there is concern that heavy attacks can reduce tree vigour. We monitored the flight times of adult male Synanthedon and established two long-term plots to assess the effect of attacks on tree health. Flights were monitored with pheromone traps placed in Pli seed orchards and breeding arboreta around the Okanagan Valley. Synanthedon males started flying in mid-May, peaked in mid-June, and were done by mid-July (Fig. 4). Female flight probably follows this trend with a delay of one or two weeks. I suspect oviposition is complete by late July. Therefore digging out new larvae in September or October is a good time, since the larvae are still young and have not caused much damage. Larvae live for two years, and the older larvae are much more damaging than younger larvae. Many of the traps were placed in fields which have had concerted digging efforts as well as spray applications for other pests, so it seems that these efforts have not kept adult numbers to acceptable levels; they probably fly in from other areas.

Orchards in the Interior have been plagued with Sequoia pitch moths for a long time.

Long-term plots were established at the Kalamalka Forestry Centre in two breeding arboreta. Clonal pairs were located within each orchard, 17 in Block 8 and 26 in

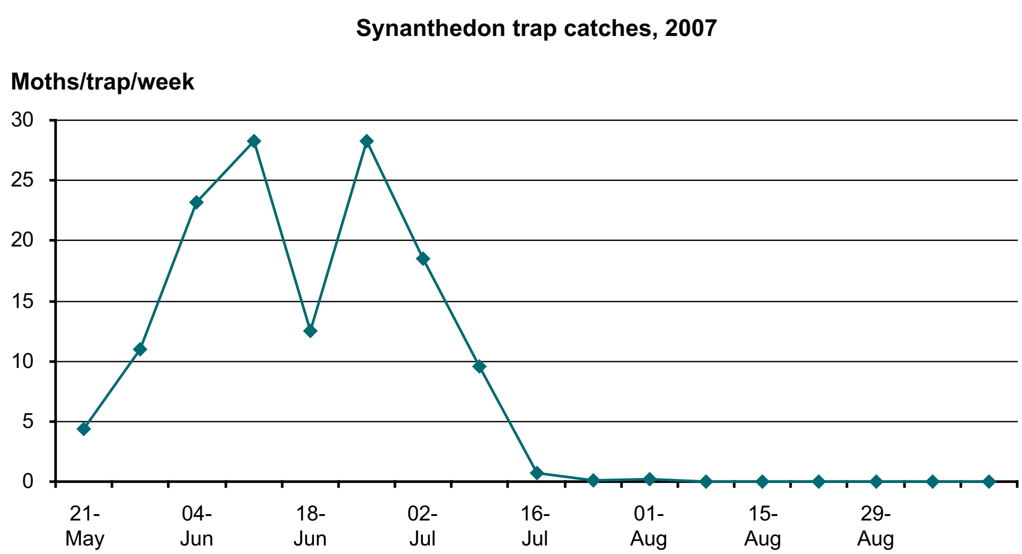

Figure 4. Male *Synanthedon sequoiae* caught in pheromone traps in Pli seed orchards of the Okanagan Valley.

Block 10. One ramet of each pair was randomly assigned "protected" status, the other was unprotected. In Block 8, ramets were protected by digging out all existing synanthedon pitch masses in June, and again at the end of September. In Block 10, ramets were protected by spraying with an experimental bole spray of Sevin, similar to a MPB protective spray. New pitch masses were counted in late September on all experimental trees, and health of all trees was rated on a scale of 0 (healthy tree) through 4 (dead). There were no significant differences in tree health or number of new pitch masses in either of the treatments by the end of September (Fig. 5). There were as many new pitch masses in the Sevin-treated trees as in the untreated trees, suggesting that Sevin bole sprays are not able to protect trees from attack by Synanthedon. This has also been observed on trees sprayed with Sevin for mountain pine beetle protection at the Kalamalka Breeding Arboreta and at Kalamalka Seed Orchards (observations of Jim Corrigan). To assess long-term tree health, we might need to resort to digging larvae rather than relying on a chemical application.

4. *Contarinia oregonensis* flight phenology, Interior Fdi orchards (in-house).

This quick project was designed to determine when flights occur, and what the density of *Contarinia* is at various locations in the Interior. Coastal areas are still losing Fdc seed due to this pest, and with the increase in acreage in the Interior, it is likely to become a significant pest here too. Pheromone traps were set out at the four Fdi seed orchard locations in the Interior. Trap catches started in early May, peaked in mid-May, and were done by early June (Fig. 6). Very high numbers were caught at the Kal Breeding Arboreta, peaking at over 300 males/trap/week, but lower numbers were found in the seed orchards. In the breeding orchards, cones without protective insect exclusion bags have virtually no seed because of the

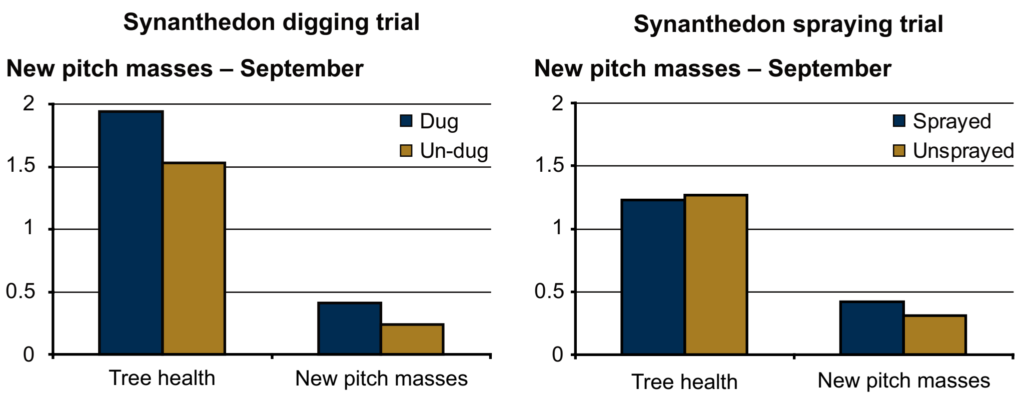

Figure 5. Tree health (scale of 0 through 4) and new pitch masses in protected vs. unprotected trees.

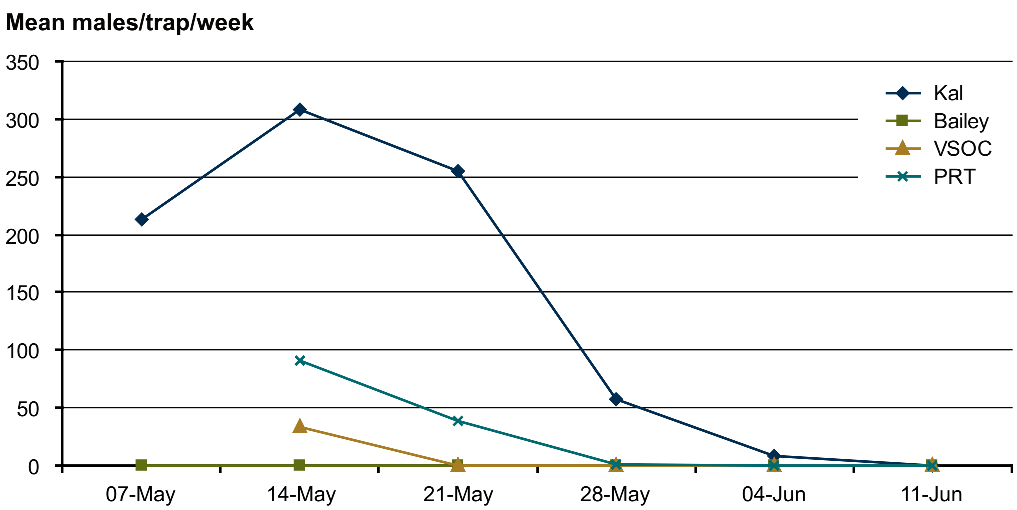

Figure 6. *Contarinia* trap catches in Interior Fdi orchards in 2007. Kal, Kalamalka Research Centre.

There were no significant differences in tree health or number of new pitch masses in either of the treatments by the end of September.

In the breeding orchards, cones without protective insect exclusion bags have virtually no seed because of the *Contarinia* infestation.

Contarinia infestation. Without protection, it's possible that the seed orchards will also sustain heavy losses. In the face of current problems on the Coast, and potential future losses in the Interior, the use of pheromones to time-spray applications, or possibly to control insects through mating disruption or attract-and-kill, will be investigated in the future.

5. *Leptoglossus* mark-release-recapture (in-house).

This project received funding last year, but because we could find no one to take it to the next step and make a solid project out of it, no funding was put into it this year. Last year we determined a marking method; tested the effects of marking on normal activity, feeding, mating, and longevity (none); made point-source and broad-scale releases; and determined that *Leptoglossus* can move up to 250 m within a short period of time. This year, because our co-operator Dr. Sylvie Desjardins of UBC-Okanagan, has some extra money, a summer student was hired (at no cost to the Forest Genetics Council) to work at my lab to continue pecking away at the project. Objectives included to determine the feasibility and desirability of tracking the release and recapture point of each insect to individual trees. We found that keeping track of individual trees slowed down marking and releasing to a great extent. Unfortunately, we had a manpower crunch at the end of August, just after a large number of *Lepto* had been marked, and were not able to visit the orchards to determine recapture rates. There is still much to be learned with this and related techniques – we hope to pursue it further in the future.

Objectives included to determine the feasibility and desirability of tracking the release and recapture point of each insect to individual trees.

6. *Leptoglossus* host-finding studies (Gerhard Gries lab, Simon Fraser University).

Gerhard Gries and his laboratory determined in 2005–06 that *Leptoglossus* makes a clicking sound which is transmitted through trees and which is attractive to other *Leptos*. It seems that this is only part of the story, though. *Lepto* seem to use a mixture of complementary methods to orient to other members of their species, and to cones for feeding. Their latest discovery is that *Lepto* finds cones by seeing infrared radiation (IR). Cones heat up in the sun; when viewed through an IR camera they light up like candles on a Christmas tree (Fig. 7). *Lepto* are attracted to this IR, which they detect through sensors on their lower abdomens. The Gries lab has developed a prototype trap using IR. In the course of these studies, they found that green is the most attractive colour. They hypothesize that both IR and green colour are used to find cones; they will test this in 2008.

7. Adelgid studies (Babita Bains, University of British Columbia).

Babita is a new graduate student working with John McLean at UBC who has been funded by the FGC for one year now. She made excellent progress on her thesis and has strong plans for the future. She reports on her research in another article in this volume.

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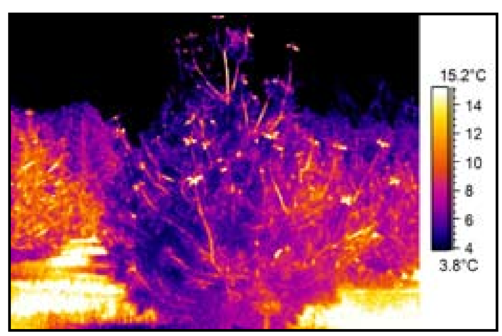

Figure 7. A white pine tree photographed in visible light (left) and infrared radiation (above).

Adelgid Research at Kalamalka Forestry Centre

submitted by Babita Bains, Ward Strong, John McLean

Reforestation is an important part of silviculture in British Columbia (BC). Over 200 million trees were planted in BC in 2006 and approximately 60 million of these trees were spruce (BCMFR). Roughly 60% of the spruce seed used for regeneration comes from seed orchards (BCMFR). Seed orchards are intensively managed agroecosystems and the seed produced is of high value. Insects that damage cones and decrease seed yields can be costly and their management is of high priority. Adelgids *(Hemiptera: Adelgidae)* are a small clade of insects that feed on conifers and can be serious pests in seed orchards. Adelgids have a complex life history and cycle between a primary host and secondary host. Spruce (*Picea* spp.) is always the primary host whereas the secondary host is different among adelgid species. Adelgids feed on the buds of spruce trees resulting in galling. Galling of reproductive buds causes swollen scales, swollen bracts and galled cones – this directly reduces seed yields, whereas galling of vegetative buds decreases the potential number of future cone sites. Feeding on secondary hosts can also reduce seed yields by impairing seed extraction efficiency. Furthermore, feeding on the needles of secondary hosts can cause twisting and yellowing, hence reducing tree vigour. Damage induced by adelgids is of significance on spruce trees, whereas damage on secondary hosts is minimal. Feeding on the secondary hosts can gum up cones and decrease seed yield, but most often feeding occurs on needles where damage is negligible.

Adelgid population build-ups can be fast and erratic and they have proven to be a pest at the Ministry of Forests and Range Kalamalka Forestry Centre (KFC). KFC is located in the north Okanagan, south of Vernon, BC. Considering the losses endured from adelgid-induced damage, we explored questions regarding their biology and impact in the Kalamalka Breeding Arboretum. Information gathered will be used to design a rational pest management plan to reduce adelgid impacts in BC seed orchards.

The objectives of our study were to:

- determine the role of a mother adelgid and her nymphs in the gall formation process
- determine the relative abundance, species composition, seasonality and movement among orchards
- attempt to characterize gall morphology for different adelgid species
- determine if weevil-resistant spruce trees show resistance to adelgids (preliminary study)

Determining the Role of Fundatrices and Nymphs in Gall Formation

Manipulation of adelgids on spruce branches determined that an adelgid mother and nymphs are both required to gall an expanding bud. Mothers alone and nymphs alone were not able to successfully form a gall. Adelgid mothers and nymphs did not need to be related. General observations from this study also showed that a single adelgid mother with nymphs typically formed a single gall. Understanding the role of adelgid mothers and nymphs, and linking adelgid mother abundance to gall abundance can contribute to determining an action threshold for monitoring adelgid populations. Current management at the Kalamalka Breeding Arboretum focuses on spraying adelgid mothers in early spring. This is clearly the best time to spray, considering adelgid mothers play a key role in galling of buds. Further testing of adelgid mothers without offspring and their role in gall formation will be explored. We would like to increase the sample size of adelgid mothers without crawlers considering many samples were lost due to branch death and sample contamination. We would also like to explore the histological changes in branches as the two life stages feed and develop.

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Understanding the role of adelgid mothers and nymphs, and linking adelgid mother abundance to gall abundance can contribute to determining an action threshold for monitoring adelgid populations.

Associating gall morphology to a specific adelgid species could be a useful tool for orchard managers.

Summer Malaise Trapping at the Kalamalka Forestry Centre

Adelgid alates were collected weekly in four four-way Malaise traps. These large screen traps intercept adelgids in flight and trapped adelgids are funneled into collecting bottles at the bottom. The information derived included relative adelgid abundance, species composition, flight times and movement/dispersal between orchards. We will compare species abundances among the traps and determine if location of orchards (e.g., spruce next to/near larch) presents a risk, considering alates are carried by wind and they cycle between hosts. It appears that the total number of adelgid alates for 2007 will be significantly lower than what was sorted from a 1996 Kalamalka collection made by Rory McIntosh (Figs. 1 and 2).

Characterizing Gall Morphology

Microscopic characteristics are used to identify adelgids to species. Considering the small size of adelgids (1–2 mm), a lengthy process, involving mounting adelgids onto slides and identification using a microscope, is necessary to determine species. Preparation of 20 specimens can take a full day of work and involves the use of various chemicals. Associating gall morphology to a specific adelgid species could be a useful tool for orchard managers (Figs. 3 and 4). It would eliminate the lengthy laboratory procedure and allow managers to determine which species are present and how orchard design is influencing movement of a particular species.

We selected and bagged 25 galls from the Kalamalka Breeding Arboreta and emerging adelgid alates were collected and identified.

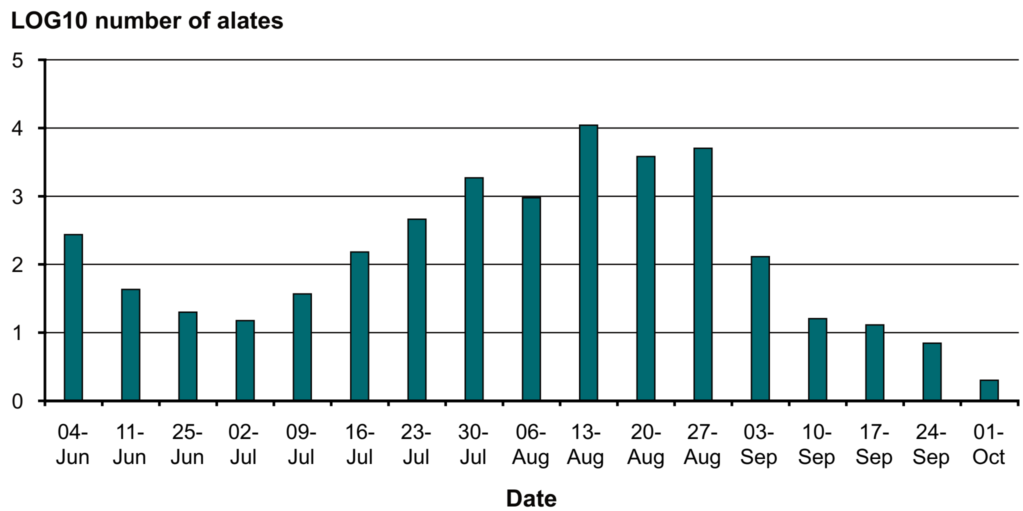

Figure 1. Weekly number of adelgid alates caught in the Kalamalka Research Orchard in the summer of 1996 (n=10 traps).

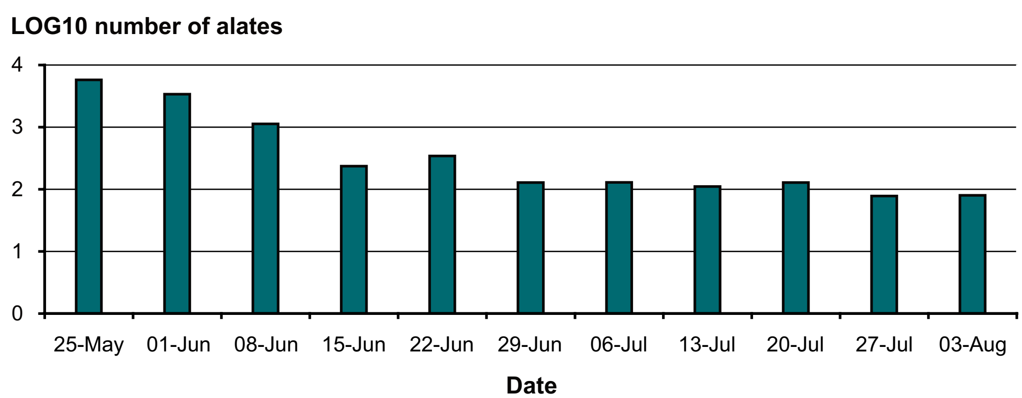

Figure 2. Weekly number of adelgid alates caught in the Kalamalka Research Orchard in the summer of 2007 (n=4 traps).

Figure 3. *Adelges lariciatus* gall on spruce.

Figure 4. *Adelges cooleyi* gall on spruce.

Just over half of the galls have had alates identified and it appears that a single species seems to be emerging from any one gall. Once the remainder of the gallicolae are identified by microscopic examination of mounted specimens, we will attempt to characterize the associated galls.

Adelgid Gall Incidence on Weevil-resistant Spruce Trees

The white pine weevil (*Pissodes strobi*) is considered to be one of the most damaging pests of spruce regeneration in BC (Alfaro et al., 1997). The white pine weevil feeds on a variety of spruce species and its most susceptible hosts in BC are Sitka spruce (*Picea sitchensis*) and interior spruce (*Picea glauca* × *Picea engelmanni*). Damage is caused by larval feeding on the phloem of the terminal leader. We thought that induced or constitutive resistance to one phloem feeder might lend resistance to others. The incidence of adelgid galls on weevil-resistant spruce presented a good opportunity to assess this idea, even though adelgids and weevils have very different feeding mechanisms and impacts on their host.

A spruce orchard located in the north-east portion of the Kalamalka Breeding Arboretum consists of 42 full-sibling families that have been classified as putatively resistant (R×R), intermediate (R×S) or susceptible (S×S) to weevil attack (Fig. 5) (Alfaro et al., 2004). Barry Jaquish (Research Scientist, Interior Tree Breeding) of the Kalamalka Forestry Centre established the orchard and collaborated with us in this work. Our objective was to determine if adelgid galling incidence varied among weevil-resistant trees.

Two branches were randomly selected from each tree (N=1493) and the total number of galls on the last two years of growth were counted and averaged for each tree. The likelihood of adelgid galling statistically showed no significant difference among groups deemed resistant, intermediate or susceptible to weevil attack (α=0.05; p-value=0.0627). However, there appears to be a trend indicating weevil-resistant trees have a lower incidence of adelgid galling (Fig. 6).

Exploring the response of different genotypes to various pests would be beneficial in high-

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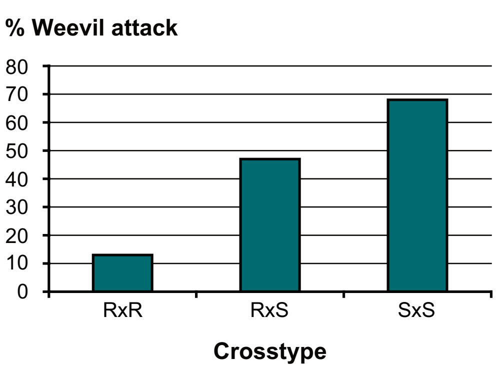


Figure 5. Percent of trees attacked by weevils in resistant (R×R), intermediate (R×S) and susceptible (S×S) crosstypes. Adapted from Alfaro et al. (2004).

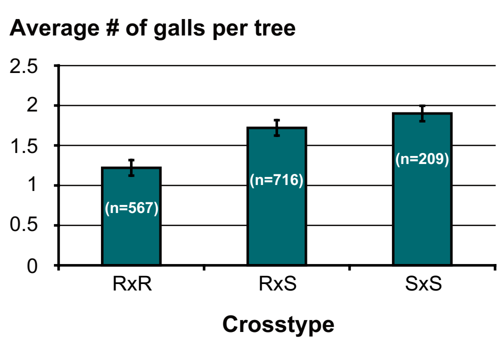


Figure 6. Average number of adelgid induced galls per tree in resistant (R×R), intermediate (R×S) and susceptible (SxS) crosstypes

A better understanding of adelgid biology will contribute to the management of these pests in high-value research orchards.

value research orchards and clone banks. Although host induced responses to adelgids and weevils have proven to be different, a biological trend indicating resistance to weevils and adelgids is desirable, and exploring resistance to other phloem feeding insects could be useful.

A better understanding of adelgid biology will contribute to the management of these pests in high-value research orchards. Understanding population dynamics, damaging life stages and species characterization are all useful tools. We will continue to finish these current research projects and we plan to explore the histology of tree hosts with and without feeding adelgids, and during different life stages. This will allow us to better understand the impact of adelgid feeding on host tissues.

Funding for this project has been provided by the Forest Genetics Council of British Columbia.

References

Alfaro, R.I., L. vanAkker, B. Jaquish, and J. King. 2004. Weevil resistance of progeny derived from putatively resistant and susceptible interior spruce parents. For. Ecol. and Manage. 202: 369–377.

British Columbia Ministry of Forests and Range: http://www.for.gov.bc.ca/hfd/pubs/docs/mr/annual/ar_2006-07/tables/.

Comandra Blister Rust on Lodgepole Pine in the Bulkley Valley: Predicting Infection

submitted by Sally E.T. John and Richard W. Reich

Losses to comandra rust (*Cronartium comandrae*) on lodgepole pine are large; mortality in young stands sometimes exceeds 85%. The Lakes TSA is one of the most heavily affected areas of the province. This project will enable assembly of custom seedlots with some rust resistance for deployment on sites at high risk of comandra infection.

Clones in the Bulkley Valley low elevation orchard (Orchard 219) at the Vernon Seed Orchard Company (VSOC) site were selected on the basis of family growth performance in Ministry of Forests and Range progeny tests. In 1999, casual observations on one of these test sites in the course of an unrelated study suggested family differences in comandra infection rates. This prompted a formal disease assessment in 2000 on the most severely affected test site (at Chowsunket) at age 15 to 16 years.

Significant and large differences in family infection rates were found, with family infection levels ranging from 0 to 69% in the 309 families assessed. Geographical patterns in infection were also evident, with some provenances showing significantly higher resistance to comandra infection. Based on results from this analysis, resistant provenances were identified as desirable sources for wild seed collections (B+ provenances) by the Ministry of Forests and Range.

Since these progeny tests were not designed for the purpose of disease assessment, the precision of infection rate estimates was limited by number of seedlings per family and their spatial arrangement. In addition, many infected trees had died and signs of disease were no longer visible, so that infection estimates were biased downwards. Consequently, confidence intervals on estimates were large, so that family rankings were not very reliable.

A field trial designed specifically to test comandra resistance of genotypes established in the Bulkley Valley seed orchard, and to allow accurate ranking of families, was established on five sites in 2004. Sites were selected on the basis of high levels of comandra incidence and abundance of the alternate host, bastard toadflax (*Geocaulon lividum* (Richardson) Fernald).

Included in the trial were 130 seedlots. By establishing 50 seedlings in single tree plots on each of three sites, it is expected that accurate infection rates can be estimated. Three sites were designed to be nearly balanced, although some families were short in the nursery. Remaining seedlings were established on two sites, in highly unbalanced designs.

Two test sites, Endako and Thompson, were assessed in 2006, 24 months after planting. To our surprise, almost 40% of the seedlings were already infected by comandra, and many infections were already sporulating. Many seedlings had multiple comandra infections (see photo).

Multiple sporulating comandra infections, May 2006, two years post-planting (photo by S. John).

Seedlots in the trial were classified by Ministry of Forests and Range staff into five types. Forty-two orchard clones were represented by both wild (open-pollinated) seed from the original ortet, and orchard clonal collections. Fifty-five seedlots in this trial series also occurred at the original Chowsunket progeny trial site, so that family infection rates between the two tests could be compared.

This is a follow-up to the articles on comandra rust in the Spring 2000 and Winter 2003 issues of TIC*talk*.

Losses to comandra rust on lodgepole pine are large; mortality in young stands sometimes exceeds 85%.

Geographical patterns in infection were also evident, with some provenances showing significantly higher resistance to comandra infection.

Counts of sporulating and non-sporulating infections were made for each tree. Trees with either a swelling or a sporulating canker or gall were classified as “infected,” and summaries and analyses were based on this classification.

All living trial trees (excluding fillers and surrounds), and those dead trial trees for which disease was identifiable as the cause of death, are included in the following summary table.

Analysis of comandra incidence showed highly significant family effects, while site effects and family–site interaction effects were not significant.

Ministry of Forests and Range seedlot categories and comandra infection rates

Category	No. seedlots	Infection rate (%)
Wild open-pollinated seed (from orchard ortets)	55	42.6
Orchard open-pollinated seed	51	36.5
Controlled crosses with putative comandra resistance	9	40.8
Operational lots	13	37.4
Identified susceptible provenances	2	42.7
All	**130**	**39.6**

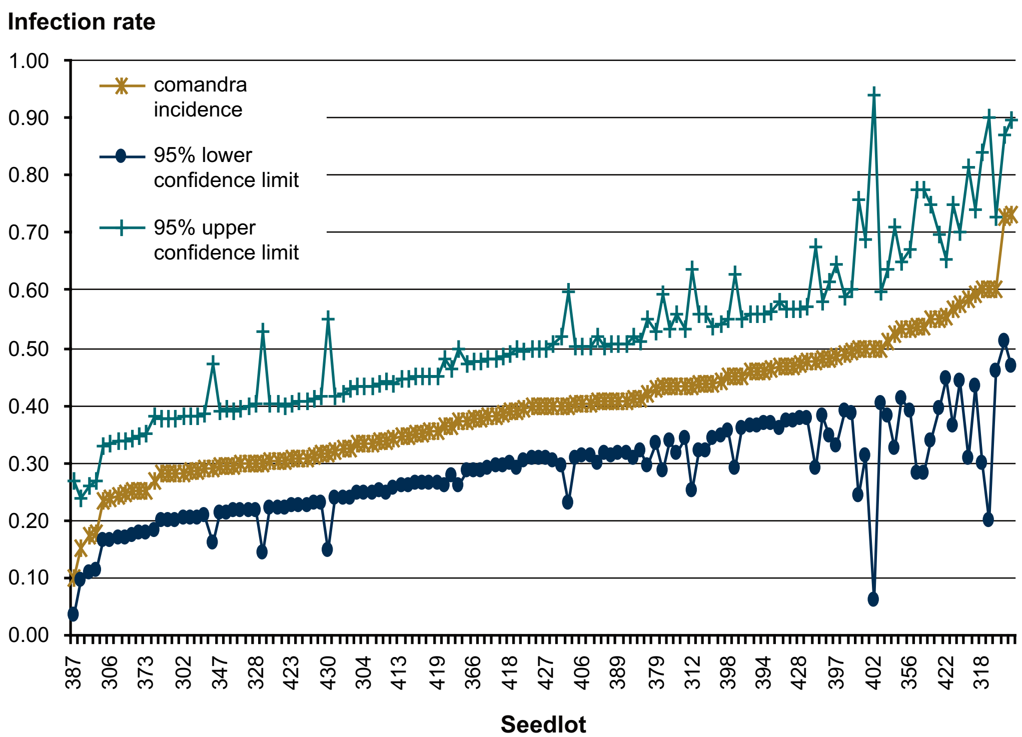
While the provenances identified as susceptible showed a slightly higher infection rate than the average, controlled crosses between parents tentatively identified as resistant on the basis of the earlier Chowsunket assessment also showed higher than average infection rates, confirming earlier suspicions that results based on the original progeny site were not sufficiently reliable to allow selection of resistant genotypes.

Analysis of Effects

Analysis of comandra incidence showed highly significant family effects, while site effects and family–site interaction effects were not significant.

```
Proc logistic output
Type III Analysis of Effects
                    Wald
 Effect      DF   Chi-Square     Pr > ChiSq
 fam        129     328.1639         <.0001   ***
 si           1       1.4985         0.2209   ns
 fam*si     110     113.9603         0.3788   ns
```

Infection rates and 95% confidence intervals are shown below. All seedlots represented by more than 85 trees in analyses had 95% confidence limits that were within 10% of the observed infection rate, as expected.



Infection rates by seedlot, with 95% confidence interval.

Susceptibility to comandra infection appears to be under strong genetic control. Confidence levels on infection rates are sufficiently tight to allow differentiation among families and selection on the basis of comandra resistance.

Next Steps

Three sites were assessed in 2007, but analysis has not been completed. The remaining two sites had such low infection rates that assessments were not felt to be worthwhile, but will be examined again in 2008. Analyses of the complete (five-site) dataset will result in further narrowing of confidence intervals. Results will allow assembly of custom seedlots from the Bulkley Valley seed orchard for deployment on sites at high risk of comandra infection.

The next phase of this project involves the alternate host, bastard toadflax (*Geocaulon lividum*). Counts of the number of stems of the alternate host were conducted on a 1.5-metre grid in 2007. Preliminary spatial analysis showed that risk of infection is very high (50–60%) when lodgepole pine seedlings are in close proximity to bastard toadflax, drops dramatically over the first several metres to about 20%, and gradually decreases to almost zero by 25–35 metres away. We will focus on modelling the influence of site, climate, ecology, host resistance, and alternate host abundance and susceptibility on comandra infection.

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Susceptibility to comandra infection appears to be under strong genetic control.

The next phase of this project involves the alternate host, bastard toadflax.

A Few Short Stories – a recent work visit to New Zealand

submitted by Alvin Yanchuk

As many of you may recall, I was lucky to be able to spend approximately three months earlier this year on a study leave to New Zealand (mid-March to early June), at the old Forest Research Institute (FRI) in Rotorua. For most of us, FRI was the 'Mecca' of tree breeding and many of the approaches we use today in tree improvement were first applied there in radiata pine. I arrived without any trouble (but see below), and spent the first few weeks 'catching up' on developments at FRI since my last visit (~16 years ago), as well as trying to understand the new model that is trying to deliver tree breeding and improvement in radiata pine (and many other species). Much has changed, and most of it not for the good, in my opinion (as well as by many of the locals too). A 'pseudo-privatization' model that was imposed by the new NZ government(s) in the '90s has fractured things substantially, creating more agencies trying to deliver the same types of research, products and services. Substantial frictions have predictably developed among the groups and people, making things vastly less efficient, and frankly, not much fun to work in. In essence, radiata pine breeding was 'privatized,' but in the end, the program runs much like a co-operative with government again contributing half or more of the money through a crown research competition. As expected, all the architects of the 'improvements' have ,of course, moved on to other agencies, or have been sacked themselves, and are now consultants (no humour intended) or have gone on to apply their highly destructive management approaches to other agencies. Improvement efforts with the other species are being addressed by FRI, but all the funds must be competed for externally, with most again being government funded.

For most of us, FRI was the 'Mecca' of tree breeding and many of the approaches we use today in tree improvement were first applied there in radiata pine.

However, there is still a substantial amount of intellectual horsepower in NZ for tree breeding and improvement, but a lot of this capability is spent trying to obtain funding, and on increased administration and reporting, etc. Worse yet is that there is no real mechanism left now to get the proper 'business model' back in place to deliver tree breeding and improvement the way it was or should be. In other words, the dedicated individuals who have poured their careers into these programs, have a very difficult job ahead to keep the projects alive. Luckily, we have avoided such a drastic meltdown here, but clearly we need to be cognizant that moving any closer to a more competitive funding system will not ultimately provide any improvements to the public good. They simply create new work for management structures, and create the elusion that public money is being spent more wisely.

The NZ forest industry is also suffering these days (although there was a slight boom in log sales earlier in the year), with large scale shifts in land use back to agriculture (mostly dairy), as sheep and trees just aren't 'cutting it' (no pun intended) these days. Large tracts of ~6- to10-year-old private radiata pine plantations near Lake Taupo are being knocked over, piled and burned for pasture. However, this is likely to swing back, as there is an expected overkill with lands going to dairy. The days of seeing sheep dotting the landscape as far as you can see are pretty much gone.

The actual forestry research work here is seeing much more interest in other species…

The actual forestry research work here is seeing much more interest in other species (i.e., native species being studied more for traditional genecology, propagation technologies, restoration, etc.), as well as to other minor exotics. Maori tribes are becoming quite involved in the financial aspects of forestry land ownership and management. It is very interesting to see how this has developed, relative to seeing how our efforts with First Nations' groups in BC are progressing and what the end results could look like. The Douglas-fir tree improvement co-operative did not get 'privatized' the way radiata pine did, and it is functioning well. As well, interest in Douglas-fir is growing, as there are increasing concerns about wood quality. For example, the radiata pine markets are demanding better wood quality, so a large Wood Quality Initiative (WQI) is underway, funded by the NZ government and industry. Many sophisticated pieces of equipment are now available to access hundreds, if not thousands, of samples for indirect measures of grain angle, and micro-fibril angle – traits that contribute to wood stiffness. We are behind quite a bit in this respect, but now that 'all the bugs' have been worked out of these rapid screening tools, we can capitalize on the use of them in some of our programs where wood quality is important. But over the last few months, we have uncovered more problems and the difficulty in assessing wood properties seems like it will always be a challenge for us.

Substantial improvements have been made in Australia and New Zealand in quantitative genetics in what is sometimes referred to as "Industrial Scale Genetic Evaluations," trying to emulate breeding value estimations in livestock. It is pretty safe to say we are also far behind the programs here in this respect, so we will have to do our fair share of catching up. Our Douglas-fir, hemlock and spruce programs are complex enough that we need to implement these statistical approaches reasonably soon. I attended a genetic evaluations statistical workshop in Tasmania, and we are starting to use some of these animal breeding algorithms (Average Sparsity Restricted Maximum Likelihood – ASREML) for our breeding value predictions in BC.

However, as with most things, we are ahead of Kiwis and Australians in other areas; for instance, there is almost no reference to anything on climate change (CC) in New Zealand, but every morning on Australian TV there is something about CC! The advances they have made in adopting many of the animal breeding genetic evaluation approaches, has in fact, I believe, 'hijacked' them somewhat from moving forward on considering climatic factors affecting performance of improved germplasm, or basic adaptation to dryer or warmer climates in the future. I presented a paper at an Australasian meeting in Hobart, Tasmania, on some of the work we are doing 'mapping climate effects on wood density in lodgepole pine' (co-authored with Nick Ukrainetz) and it was probably the first time many of them had even heard of a climate model. The 'panic' over CC in Australia, versus the 'small interest' in NZ, is of course due to the widespread droughts in Auz and the large forest fires. So, we again see, interest in CC is generally driven by some environmental disaster, and CC is invoked now as the cause. The simplicity is amusing.

The main project I was working on (looking at the 'evolution of genetic correlations between traits under selection') did not start off well for a few reasons; I had my passport stolen in a break and enter and a few other unfortunate pieces of luck such as my collaborators on the project having emergency personal items to deal with which put me behind as well, but I managed to get most of the main work done. Specifically, I was looking at the implications of antagonistic (negative) genetic correlations between important traits (e.g., growth and wood density), and their impact on breeding group sizes and selection strategies, using computer simulations as well as looking at some of the data here from radiata pine. The results so far are interesting and have some important implications for our programs. The challenge now is to write this up – not an easy task.

One of the objectives of the trip, as eluded to above, was to see the advances being made in Australia and New Zealand in quantitative genetics, and the application of new software for solving mixed model equations for genetic evaluations of selected parents for seed orchards and breeding. The main reason, I think, for these advances occurring here is because of the close proximity the tree breeders have to the top animal breeding schools, which we have lost in western Canada and the USA. I think this is another invaluable aspect of having exchanges with other leading groups; it is easy for us to get stuck in a few routines, or on a few issues, and important areas just continue to get overlooked. For instance, one of the interesting things developing here is to estimate 'reliabilities' of breeding values of tested parents. (Since each genotype's breeding value is estimated with different precision, orchardists and breeders do need some idea of how solid each prediction is for management and breeding purposes). Reliabilities have become very important for farmers in dairy production breeding. This specific issue aside, it has been useful to become involved in the local debate about the applications of this in tree breeding and the statistical arguments therein, and the implications and applications in our programs. Another very interesting development being locally discussed, is that the NZ Livestock Improvement Cooperative is planning on implementing 'genomic selection' entirely (i.e., no progeny testing and selections will be based completely on single nucleotide polymorphism (SNP) genetic markers). Seems hard to believe, but even if it fails, it is clear that this direction is being pursued and thought of as a serious approach to genetic improvement. We are spending millions of dollars on genomics research in BC, so it will be very interesting to see how

The 'panic' over [climate change] in Australia, versus the 'small interest' in NZ, is of course due to the widespread droughts in Auz and the large forest fires.

Specifically, I was looking at the implications of antagonistic (negative) genetic correlations between important traits… and their impact on breeding group sizes and selection strategies, using computer simulations…

this 'experiment' in animal breeding will play out. For a number of technical reasons, many of us are expecting it to fail miserably, but we shall see.

Other than these topics, a couple of the nicest attributes of NZ is the first class fly-fishing, and the incredible wine industry that has grown there. It will be hard to go back to catching little 12- to 18-inch rainbow or cutthroat trout here, after regularly getting 3- to 5-lb'ers on a five-weight fly rod. However, although the NZ wines are spectacular, many of our BC wines are equal, but for sure the Sauvignon Blancs in the Napier area are something that grow on you!

Ooops – how did that get in here?! A nice 3+ pound Mohaka River rainbow, near Napier where those 'grassy' Sauvignon Blancs come from. They grow on you quickly!!

Seed Orchard Conference in Umeå Sweden

submitted by David Reid

David Reid, Manager of Seed Production for the Tree Improvement Branch, recently attended a seed orchard conference in Umeå Sweden at the end of September 2007. Umeå, at 64 degrees latitude (Prince George is at 54 degrees) is the home of the Swedish University of Agricultural Sciences. The conference was organized by Professor Dag Lindgren and his rationale for organizing the conference was:

"Seed orchards constitute the cradle for most cultivated forests. Sometimes seed orchards are needed just to get a reliable reproducible seed supply. Seed orchards are the most important interface between forestry on one side and tree breeding and supporting research on the other. By establishing seed orchards, we create resources future generations will need: seed orchards are one tool in the fight against global warming, and better seed orchards means a better future world. Seed orchards have, through past decades, not been regarded as a new research frontier, but as a mature science. However, knowledge and experiences of seed orchards and their role and management have accumulated during the last decades. Much of these developments have been hidden, because they do not reach the fanciest journals and are a concern only for a few specialists and managers. The time has come for a conference to synthesize and debate this new knowledge. An opportunity has arisen, as seed orchards are an issue for Treebreedex, Activity 6. Treebreedex is a consortium of 28 organizations involved in tree breeding and forest genetics in Europe. Participation in the conference is, however, open to anybody interested in seed orchards. Prior to the seed orchard conference, there was a GENECAR meeting, September 23–25 at Umeå: "Application of DNA-based tools for genetic research, molecular breeding, and management and monitoring of genetic resources."

The conference was attended by 90 participants from 27 countries (see Table 1). Thirty -six lectures and 17 posters were presented at the conference. A press release was issued from the conference and appears as Figure 1. Proceedings from the conference are being developed and will be available in the future.

Table 1. Countries and number of delegates represented at the Seed Orchard Conference

Country	Participants	Country	Participants
Australia	2		
Austria	1	Ireland	1
Belgium	2	Korea	2
Canada	2	Latvia	2
China	3	Lithuania	2
Croatia	1	Norway	4
Czech republic	3	Poland	4
Denmark	3	Portugal	1
Finland	5	Rumania	1
Germany	1	Slovakia	2
Greece	1	Spain	1
Holland	2	Sweden	37
Iceland	1	Turkey	2
India	1	USA	3
TOTAL		**27**	**90**

Details can be found on the conference website at http://www-genfys.slu.se/staff/dagl/Umea07/Umea07.htm.

Background of Treebreedex can be found on their website at http://treebreedex.mediasfrance.org/pages/body/homePage.jsp.

IUFRO Business Meeting

Another important business matter arising from the conference was the re-genesis of the International Union of Forestry Research Organizations (IUFRO) Working Party for Seed Orchards. A business meeting was held and the delegates voted overwhelmingly to re-establish the working party (WP). The WP will be established in Division 2 and the number will be 2.09.01 and will be entitled "Seed Orchards." Directors were nominated and voted upon at the meeting.

The Director is Dr Kyu-Suk Kang (kangks@foa.go.kr), Korea Forest Research Institute

The Deputy Directors are:

1. Dr. Dag Lindgren (Dag.Lindgren@genfys.slu.se), Professor, Swedish University of Agricultural Sciences

Seed orchards are the most important interface between forestry on one side and tree breeding and supporting research on the other.

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The benefits of establishing seed orchards and collecting their harvest of seeds are healthier forests which are more productive and capable of taking up more of the carbon dioxide from the earth's atmosphere.

The value of seed orchards for conserva-tion of genetic diversity was recognised especially for… species which are threatened by loss of habitat, climatic change and recurrent environmental disasters such as fires.

Seed orchards were the business of an international Treebreedex conference at SLU (Swedish University of Agricultural Sciences), Umea, September 2007.

Delegates from over twenty countries concluded that the best way to ensure a steady supply of seeds for future forests is to create dedicated areas that are managed as 'seed producing orchards'. The conference organiser professor Dag Lindgren described seed orchards as the 'cradles from which generations of seeds will come to bring benefits to the forest owners, the environment and mankind'.

Seed orchards are reservoirs of genes which are passed to future generations of trees. The benefits of establishing seed orchards and collecting their harvest of seeds are healthier forests which are more productive and capable of taking up more of the carbon dioxide from the earth's atmosphere. The latest technologies to design and manage seed orchards so that they produce seeds of the highest genetic quality were discussed at the three day conference. Many technical papers described systems of seed production which can safeguard genetic diversity as well as important genetic gains. A greater use of seed orchards for generating forests will ensure that they will be productive and sustainable in a wide range of environments.

The value of seed orchards for conservation of genetic diversity was recognised especially for tree and shrub species which are threatened by loss of habitat, climatic change and recurrent environmental disasters such as fires. Delegates heard that without seed orchards of certain pines it would not be possible to restore some Greek forests which were destroyed by the forest fires of 2007. Species, such as black pine and fir trees cannot regenerate naturally after fire. Fortunately, in this case, supplies of seed are available from black pine seed orchards. More seed orchards are needed in Europe and worldwide.

Figure 1. Press release issued from conference.

Figure 2. Group photo of the Seed Orchard Conference delegates.

2. Nebi Bilir (nebilir@orman.sdu.edu.tr), Süleyman Demirel Üniversity, ISPARTA, Turkey
3. David Reid (David.Reid@gov.bc.ca), Manager, Seed Production, Ministry of Forests and Range, British Columbia, Canada.

The last IUFRO meeting where a working party on seed orchards was involved took place in 1986. [Weir B. and (editors) 1986. Conference Proceedings: A joint meeting of IUFRO WP on Breeding Theory, Progeny Testing and Seed Orchards. October 13–17, 1986, Williamsburg, Virginia.] The proceedings contain 17 papers with reference to seed orchards. It seems likely the proceedings from the current meeting will contain more papers.

It was proposed at the business meeting that a formal Working Party meeting should be held every two years, so the next formal meeting will be in 2009 and could take place in either Turkey or Greece. The rationale for Greece would be to see first hand how seed orchards are helping reforest after the devastating fires of 2007.

The IUFRO World Congress will meet in Korea in 2010, and it was voted that the Seed Orchard Working Party should also convene there either prior to or just after the World Congress, even though it will have met in 2009. The biennial interval will then be re-established with the next meeting being in 2012.

It was also voted on at the meeting to update the publication "Seed Orchards" that was printed in 1974 and edited by Roy Faulkner of Scotland under the old IUFRO WP # 2.03.3. The Director and Deputies will be updating the table of contents and then will be looking for volunteers to undertake responsibility for the content of those chapters.

IUFRO Division 2 – Physiology and Genetics: Background

Division 2 includes research on the physiology of forest trees as a whole and, more specifically, on xylem, stem, canopy and roots; on sexual and vegetative reproduction; on breeding and genetic resources of conifers and hardwoods in virtually all regions of the world; on quantitative and biological genetics of trees and tree populations, including molecular and cellular genetics; and finally on seed physiology and technology.

For more information, please go to the IUFRO website at http://www.iufro.org.

The IUFRO World Congress will meet in Korea in 2010, and it was voted that the Seed Orchard Working Party should also convene there either prior to or just after the World Congress, even though it will have met in 2009.

Whitebark Pine in Western Canada: A workshop on current research and management issues – Whistler, BC, August 22–24, 2007

submitted by A. Yanchuk, D. Douglas, E. Campbell, D. Kolotelo and S. Aitken

A three-day workshop was held in Whistler, BC this summer, sponsored by the Forest Genetics Council (FGC) of BC, the BC Ministry of Forests and Range and the University of British Columbia, to discuss research efforts in whitebark pine genetics, ecology and developments in restoration activities. Interest in the future of whitebark pine in BC is increasing, largely brought on by the mountain pine beetle outbreak and the looming uncertainty of climate change in high elevation ecosystems.

While the workshop attempted to focus on activities in BC, it was critically important to have the latest developments and experience from the United States, as much more work has been underway there of late.

While the workshop attempted to focus on activities in BC, it was critically important to have the latest developments and experience from the United States, as much more work has been underway there of late. It was terrific that Diana Tomback from the University of Colorado could attend, and she gave us an excellent overview and update in her keynote address entitled "Whitebark pine: uncertain future for the high elevation keystone species." That set the stage for a wonderful event, with talks ranging from the status of seed collections, recent findings on blister rust and mountain pine beetle mortality to the latest information on whitebark pine population genetics. Other whitebark pine researchers from the US, such as Bob Keane, Michael Murray and John Schwandt, also provided us with excellent updates on research activities and practical experiences of late in planting field trials. These presentations were critically important to the success of the meeting in our view. Thanks again to you all for travelling so far!

The Whitebark Pine Ecosystem Foundation is already doing a great job; more membership in the Foundation would assist.

The workshop speakers, titles and some of the PowerPoint presentations have recently been posted on the UBC website at http://www.genetics.forestry.ubc.ca/cfcg/pa-workshop.html.

We wrapped up the Thursday afternoon presentation session with a break-out session, which provided an opportunity for participants to discuss four key research and conservation questions. Following are the questions and a brief summary of group discussion points.

1. **What is the role of seed collections and outplantings?**
   a. Since seed collections are difficult, we should take all opportunities we can to collect as much seed as possible.
   b. If possible, collect from trees not infected by blister rust in high blister rust attacked stands, even though we are not sure how resistant these trees may actually be.
   c. More information/research on seed pre-treatment, seedling production (cost-effectiveness/production expertise), out-planting protocols (e.g., micro-site selection), site preparation, seed and seedling predation and protection is required.
   d. Additional work and strategies are needed around priority areas for seed collections, seed stratification procedures, seed longevity in storage, provenance testing approaches, blister rust screening, climate change modelling for strategic restoration activities, and the future out-plantings with respect to the slow growth of the whitebark pine and the continued threats from blister rust.
2. **How can we maintain communications among whitebark pine researchers and managers?**
   a. The Whitebark Pine Ecosystem Foundation is already doing a great job; more membership in the Foundation would assist (several BC groups have joined).
   b. Additional web utilization would be very helpful (e.g., a 'blog,' posting presentations from this meeting, and considering other ways of sharing data).
   c. More brochures, posters and other extension mechanisms should be undertaken to increase awareness of the threatened whitebark pine ecosystems in North America.
   d. Canadian whitebark pine research and conservation work should be presented at the 2010 Whitebark Pine Symposium, and also at regional forums and local forest health meetings, wherever possible.

e. Since *Pinus flexilis* is also threatened, it should be included in whitebark pine discussions.

f. Communication with industry to stop (reduce) by-catch logging of whitebark pine.

3. How do we incorporate gene conservation into restoration activities?

Two fundamental approaches were discussed.

a. Since seed collections are the only practical short-term *ex situ* approach, seed collection criteria and protocols should be developed, including a plan for geographic areas to be covered, seed banks to be maintained by the BC Tree Seed Centre, voluntary contributions to a seed bank solicited and a central seed registry maintained.

b. *In situ* approaches should include: i) continuing to catalogue range, populations, and reserves and ii) develop specific 'criteria and indicators' of status (including decline rates).

4. What are the restoration activities that could work and how to prioritize where they should be targeted?

a. We already have in our 'toolbox' some experience for starting restoration, including:

- planting (seed, seedlings, resistant seedlings)
- burning (prescribed and wildfire management)
- stand management options (e.g., thinning, fuel augmentation, pruning)
- protection (beetle: verbenone, baiting, cut and peel), fire suppression or protection to save individual trees
- attempting to monitor success.

b. We should develop a range-wide strategy for restoration (i.e., an AB, BC, US collaborative plan).

c. We should coordinate planning activities with an array of tools applied at different scales (tree, stand, watershed, landscape, region, range), with a central database of GIS layers that we could share for developing and implementing a range-wide strategy.

d. In the meantime, we should make use of documents like 'Whitebark pine in peril: A case for restoration' (Schwandt, J. 2006., USDA, Forest Service, Northern Region, R1-06-28) and 'Whitebark pine communities: ecology and restoration' (Tomback, D.F., Arno, S.F., and R.E. Keane (eds.) 2001. Island Press, Washington).

e. Since our inventory of whitebark pine is not optimal, we need to take steps to improve this.

f. We should prioritize restoration activities where whitebark pine is most imperilled (e.g., blister rust monitoring) and monitor for climate change impacts, particularly where models suggest they will be the greatest.

The last day was a field trip up Blackcomb Mountain, with several stops to see cone collection sites and techniques (Don Pigott), outplantings (Bob Brett) and blister rust survey plots (Stefan Zeglen). Bob Brett (SnowLine Research) was the field tour host, the weather was spectacular, and the discussions and the views made it a wonderful day in the mountains and in whitebark pine country. The amount of technical information exchanged, along with ideas and the outcomes of the break-out groups, was nothing short of fantastic. The meeting went a long way to rejuvenate interest in whitebark pine restoration strategies in BC, and set substantial groundwork for cooperative efforts on a Canada and US range-wide conservation strategy for whitebark pine.

(Article recently published in Nutcracker Notes *(Whitebark Pine Ecosystem Foundation), Issue No. 13: Fall/Winter 2007)*

Whitebark Pine field trip, Whistler BC.

We should develop a range-wide strategy for restoration.

Upcoming Events

Western White Pine Management Conference
Best Western Vernon Lodge
Vernon BC
June 17–18, 2008

Western white pine *(Pinus monticola)* has been decimated throughout its natural range since the introduction of white pine blister rust *(Cronartium ribicola)* to western North America. For several decades now, the selection and breeding of white pines resistant to blister rust has remained a high priority for pathologists, geneticists, and forest practitioners.

There has been a reluctance to include western white pine in reforestation plans despite its high ecological and commercial values to forestry in BC. However, high survival rates of genetically improved, blister rust-resistance stock and impressive growth yields have been demonstrated which now warrants us to 'rethink' our desire to manage this species.

This workshop will provide silviculturalists opportunities to learn information on a wide range of topics including: the autoecology of western white pine, wood properties and utilization; the biology of the fungus and the history of rust in BC and US; advances in genetic resistance of western white pine and the status of the resistance breeding programs in the US and Canada; growth and yield results from operational research trials; and management strategies for western white pine, now and in the future. Registration information can be found at http://www.for.gov.bc.ca/rsi/ForestHealth.

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IUFRO – CTIA 2008 Joint Conference
Adaptation, Breeding and Conservation
In the Era of Forest Tree Genomics and Environmental Change
August 25–28, 2008
Loews Le Concorde, Quebec City

For conference details and registration go to http://www.iufro-ctia2008.ca/index.php?id=40

FNABC (Forest Nursery Association of BC)
September 8–11, 2008
Sheraton Guilford Hotel
Surrey, BC

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TIC*talk* Availability

TIC*talk* is available in electronic format at http://www.fgcouncil.bc.ca/new-tict.html.

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