TIC*talk*

FGC Forest Genetics Council of British Columbia

Information for and from the tree improvement community of British Columbia

Diane Douglas, Editor

Vol. 11 April 2012

Eleventh Edition

Welcome readers to the 11th edition of TIC*talk*. This newsletter contains a range of articles that reflect the diversity of British Columbia's tree improvement and seed management communities. This newsletter is intended to compliment the Forest Genetics Council's annual report and annual project plans without the formality and structure. So, I won't repeat the key messages and highlights mentioned in the aforementioned publications, which are available on-line at: http://www.fgcouncil.bc.ca/

A hundred years has passed since the BC Forest Service was established under the first *Forest Act* and led by the first provincial chief forester, H.R. MacMillan. Please visit the BCFS100 website referenced in the first article for more information. However, with the formation of a new ministry and the integration of natural resource agencies and staff, it remains unclear if the Forest Service and its iconic logo will persist for much longer. None-the-less, the work conducted by Forest Service staff in tree improvement, seed production and management, will continue despite changes to ministry names and logos. I expect staff dedication and passion will remain high, as evidenced by their articles submitted to this edition.

Several articles are technical in nature – information about cone and seed pests and their management, new stratification techniques for yellow cypress, and rooting techniques for Douglas-fir. This edition also includes updates on the History of Tree Improvement project, SelectSeed orchard production, Climate-based Seed Transfer, and the Whitebark Pine Ecosystem Foundation.

Of note, is an article by Dr. John Russell on the scientific renaming of yellow cypress (cedar) to *Callitropsis nootkatensis*. It reminds me of films of heavy suited, grey-bearded Victorian fellows discussing scientific discoveries within chambers of the Royal Society. This, apparently, still happens – minus the chops and top hats.

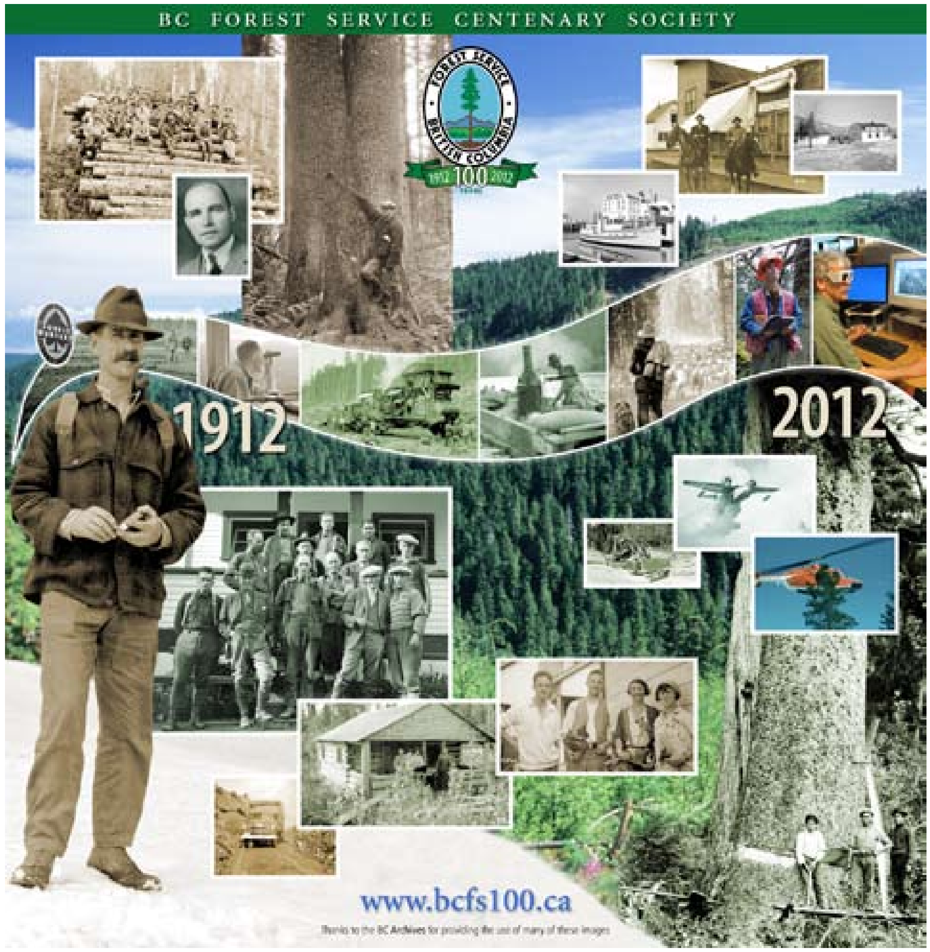
Barry Jaquish's travelogue on Iceland, forestry and larch is also a delightful read. Iceland was once covered in forests and thanks to climate change (again) and assisted migration, they are returning. Fortunately, a few persons within our community (besides Dr. Yousry El-Kassaby ☺, who was recently honoured by the Czech Republic, p 46) will also be able to travel overseas this year. Next edition should therefore include more travel stories and photos. One international excursion that is within reach of most is the combined meeting of the BC and Northwest Seed Orchard Managers Associations in Port Angeles/Victoria this June. See Events on p. 46 for more details.

I hope you find this edition informative and entertaining. I've asked the Extension TAC to review TIC*talk*'s format to make future editions also attractive to our stakeholders and clients (i.e. to increase readership). Your feedback and suggestions would also be helpful.

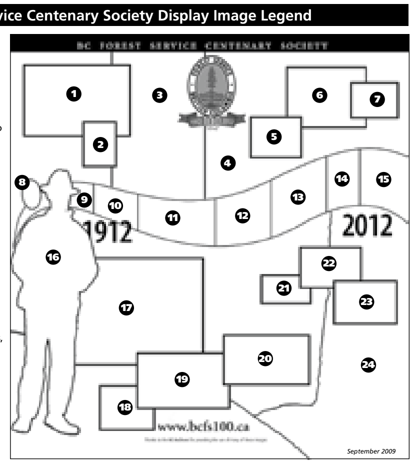
Many thanks to the article contributors. Wishing you all a happy and productive year.

Brian T Barber, RPF
Director
Tree Improvement Branch

INSIDE



BC Forest Service Centenary Society Display Image Legend



1 District officers at Ranger meeting, Aleza Lake Experimental Station
Barr, 1928

2 Harvey Reginald ("HR") MacMillan was a Canadian forester, forestry industrialist,wartime administrator and philanthropist.Born in Newmarket, Ontario, he graduated from the Ontario Agricultural College in 1906 with an honours degree in biology. He obtained a Master of Science degree in Forestry at Yale University in 1908. In 1912, he was appointed first Chief Forester of British Columbia, and in that capacity he established the British Columbia Forest Service.

3 Mature white pine on Big Sheep Creek. Rossland Forest Reserve
A.E. Collins, 1926

4 Background image – southern interior region
Zibgnew Olak, 1988

5 Forest Service Launch "Wells Gray" Forest Service Marine Station, Southlands, Vancouver
P.W. Johnson, Sept 1948

6 W.A. Grainger and J. Latham on Inspection Trip Hazelton district
W.A. Grainger, May 1914

7 Forest Ranger Station and Garage – McBride
E Druce, February 1951

8 Sign on the highway at Green Timbers Nursery near New Westminster. Vancouver Forest District
M.W. Weatherby, February 1940

9 Lifting 1-1 Sitka spruce in Block 19 Green Timbers Nursery
Gormely, March 1932

10 A Lookout man in his tower Little Mountain
Weatherby, June 1941

11 120 ton skidder "unit" operating 13 tons of line. 75 ton Climax "loco" in foreground. West fork, Camp 6. Industrial Timber Mills Cowichan Lake
A.P. MacBean, July 21, 1937

12 Steam boating in the Wilds. These men have built a small steam boat on a mountain lake that works very well. The hull is made of planks sawed by hand (Whipsaw) and the power is supplied by a small boiler that was transported along a mountain trail on a go-devil after a great deal of labour. The propeller shaft and other metal fittings were likewise carried. The boat is used for towing logs and carrying supplies to the logging camps on this lake, Humamilt Lake, BC
G P Melrose

13 Herd of 2700 sheep en route to summer feeding grounds via Meadow Creek 1931

14 Todd Manning surveying wildlife trees in Metchosin
Tim Mock, 2002

15 Roman Bilek, (BC Ministry of Forests and Range, Forest Analysis and Inventory Branch) mapping the forest inventory using a Digital Stereo Viewer
Ann Morrison, 2009

16 Forest Service Ranger Pym at the top of Mount Moyie, Cranbrook District
A. T. Wilkinson, June 1924

17 Forest Service Prince George Rangers and others at Ranger Meeting. Aleza Lake Experiment Station, 1928. Front Row – Sanson, Langmuir, Lowry, Dr. Laishley (Giscome), Kerkhoff. Second row – Norman, Faherty, Mathieson, Wilson, Orchard. Back row – Forbes, Hunter, Russell

18 Forest Service transport truck used in transporting men and materials to the Gordon River planting area
R. Golding, 1953

19 Adams Lake Ranger Station, Depot Camp Kamloops district
G P Melrose

20 Pathologists at Cowichan Lake Experimental Station – Misses: Irene Mounce Maude Allen and W. R. Foster with J. D. Curtis, August 1932

21 Road grader at work, constructing forest access road, Adams Lake (Building forest access road Adams Lake)
P Johnson, 1951

22 Grumman goose equipped with 2 fifty gal. rotary tanks water bombing in simulated fire fighting.
Pilot Dan McIvor, Sproat Lake
B Davies, May 8, 1959

23 Helicopter used to collect scion wood for grafting in Tree Improvement program, MFR, near Fort Saint James in the late 1970s. *FS photographer*

24 Cutting a Sitka Spruce in the Queen Charlotte Islands

February 27, 2012

British Columbia celebrated a truly significant milestone: the centennial birthday of the BC Forest Service.

One hundred years ago today, the Province created the first government agency to preserve B.C.'s forests through forest fire prevention, use of timber management areas, tree planting and the diversification of tree-growing.

Since Feb. 27, 1912, the BC Forest Service has been in charge of managing and protecting the province's forests and range lands. The dedication and hard work of the men and women of the BC Forest Service have resulted in 100 years of excellent forest stewardship in British Columbia.

http://www.newsroom.gov.bc.ca/2012/02/bc-forest-service-celebrates-100-years-of-excellence.html

A New Conifer Species Affects Taxonomic Classification in the Cupressaceae

submitted by John Russell

The discovery of a new conifer species and its subsequent phylogenetic description has had significant and controversial impacts on classification within the Cupressaceae including yellow cypress (formerly known as *Chamaecyparis nootkatensis)*. In this article I will outline the cause of this disagreement and how it is influencing the taxonomic classification of the new world cypresses including yellow cypress, for which I will refer to by various genera as it was then commonly accepted.

In the fall of 1999 a new conifer species was found in a moist forest on limestone karst ridges in northern Vietnam. This species had a morphological resemblance to others in the Cupressoideae subfamily of the Cupressaceae especially *Chamaecyparis* and *Cupressus*. However after a thorough morphological description, the conifer was distinct enough to warrant a new genus and species, and was given the new scientific name *Xanthocyparis* (xantho=yellow, cyparis=cypress) *vietnamensis* Farjon & Hiep (Farjon et al. 2002) with the common name of Vietnamese golden cypress. The most distinct morphological feature of this species is the occurrence of juvenile, intermediate and mature foliage in the upper crown (Farjon et al. 2002*)*. Upon closer examination including molecular data, a number of authors placed *Chamaecyparis nootkatensis* as a sister taxa. Morphological similarities included seed cones with 4 (to 6) bract-scale complexes (Farjon et al. 2002), apically distributed ultimate branchlets and externally dimorphic mature leaves (Farjon et al. 2002, Little et al. 2004). It was proposed initially by Farjon et al. (2002) that *Chamaecyparis nootkatensis* be renamed as *Xanthocyparis nootkatensis.* This genus name was later disputed by Little et al. (2004) in which they proposed the name *Callitropsis* for both species – more on this later.

Chamaecyparis nootkatensis has had an interesting taxonomic past being first placed in *Cupressus* in 1824, and later transferred to *Chamaecyparis* in 1842 (Little et al. 2004). To complicate matters further, Orsted created the monotypic genus *Callitropsis* in 1865 for *Chamaecyparis nootkatensis* because of the somewhat unusual ovulate cone configuration; however this classification did not catch on (Little et al. 2004, Mill and Farjon 2006). Recently, new molecular evidence from Gadek et al. (2000) indicated that *Chamaecyparis nootkatensis* was closely related more to the genus *Cupressus* *(http://en.wikipedia.org/wiki/Cupressus)* than to *Chamaecyparis.* There was also growing evidence that showed the species was unique within the *Chamaecyparis* including duration of seed maturation, seed wing anatomy, wood anatomy and secondary chemistry, fertilization and low cross-compatibility of microsatellite primers among others (citations in Little et al. 2004). *Chamaecyparis nootkatensis* also hybridizes with a number of *Cupressus* species (e.g. Leyland cypress); however there are no documented hybrids with other *Chamaecyparis* species. We have been hybridizing *Chamaecyparis nootkatensis* with both *Chamaecyparis* and *Cupressus* species over the years at *Cowichan Lake Research S*tation and in New Zealand and have had success only with the latter genus.

This leads us to the dilemma of naming *Chamaecyparis nootkatensis.* Compelling evidence has shown that this species is a sister taxa with *Xanthocyparis vietnamensis* (Farjon et al. 2002, Little et al. 2004, Mill and Farjon 2006, Little 2006) coupled with the above evidence that it is unique within *Chamaecyparis*. Farjon et al. (2002) correctly placed both species in a new genus since they were clearly distinct from those in *Cupressus* and *Chamaecyparis*. However it seems that taxonomic precedent favours *Callitropsis* under the rules of the International Code of Botanical Nomenclature (http://en.wikipedia.org/wiki/International_Code_of_Botanical_Nomenclature), as the earlier-published name has priority over *Xanthocyparis* if that genus includes *Chamaecyparis nootkatensis* (Little et al. 2004).

A proposal was put forth by Farjon and others at the 2011 International Botanical Congress to use *Xanthocyparis* but it did not make it to the committee that decides on taxonomic conflicts. Essentially that leaves *Callitropsis* as the genus name we should now use, so following Little (2006) the new scientific name for yellow cypress

Essentially that leaves *Callitropsis* as the genus name we should now use, so following Little (2006) the new scientific name for yellow cypress is *Callitropsis nootkatensis.*

Given that it is now closely aligned with cypress species and that the description as a false cedar using a hyphen[1] is rather outdated, and yellow is an apt description for its heartwood colour, then yellow cypress seems appropriate.

is *Callitropsis nootkatensis* (D. Don in Lambert) along with its sister taxa *Callitropsis vietnamensis (*Farjon&Hiep).

The Cupressaceae taxonomic controversy doesn't end here. Little (2006) states that "classifications within the Cupressoideae have been contradictory as a result of taxonomically incomplete intuitive analyses combined with an emphasis on characteristics of ovulate cones to the exclusion of vegetative, anatomical, and chemical characteristics". Little also presented exhaustive evidence supporting that the New World species of *Cupressus* are more closely related to *Callitropsis* than they are to the Old World *Cupressus* species. Little proposes to restrict *Cupressus* to the Old World species and to expand *Callitropsis* to include New World species currently classified as *Cupressus*. Species from *Juniperus* and *Chamaecyparis* would still be recognized separately. Although compelling, this reclassification is currently not universally accepted mainly because the relationship between *Callitropsis nootkatensis*, *Callitropsis vietnamensis* and the New World species of *Cupressus* has not been resolved. Little (2006) states that this may change in the future based on research currently underway involving additional character data.

On a less significant note, the common name of *Callitropsis nootkatensis* is also being debated. The species has been known under a number of common names including yellow-cedar, Nootka cypress Alaska-cedar and yellow cypress. Given that it is now closely aligned with cypress species and that the description as a false cedar using a hyphen[1] is rather outdated, and yellow is an apt description for its heartwood colour, then yellow cypress seems appropriate. This common name has been used in British Columbia for quite some time along with yellow-cedar.

1. True cedars (*Cedrus* spp.) are in the Pinaceae and convention dictates that any common name referring to a false species should have a hyphen or be one word (e.g. Douglas-fir, western redcedar).

Literature Citation

Gadek, P.A., Alpers, D.L., Heslewood, M.M. and Quinn, C.J. 2000. Relationships within Cupressaceae sensu lato: a combined morphological and molecular approach. Amer. J. Bot. 87:1044-1057.

Farjon, A., Hiep, N.T., Harder, D.K., Loc, P.K. and Averyanov, L. 2002. The new genus and species in Cupressaceae (Coniferales) from northern Vietnam, *Xanthocyparis vietnamensis*. Novon. 12: 179-189.

Little, D.P. 2006. Evolution and circumscription of the true cypresses (Cupressaceae: *Cupresssus*). Systematic Botany. 31:461-480.

Little, D.P., Schwarzbach, A.E., Adams, R.P. and Hsieh, C.F. 2004. The circumscription and phylogenetic relationships of *Callitropsis* and the newly described genus *Xanthocyparis* (Cupressaceae). Amer. J. Bot. 91: 1872-1881.

Mill, R.R. and Farjon, A. 2006. Proposal to conserve the name *Xanthocyparis* against *Callitropsis* Öerst. (Cuppressaceae). Taxon. 55: 229-231.

Figure 1. Yc drawing by Jodie Krakowski.

Tree Seed Working Group News Bulletin. No. 54. December 2011

http://www.for.gov.bc.ca/hti/publications/tswg/TSWGNewsbulletin54.pdf

Page 4 - A New Conifer species affects taxonomic classification in the Cupressaceae by John Russell.

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New Stratification Procedure for Yellow Cypress

submitted by Dave Kolotelo

A new stratification procedure for yellow cypress (*Callitropsis nootkatensis*) has been introduced for testing and seed pretreatment at the Tree Seed Centre (TSC). The new pretreatment extends the soak duration from 48 to 72 hours and extends cold stratification from 56 to 77 days. New germination results are available on SPAR with a G57 test code and the test specifics are presented below for lab testing and seed preparation (Table 1).

	Testing	Seed Preparation
Soak	►72-hour running water soak	►72-hour running water soak
Warm Stratification	►28 days at 20°C on Accelerated Aging trays in closed germination dishes ►Monitored 3X weekly for moisture levels with misting if any seed coat drying is observed	►28 days at 20°C in plastic bags with an absorbent media covering ►Moisture content targeted to 44%, seed agitated and weight monitored 3X per week. Moisture misted onto seed if weight is reduced or drying is observed
Cold Stratification	►77 days at 2-5°C on Accelerated Aging trays in closed germination dishes ► Monitored initially 3X week for moisture levels and then weekly after no seed coat drying is observed	►77 days at 2-5°C in plastic bags with an absorbent media covering ► Moisture content targeted to 44%, seed agitated 2X per week and weighed every two weeks. Moisture misted onto seed if weight is reduced or drying is observed

Table 1. An overview of pretreatment details for yellow cypress (YC).

The long soak and subsequent moisture content monitoring and maintenance at high levels are critical to successful pretreatment. That has been a consistent observation from everyone who has been successful germinating the species. The long soak duration ensures adequate moisture is absorbed through the megaspore membrane and the cuticle of the megagametophyte which were found to be the most important structures restricting moisture uptake. The waxy seed coat itself was not a significant factor restricting water uptake (Tillman-Sutela and Kauppi 1998).

The extension of cold stratification is considered the major factor resulting in overcoming dormancy and increasing germination capacity. In previous trials, cold stratification was extended up to 119 days, but this unfortunately resulted in large numbers of pre-germinated and unproductive seed. The extension of cold stratification to 77 days is considered beneficial in substantially increasing germination and not increasing the risk of pregermination even with an additional few weeks delay in sowing at the nursery.

Forty one seedlots were tested with this new G57 pretreatment and an average gain in germination of 17.3% was obtained. Four of the seedlots were out of tolerance and require retesting and an additional 12 seedlots were not tested as they are quite small (all <60 grams and <2000 potential seedlings). Seed owners can expect similar gains in germination for these small seedlots and owners are encouraged to review their seed inventories and use these small lots or consider donating them to the provincial seed bank for genetic conservation purposes. Please contact me directly if you wish to donate seed to the provincial seed bank.

References

Tillman-Sutela, E and A. Kauppi. 1998. Structures restricting passage of water in the mature seeds of yellow-cedar (*Chamaecyparis nootkatensis*). Can. J. Bot. 76:1458-1466.

New stratification procedures for yellow cypress are being introduced for testing and seed pretreatment at the TSC.

Provenance Trials Help Refine Forest Growth Models

submitted by Greg O'Neill and Gord Nigh

Climate change is expected to have a significant impact on forest productivity.

Climate change is expected to have a significant impact on forest productivity. Accurate estimates of future forest growth are needed in order to continue to manage forests sustainably. Provenance tests are ideally suited to assist with this task because they contain many thousands of mature trees growing across a wide range of climates. In addition, the trees are exposed to many natural soil, wildlife, insect, pathogen and microbial factors, as well as extreme and variable climate events that can affect growth, and that nursery, growth chamber or greenhouse trials seldom see.

Transfer functions which relate provenance growth to climate transfer distance have been used to predict impacts of climate change on forest growth for almost 20 years, however, they predict changes to growth *rate* at a single point in the future (e.g., in 70 years or when the climate is 3° C warmer). Timber supply analyses need estimates of cumulative impacts of climate change on future timber volumes.

To better represent changes to forest productivity as climates gradually change, we have developed a method of dynamically merging transfer functions with height–age functions (i.e., site index curves) that drive forest growth models such as TASS. Our simulations with data from the Illingworth lodgepole pine provenance trial suggest that climate change will reduce production in lodgepole pine forests established today by at least 7–13% at the end of this century – considerably less than most predictions based solely on transfer or response functions, which do not integrate impacts as climate gradually changes.

The next phase of this project will refine the model to incorporate impacts of climate change on survival, and will allow both site and provenance climate to be included as variables in the model. These refinements will enable examination of the impacts of assisted migration on forest production, and may be used to identify seed sources expected to be most productive at a given location.

For more information on this project, please contact Greg O'Neill or Gord Nigh.

O'Neill, G.A. and Nigh G. 2011. Linking population genetics and tree height growth models to predict impacts of climate change on forest productivity. Global Change Biology 17: 3208–3217. doi: 10.1111/j.1365-2486.2011.02467.x

To better represent changes to forest productivity as climates gradually change, we have developed a method of dynamically merging transfer functions with height–age functions (i.e., site index curves) that drive forest growth models such as TASS.

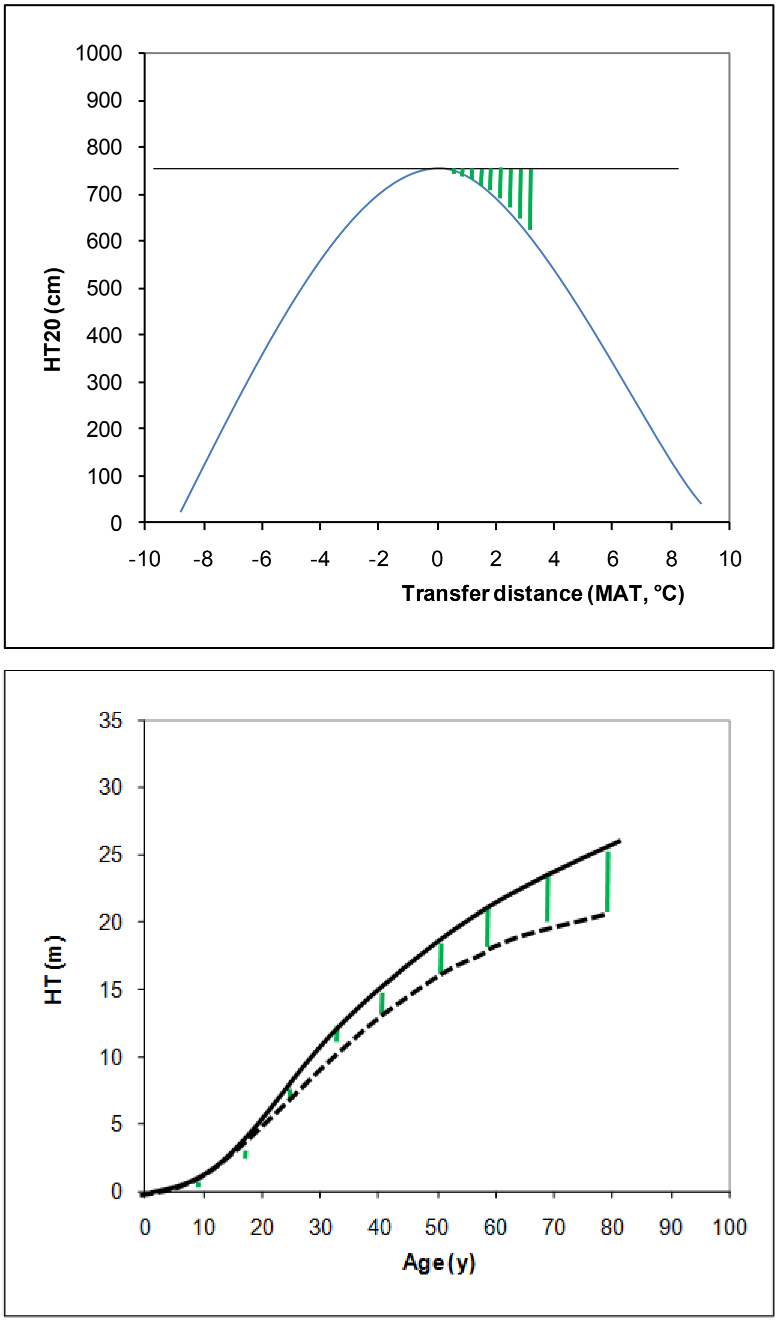

Figure 1. Schematic of transfer function showing the effect of seed transfer distance on height growth (top figure). Vertical bars represent the impact of climate change on height. In the bottom figure, a site index curve (solid line) is adjusted annually using climate change impacts on height to develop a climate-sensitive site index curve (dashed line). Climate-adjusted site index curves capture the gradual and cumulative impact of climate change, for use in climate-sensitive forest growth models.

Rooting of Cuttings from 10-year Old Coastal Douglas-fir

submitted by Keith Bird, Lisa Hayton and Michael Stoehr

An alternative to grafting is the rooting of cuttings, which presents its own problems in Douglas-fir: low rootability with age and topophytic (positioning and age) effects in the growth form observed after rooting., i.e., if the scion were taken from a lateral branch, the rooted cutting may keep growing in a horizontal fashion.

Introduction

Forward selections in coastal Douglas-fir in BC are made between the ages of 10 to 15 years. The general practice is to graft the scions on to graft compatible root stock. Two potential problems are associated with this practice: First, despite the use of compatible root stock, graft incompatibility can still be apparent in later stages of ramet development at times after seed production in the orchard commenced. Secondly, graft compatible root stock is at a premium and demand may be higher than the yearly supply due to small number of specific parental crosses that yield graft-compatible root stock. This is especially prevalent in years of orchard expansions and/or years of selections. An alternative to grafting is the rooting of cuttings, which presents its own problems in Douglas-fir: low rootability with age and topophytic (positioning and age) effects in the growth form observed after rooting., i.e., if the scion were taken from a lateral branch, the rooted cutting may keep growing in a horizontal fashion.

Through the use of a factorial study, we attempt to identify the most promising treatment combinations for successful rooting of scions taken from trees at age 10. The following factors were investigated: Donor genotype (clone), scion collection position along the crown of the tree, collection date and rooting hormone composition.

Material and Methods

Scions were collected from 10-year old full-sib trees growing in a family block test at North Arm near Cowichan Lake Research Station. Ten different full-sib families were selected (none of the parents in common) and the tallest tree within the selected families was used as donor. The donor trees (ortets) are about 8 m tall and were stratified into two zones for collections, a lower, and upper zone. Roughly 10 cm long lateral branches and sub-terminal lateral shoots were used as scion material, with the bottom 5 cm of needles plugged off. At each collection date, 24 cuttings were collected per zone. The collection dates are: mid-December, mid-January and mid-February.

We used two liquid, commercially-available, rooting hormones: Hormone 1 was Stimroot 10000 (1% IBA (indole-3-butyric acid at full strength, Plant Products Co.), Hormone 2 was a 1% IBA/0.5% NAA (naphthalene acedic acid, (Westgro Products)) mixture. Cuttings were dipped into the rooting liquid for 5 seconds before being randomly planted in Spencer-Lemaire “Rootrainers” (Hillsons 170-4) (Beaver Plastics) filled with regular nursery potting soil (peat:perlite). All cuttings were placed in a heated greenhouse with repeated misting cycles. During each collection date, a total of 480 cuttings were set (10 clones x 2 collection zones x 2 hormone treatments x 3 blocks x 4 cutting/clone). After two months in the misting environment, cuttings were moved into a heated greenhouse prior to assessment. Rooting was assessed 3 months after setting the cuttings. Rooting success was expressed as percentage across identical experimental units (i.e., average across the 4 cuttings from the same clone, taken from the same zone on a tree and treated with the same hormone in the same block). After assessment, rooted cuttings were potted in 1 gal. pots and placed in an unheated greenhouse for further development. In the mid-summer they were moved outside and kept there over the winter.

Rooting data were analysed over the three collection dates using replication means in the fixed-effect ANOVA after rooting percentages were transformed using the arcsin transformation.

Results and Discussion

Significant differences due to clone and rooting hormone, but not in the zone of collection, were observed in the analysis (details of ANOVA not shown). The large levels of genetic or clonal variation observed in rootability ranged from 5.5% to 40% over all treatments and collection dates (Figure 1a). Similarly, the application of rooting hormone affected rootability significantly with Hormone 2 being the more successful treatment (Figure 1b). Zone or location of scion collection along the tree did not affect rootability (Figure 1c). Collection date, although not testable in the analysis, affected rootability, with the December collection being the most successful (Figure 1d).

Two interactions were significant. In general, scions collected in December rooted best for 8 out of the 10 clones, for two clones (826 and 1057), the February collection rooted best (Figure 2a). Furthermore, Hormone 2 yielded better results for nine clones, Hormone 1 was better for clone 1420, causing this statistical interaction in the clone by hormone treatment combination (Figure 2b). Higher order (three-way and higher) interactions were not tested.

What do the results mean and can we incorporate the rooting as a means to enhance vegetative propagation success of our juvenile selections? The high level of clonal or genetic variation in rootability was expected. In practical terms, this means that we do not know ahead of time which selection would be amenable to rooting and which not. The interaction of clones with date of collection and clone with hormone complicates matters even more as we do not know beforehand how individual clones will behave. However, if candidate clones, say based on year 7 height analysis, are identified and exposed to the best treatment combination (in this case scions collected in December and treated with Hormone 2), we will know which clones must be grafted (as their rootability is very low) and which clones we could propagate via rooting of cuttings. This information could strategically be used to allocate compatible root stock for grafting at age 11 or 12 when final selection would be made. However, before we can entertain this strategy we must wait to the spring, when we will evaluate any potential topophytic effects on the growth pattern of the rooted cuttings growing in the outdoor compound.

What do the results mean and can we incorporate the rooting as a means to enhance vegetative propagation success of our juvenile selections?

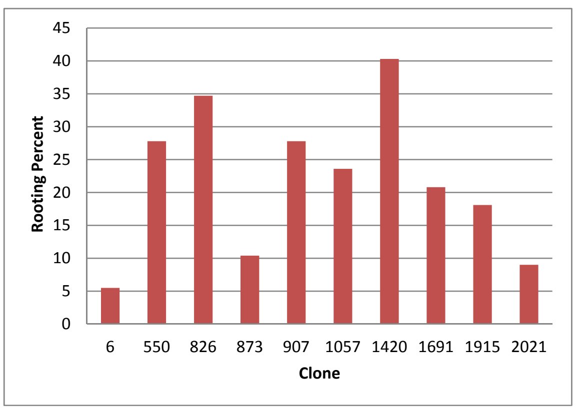

Figure 1a: Rooting percent as affected by donor clone

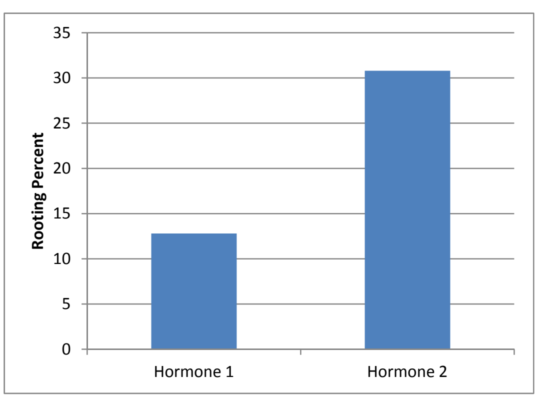

Figure 1b: Rooting percent as affected by rooting hormone

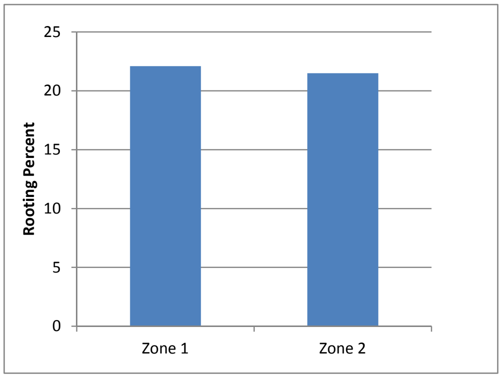

Figure 1c: Rooting was not affected by location of scion collection within the crown.

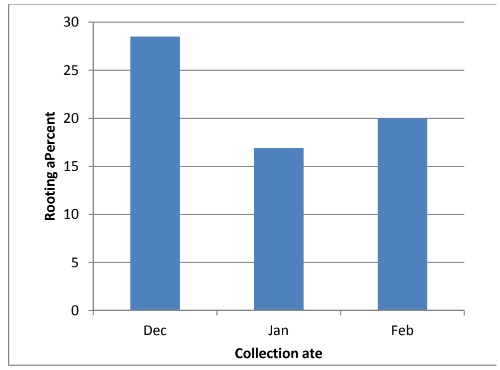

Figure 1d: Best rooting was observed in December collections.

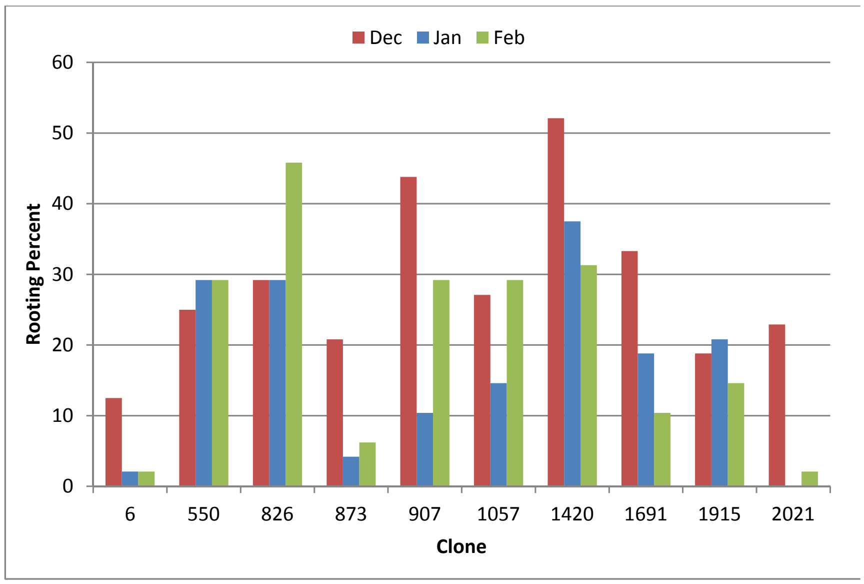

Figure 2a: Not every clone reacted the same way to collection date.

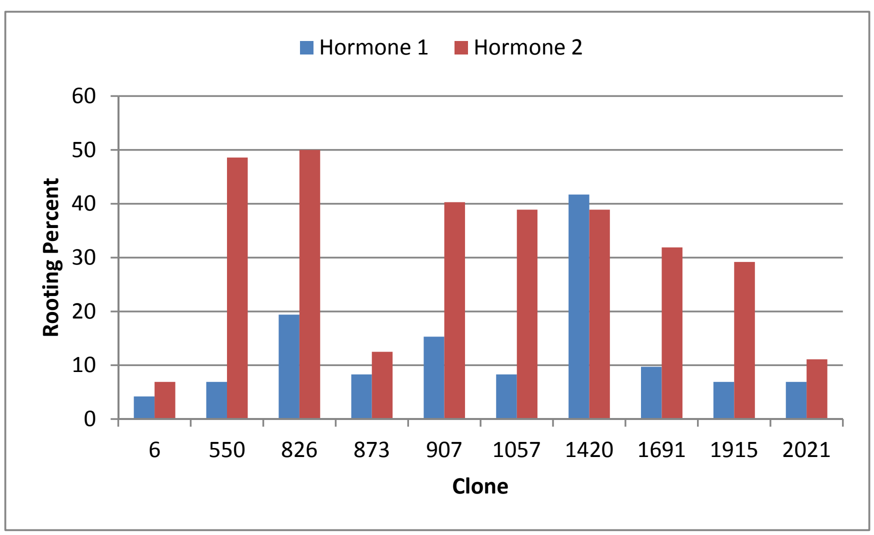

Figure 2b: Hormone 2 was generally more successful except for clone 1420.

Western Larch in Iceland: Early Growth and Survival in a Treeless Land

submitted by Barry Jaquish and Throstur Eysteinsson

Over the last decade the effects of global climate change on species distributions and ecosystem stability has emerged as a preeminent issue facing land managers worldwide. Scientific journals are teeming with climate change discussion papers, letters to editors and research results from the modeling of ecosystem and species' distributions on a climate basis. Global circulation models and their various scenarios have been widely used to make predictions of species and population responses to future climates. However in most jurisdictions, forest legislation, policy, planning and operational practices that attempt to provide forest resources for human consumption, achieve sustainability goals and mitigate the effects of climate change are in their formative stages.

In central British Columbia, mountain pine beetle has had devastating effects on local forest ecosystems and forestry based communities, and its recent outbreak has been linked, in part, to climate change. Local forest managers hope to mitigate the effects of climate change and achieve long-term ecosystem sustainability by increasing forest complexity through enhanced species diversity and a diversified stand structure. One approach to enhancing species diversity is to expand the planting of adapted non-local tree species. Based on good survival and growth performance in small-scale operational and research plantings, western larch (*Larix occidentalis* Nutt.) has been identified as a candidate species for introduction. However, prior to accepting western larch as an acceptable species for planting in the central Interior, research was needed to: 1) delineate lands that might be climatically suitable for western larch, and 2) identify seedlots that would be genetically adapted to these sites.

Initially, Rehfeldt and Jaquish (2010) used climate, inventory and ecological data to develop a regression tree model that predicted the presence and absence of western larch in western North America. Predictions from the model closely agreed with the current distribution of western larch. Genetic data from range-wide western larch provenance tests in BC and Idaho were also used to construct maps of genetic variation for growth and adaptive traits. Finally, global circulation models and the genetic maps were used to predict western larch's future climate space subdivided into zones of adaptive genetic similarity. From these projections, management strategies were proposed to guide the conservation and deployment of western larch in the face of climate change.

Results from the work were reviewed by a multi-disciplinary panel and in June 2010, the B.C. *Chief Forester's Standards for Seed Use* were amended to expand the seed transfer limits of western larch outside of its natural distribution. While the new amendments were based on these combined climate and genetic models, attempts are ongoing to validate the new zones by locating, viewing and documenting western larch trial plantings outside of its natural range. The majority of the trial plantings of western larch are located in BC, but occasionally western larch has been planted far outside of its natural range.

In January 2010 Throstur Eysteinsson (Division Chief, National Forests; Iceland Forest Service) provided nine-year growth and survival results from a western larch provenance trial using twenty B.C. seedlots in Iceland. The arrival of these results was serendipitous in that we were searching for exotic plantings of western larch to help validate the new climate-based seed zones and transfer rules. Since my wife and I were yearning for an exotic holiday, we quickly arranged an excursion to Iceland to view the diverse volcanic landscape, experience the Icelandic culture, and view the planting of western larch far outside of its natural range. This note, which is part travelogue and part forestry, recounts some of the journey. It provides some information about Iceland and its forests – yes, they exist - and presents the early growth of 20 B.C. populations of western larch in Iceland.

Since my wife and I were yearning for an exotic holiday, we quickly arranged an excursion to Iceland to view the diverse volcanic landscape, experience the Icelandic culture, and view the planting of western larch far outside of its natural range.

Forestry officially started in Iceland in 1899 with the planting of an exotic pine stand at Thingvellir, the site of Iceland's first parliament in 930 AD.

Introduction to Iceland

Although the eruption of the volcano Eyjafjallajökull[1] in spring 2010 caused apprehension for travellers and created general chaos in Europe, we landed safely at Keflavik about 50 kilometres southwest of Reykjavik, the world's northernmost (64° N latitude) capital of a sovereign state (Plate 1). The island of Iceland is about 1/10 the size of B.C. and is sparsely populated by about 320,000 people, 65 percent of whom live in the greater Reykjavik area in south-western Iceland (Plate 2). Geologically, Iceland is located atop a mantle plume along the Mid-Atlantic Ridge where the Eurasian and North American plates adjoin (Plate 1). The island was created largely through rifting between the two plates and heavy volcanic accretion. Iceland is the only point where the Mid-Atlantic Ridge emerges above sea level. The climate is classified as sub-polar Oceanic and the landscape is dominated by volcanoes, thermal vents, geysers, hot pools, glaciers, lava beds, waterfalls, small mountains and a vast dry interior desert (Plates 3 – 7).

Upon landing at Keflavik the first thing we noticed was that there were no trees, just barren lava fields and vast fields of flowering Nootka lupine (*Lupinus nootkatensis*), an exotic plant that was introduced to Iceland in the late 1800s and has since become highly invasive in the fragile, highly disturbed Icelandic landscape (Plate 8 and 9). Also, it wasn't very warm for the end of June and it was light 24 hours a day. Given the high latitude and cool temperatures of Iceland, one assumes that the climate is simply too cold for forests. This notion is reinforced when you see the native forests, which consist mostly of very short and crooked downy birch (*Betula pubescens*), low growing willows (*Salix spp.*) and rare (seven known locations) samples of aspen (*Populus tremula*) (Plates 10 and 11).

Forest History of Iceland

Like most high latitude regions in the Northern Hemishpere, the mid-to-late Tertiary (5-15 million years ago) Iceland had a warm temperate climate and was covered with Arcto-Tertiary forest consisting of taxa such as *Sequoia*, *Magnolia*, *Sassafras* and *Fagus*. By the late Pliocene (3-5 mya), seismic activity, a cooling climate and repeated glaciations had reduced this rich Arcto-Tertiary flora to a Boreal flora consisting mostly of conifers (*Pinus, Larix, Picea, and Abies*) and a few broadleaf taxa (*Alnus and Betula*). Succeeding Pleistocene glaciations further reduced the flora to the point where at the time of human settlement (about 1140 years ago) 25-40 percent of Iceland was covered with short birch forests.

As with most agrarian societies, the early settlers harvested the birch forests to create fields and grazing land for sheep, which by year 1300 had become a staple source of wool and food for the native Icelanders. The birch forests also served as a source of fuel-wood, building material, livestock fodder and, most importantly, charcoal that was used for smelting iron and making steel tools. Houses of these early settlers were constructed mostly of stone and sod (Plate 12) and rural homes remained modest and multi-functional until the mid-1900s (Plate 13). The deforestation of the short birch forests continued until the middle of the 20th century and by about 1950, the extent of the birch forests likely reached a post-glacial minimum of less than one percent of the land base. Today, the remnant birch forests are important for recreation and as a legacy of the woodlands that once covered much of Iceland. Unfortunately, today's intense summer sheep grazing pressure prevents any natural extension of the native birch forests outside of protected areas.

Forestry officially started in Iceland in 1899 with the planting of an exotic pine stand northeast of Reykjavik at Thingvellir, the site of Iceland's first parliament in 930 AD (Plate 14). The first Forestry and Soil Conservation Act was adopted in 1907 and the Iceland Forest Service (IFS) was established in 1908. Early forestry efforts focused largely on protecting the remnant birch forests and field testing exotic tree species. In the early 1950s the emphasis of the IFS turned to afforestation with exotic coniferous tree species, mainly *Picea abies, Picea sitchensis, Pinus sylvestris, Pinus contorta and Larix sibirica*. Between 1963 and 1990 approximately 1 million trees were planted annually and by 2005, the annual planting numbers had increased to over 6 million, mainly *Larix sukaczewii, Picea sitchensis, Betula pubescens* and *Pinus contorta.*

1 In Icelandic, "Eyja" refers to an island, while "fjall" and "jökull" refer to mountains and glacier, respectively. Many of these long, complex scrabble-like Icelandic words that seem so unusual and unpronounceable to North Americans simply describe a location or feature.

Up to 1990, tree planting was split evenly between the IFS on productive Forest Service lands and a number of forestry societies who were involved with afforestation of treeless lands. In 1970, state sponsored afforestation on farms became widespread and today comprises approximately 80 percent of Iceland's afforestation effort. As these plantations mature they are becoming noticeable across the landscape (Plate 15) and it is obvious that a forest resource is developing in Iceland. Current annual increments for these young forests of larch, spruce, pine and poplars are impressive and range between 10 and 20 m^3/ha/year on good sites (Plate 16). Materials from early thinnings are being used for fuel-wood, posts, boards, hand-crafts, and various fishing and agricultural activities (Plates 17 - 19). Presently, Iceland has about 35,000 ha of productive forests, more than 50 percent of which are less than 20-years-old.

The Iceland Forest Service is administered through the Ministry of Environment and manages over 40 national forests totalling over 7000 ha, or 5 percent of Iceland's forests and woodlands (Plate 20). Most of these forests within the national forest system are protected native birch woodlands and a combination of cultivated forests of exotic tree species, experimental forests, arboreta and recreation areas (Plates 21 - 24). The IFS Research Division is located at Mógilsá, near Reykjavik. Historically, research projects have focussed on species and provenance testing, ecology, insects and disease, and carbon and nutrient cycling. Current projects focus on growth and yield, climate change and social aspects of forestry.

As Dr. Eysteinsson states, "A century ago, most Icelanders had never seen a tree. Fifty years ago, few Icelanders believed that trees of any size could even grow in Iceland. Planting trees was the harmless hobby of a few eccentrics, but forests for timber production were out of the question. Today, forestry for timber production, land reclamation and amenity is being carried out by thousands of people throughout Iceland."

Several factors are expected to have far-reaching effects on the future forests of Iceland. Land use changes, specifically a decline in sheep numbers and grazing, are expected to result in more natural regeneration and extension of the ancient birch woods. Moreover, climate change, especially global warming, could lead to an expanded base for land reclamation and forest establishment, increased growth of planted trees, and increased tree species diversity through the use of a wider array of exotic species. The future of Icelandic forestry looks bright.

Icelandic western larch provenance tests

Historically, species of *Larix*, primarily *Larix sukaczewii* from north-western Russia, have shown good growth and adaptation in Iceland and are widely planted. To explore the utility of North American species of *Larix*, a trial planting of western larch was established in 1990, near Egilsstadir in north-eastern Iceland. The seedlot selected for planting was Tyner Lake, a slow growing seed source from just north of Merritt, BC. While survival of this seedlot was acceptable, early seedling growth is generally poor (Plate 25). In 2000, the IFS established a western larch provenance test using 20 BC seedlots planted on two sites. Unfortunately, one site was lost due to frost damage and grass competition. The remaining site is located near the Hallormsstadur National Forest, south of Egilsstadir, on a rocky, north facing slope (65º 14.4' N lat; 14º 27' W long; 60-80 m elevation) (Plate 1). Despite its high latitude, the climate at the site is temperate (mean annual temperature = 3.2ºC; mean annual precipitation = 765.6 mm) and characterized by cool summers (mean summer temperature = 13.8ºC), relatively mild winters (mean winter temperature = -4.7ºC) with precipitation distributed fairly evenly throughout the year. The North American analog of this climate would be the Alaskan Peninsula and Aleutian Islands. The range of climate values on the site generally falls far outside the climate experienced by western larch within its natural range (Rehfeldt and Jaquish 2010, Rehfeldt 1995). While the mean annual temperatures are near the minimum required for western larch, the summers are far too cool for the good growth of western larch.

In 2000, the Iceland Forest Service established a western larch provenance test using 20 B.C. seedlots planted on two sites.

As expected, the 20 BC western larch seed sources in Iceland grew far slower than in their natural habitat (Plates 26 – 28). Nevertheless, the best provenances tended to come from the Cranbrook/Flathead Valley area of south-eastern BC. Nine-year survival ranged from 16 – 71 percent (Fig 1) and nine-year height ranged from 78 cm (Plumbob Mtn.) to 46 cm (Merritt, Tyner Lake) (Fig. 2). Tree mortality and damage was largely

As the climate changes and Iceland warms, western larch could become a useful species for planting on productive sites.

attributed to delayed bud set caused by the long summer photoperiod, inadequate hardening-off and early fall frost events.

These growth and survival results suggest that western larch currently has limited value in Iceland. However, as the climate changes and Iceland warms, western larch could become a useful species for planting on productive sites. The results also help validate the western larch climate projections presented by Rehfeldt and Jaquish (2010) and Rehfeldt (1995), which suggest that the current climate of Iceland is outside the limits for western larch.

Finally, my sincerest appreciation and thank you is extended to Throstur Eysteinsson (Plate 29) for establishing, maintaining and measuring these western larch plantations, for hosting our visit to the Hallormsstadur National Forest, and for providing information on forestry in Iceland.

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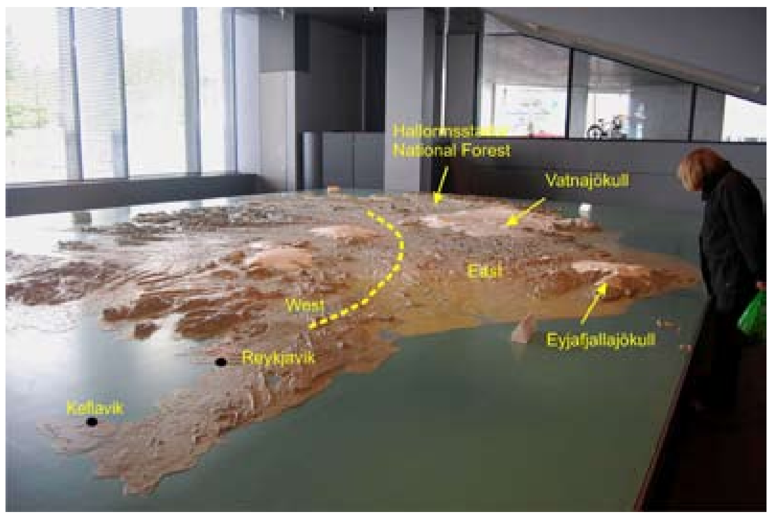

Plate 1. A model relief map of Iceland showing geographic points of interest. The perspective is from the south-west looking north-east. The dashed yellow line locates the Mid Atlantic Ridge between the North American and Eurasian Plates. West and East indicate the respective zones of volcanic activity. White caps are glaciers.

Plate 2. Reykjavik city centre from atop steeple of Hallgrimskirkja chuch.

Plate 3. Godafoss waterfalls in north-central Iceland.

Plate 4. Jokulsarlon glacier lagoon at the south end of the glacier Vatnajökull. Black ash on glacier fragments are deposits from the spring 2010 eruption of the volcano Eyjafjallajökull.

Plate 5. Dry interior highland desert east of Lake Myvatn in north-central Iceland.

Plate 6. Geothermal power station in north-central Iceland near Lake Myvatn with *Larix* **afforestation in foreground.**

Plate 7. Myvatn Nature Bath in one of the most geologically active areas of Iceland.

Plate 8. Nootka lupine (*Lupinus nootkatensis*), a non-native, highly invasive species that was introduced to Iceland in the late-1800s.

Plate 9. Icelandic landscape north of Reykjavik showing invasive Nootka lupine, lodgepole pine (*Pinus contorta*) and native willows (*Salix* spp).

Plate 10. Native Icelandic birch woodland comprised of downy birch (*Betula pubescens*) and willows (*Salix* spp.).

Plate 11. Dwarf birch and willow woodlands commonly used for recreation. Buildings are weekend retreats and summer cottages owned by urban dwellers from Reykjavik.

Plate 12. Typical early Icelandic settlement house constructed of stone, sod and wood.

Plate 13. Early to mid-20th century rural farmhouse and adjoining barn. Humans inhabited the far right section and the upper floor of the middle section. Farm animals were kept in the lower middle and equipment was stored on the left. Note the one metre thick sod insulation walls - fuel-wood for heating was a rare commodity.

Plate 14. Thingvillur, site of first Icelandic planting of exotic pine in 1899 and the first parliament in year 930. The origin of forestry in Iceland.

Plate 15. Example of farm afforestation mostly with ***Larix sukaczewii, Picea sitchensis*** and ***Pinus contorta***. Plantations are typically fenced to avoid sheep grazing.

Plate 16. Plantation of *Larix sukaczewii* at Hallormsstadur National Forest, south of Egilsstadir, Iceland.

Plate 17. Young plantation thinning in spring at Hallormsstadur National Forest, south of Egilsstadir, Iceland. (photo courtesy of Throstur Eysteinsson)

Plate 18. Thinning a planted stand of *Larix sukaczewii* at Hallormsstadur National Forest, south of Egilsstadir, Iceland. (photo courtesy of Throstur Eysteinsson)

Plate 19. Boards, stakes and firewood produced from plantation thinning at Hallormsstadur National Forest, south of Egilsstadir, Iceland.

Plate 20. Hallormsstadur National Forest, south of Egilsstadir, is Iceland's oldest and largest Nation Forest. The forest was fenced along the upper boundary to exclude sheep and planted with exotic conifers.

Plate 21. Lodgepole pine (*Pinus contorta*) from Smithers BC planted in 1940 in the Hallormsstadur National Forest.

Plate 22. Engelmann spruce (*Picea engelmannii*) from Utah USA planted in the Hallormsstadur National Forest.

Plate 23. Whitebark pine (*Pinus albicaulis*) (unknown provenance) planted in the Hallormsstadur National Forest.

Plate 24. Interior Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) from Vernon, BC planted in the Hallormsstadur National Forest.

Plate 25. Thirteen-year-old plantation of western larch (*Larix occidentalis*) from Tyner Lake, north of Merritt BC.

Plate 26. Nine-year-old western larch provenance test in north-east Iceland.

Plate 27. Nine-year-old western larch provenance test in north-east Iceland.

Plate 28. Nine-year-old western larch provenance test in north-east Iceland.

Plate 29. Dr Throstur Eysteinsson, a fellow *Larix* fanatic, - note personalized licence plate - and Mary Tremayne at Hallormsstadur National Forest.

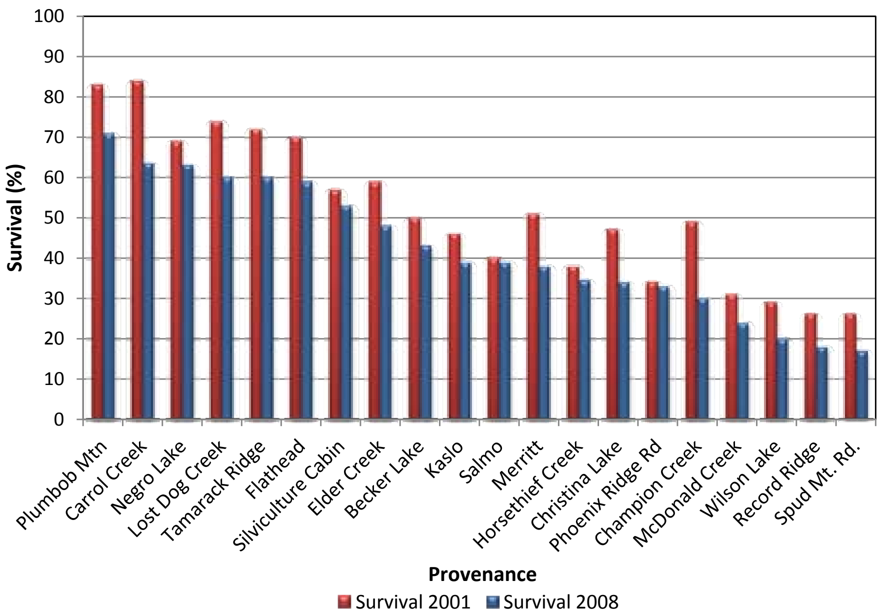

Figure 1. Survival of twenty B.C. western larch provenances in north-eastern Iceland after two and nine growing seasons.

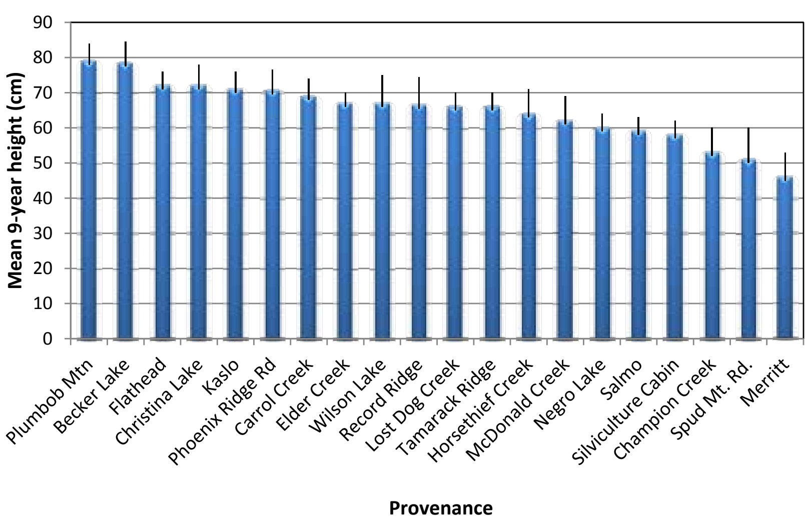

Figure 2. Average nine-year height (+/- se) of 20 BC western larch provenances in north-eastern Iceland.

FGC-owned SelectSeed Co. Ltd. Meets Seed Production Objectives

submitted by Jack Woods

SelectSeed was set up by the Forest Genetics Council in 1999.

In 1999, the Forest Genetics Council set provincial objectives for the use of select seed based on an economic benefit analysis. Seed planning units (SPU - species within a seed zone and elevation band) that met economic criteria for investment were identified. This required a further analysis of breeding programs and seed orchard production capacity to determine where shortfalls existed. The result was the identification of substantial shortfalls in orchard capacity for some SPU. Much of the needed orchard expansion was for lodgepole pine; a species that is more difficult than most to manage for seed production.

At the time, Forest Renewal BC (FRBC) was seeking investments that would positively contribute to timber supply on Crown lands. The opportunity to work with FRBC to make the needed capital investments in seed orchards led Council to create SelectSeed Co. Ltd. Council also set up the non-profit BC Forest Genetics Society to hold shares of SelectSeed and to ensure that any future profits could only be used to support tree improvement in British Columbia.

Under the oversight of a board of directors reporting to the FGC, SelectSeed developed a business plan and negotiated a long-term contract with FRBC that provided capital for seed orchard development. SelectSeed's business plan set out an ambitious schedule to develop orchards to help meet FGC objectives. As SelectSeed is wholly owned by the FGC, Council set the expectation that the Company would also provide management services for Council, including business planning and reporting, meeting organization, facilitating committees reporting to Council, providing analyses, and representing Council on various issues.

Starting in 2000, SelectSeed negotiated long-term seed orchard agreements with five companies for the development of 14 seed orchards with over 35,000 ramets (nine lodgepole pine, three interior Douglas-fir, and two interior spruce). Grafting was undertaken with advice from BC Forest Service tree breeders to ensure parent trees of the highest possible genetic quality were used. Orchards were then developed and planted on a large scale. A decade later, all 14 seed orchards are producing and over 1,000 hectoliters of cones have been harvested, yielding 470 kilograms of seed capable of producing over 65 million seedlings of high genetic worth. Nearly all seed has been sold to over 70 clients, including forest companies, BC Timber Sales, community forests, first nations, and woodlot licensees. The original SelectSeed business plan forecast total seed sales by March 2011 of $1.3 million; actual sales to date are $1.26 million, with additional seed in inventory. Production continues to ramp up in these young orchards and it is expected SelectSeed will generate a profit and begin returning capital to the FGC[1] within the next 5 years.

This success story is a testament to the vision of FGC members who structured it in 1999, to consistent support from subsequent FGC members and the BC Forest Service, and to the knowledge and experience of orchard staff who have kept operations on track over the past decade.

[1]Under the terms of the contract originally negotiated between FRBC and SelectSeed, and subsequently transferred from FRBC to the BC Forest Service, up to 50% of profits will return to the BC Forest Service. The BC Forest Service could, at their discretion, choose to have these profits remain with the FGC for re-investment in genetic resource management activities in BC.

Figure 1. Picking lodgepole pine cones for the Thompson Okanagan zone in the SelectSeed orchard operated by Pacific Regeneration Technologies north of Vernon. (photo by J. Woods)

Figure 2. A developing spruce crop at the SelectSeed orchard on the Tolko Ltd. site near Armstrong. (photo by G. Pieper)

Figure 3. SelectSeed Orchard lodgepole pine seed orchard at the Kettle River Seed Orchard Co. site. This 11 hectare orchard is now producing high genetic worth seed for the Prince George seed zone. (photo by J. Woods)

After a decade, SelectSeed orchards have produced seed for over 65 million seedlings.

History of Tree Improvement in BC

submitted by Roger Painter

"You have to swallow the tree Improvement pill and believe in it." Tim Lee

Many of you are aware that I am in the process of writing a History of Seed Orchards and Tree Improvement over the past 50 years. This is proving to be wonderful journey, looking back not only at our history but paralleling how the Province got into reforestation in the first place and the industry that was developed from it.

One of the original targets was set up by Minister of Forests Ray Williston, aimed for 75-75, meaning 75 million seedlings planted by 1975. Many nurseries were established during those years and the Reforestation Division became a giant arm of the Forest Service.

Paralleling this huge growth was the tree improvement/forest genetics program. Originally promoted by people like Alan Orr-Ewing and others the program worked in the shadow of reforestation, often struggling but never falling apart. Looking back at what has been accomplished from this is truly astounding. The tree improvement program in BC took a long time to reach maturity but it is now a world leader. One could look at it strictly from its technical roots and be overwhelmed.

Today, almost 60% of all seed for reforestation come from seed orchards and the genetic worth is closing on an average of 20% above wild stand. Look how many trees are now going out the door and onto the landscape.

But a rich part of the story lies in the people that have made it happen and how. That's the story of this publication. To date I've interviewed over 90 people and have a number left to go. They cover breeders, orchard managers, decision makers, program champions, technicians, researchers and many others who have made this program what it is today. As one should expect we have lost a few key players over time, but many of our pioneers are still with us and

Photo 1. Bob Derrinberg plants the first tree at the Saanich Forestry Centre in 1965.

I have spent numerous wonderful hours talking with people about their careers.

They are not giants, no matter how much we want them to be. They are just ordinary people who became enthused about their vocations and who contributed in their own way over time.

Originally there was no overall plan, from the days of the Sloan Commission looking forward. There was probably more a continued belief that this was the right thing to do and a need to keep it moving ahead. And no matter how poor the funding or the economy, we've always seemed to keep this program alive. In recent years we have become better at the planning processes and out of that has come the success we've all hoped for.

There have many key players and key points over time where we've been able to move ahead, thanks to some wonderful champions who convinced superiors of the value of Tree Improvement. Both industry and government have shared in this.

Equally important are all the people that worked from the ground level up, learning how to do things and how to make them successful. As one of our more senior colleagues said, "When we started we really knew nothing. We basically had to go out and create a "knowledge base". This has been true of our industry from its inception. When we've had a problem we would find a way to solve it.

I'm hoping that my product will capture that sense of purpose and provide people with the true worth of our efforts. The publication is scheduled to be complete in time to celebrate the 100th anniversary of the BC Forest Service. I think we have as much to celebrate as that older organization does. In many ways we have contributed significantly to its successes as well. The story is going to be a good one.

I am still looking for any interesting and significant pictures that you might have and wish to share. Part of the product of this work will be to create a library of pictures that anyone can have access to for future publications. So if you have any items you wish to share, pass them on to me.

"When we started we really knew nothing. We basically had to go out and create a "knowledge base". Bruce Devitt

Photo 2. Dr. Alan Orr-Ewing (in red jacket) and nursery management group discussing Douglas-fir seedlings with varying growth responses at the Duncan Nursery, Chesterfield Road site (1956).

Cone and Seed Pest Research Update

submitted by Ward Strong

Cone and seed research focussed on the Fir Coneworm and Western Conifer Seedbug.

In the last couple of years, the cone and seed pest research lab has continued working on the most critical pests of concern to BC seed orchards. Two graduate students have completed their research, and a foreign graduate student spent the summer in my lab. This report highlights some of the findings that are relevant to BC seed orchards.

Biology of the Fir Coneworm (*Dioryctria abietivorella*).

Graduate Student: Caroline Whitehouse, University of Alberta.

The focus of Caroline's work was to understand the reproductive ecology of *Dioryctria*, in order to determine whether it is a candidate for pheromone-based control such as Mating Disruption. She looked at several critical aspects of their life cycle.

- *Female flight period*. Male *Dioryctria* are known to fly throughout the summer, from May through October. Since this was determined with pheromone traps, which attract only males, female flight period was unknown. Caroline used light traps to attract females and determine their flight period. She found that females also fly throughout summer, starting in early June and ending in late August. Although the flight period is not as long as the males, females are still in our orchards, flying and laying eggs, all summer long. This adds difficulty and complexity in managing these creatures.

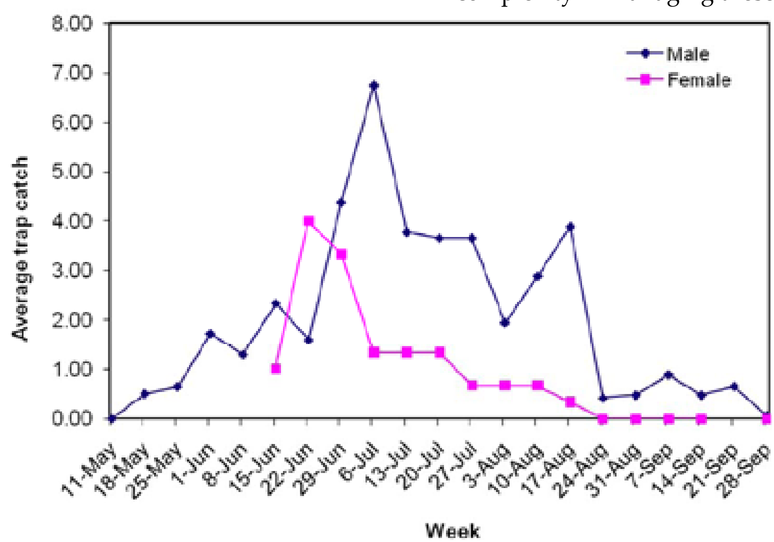

Figure 1. *Dioryctria* flight period in the Vernon area.

Figure 2. *Dioryctria* egg.

- *Life span and egg production*. Caging insects in the laboratory, Caroline found that females live 21 to 27 days. They start to lay eggs 2 days after emerging, and lay eggs whether they are mated or not. This is odd, since unfertilized eggs do not hatch. Mated females lay over 10 eggs per day, tapering off as they age. Mean number of eggs per female is over 150, each laid individually (not in clusters). This long oviposition period and the distributed nature of the eggs again makes for challenges in managing the insect.

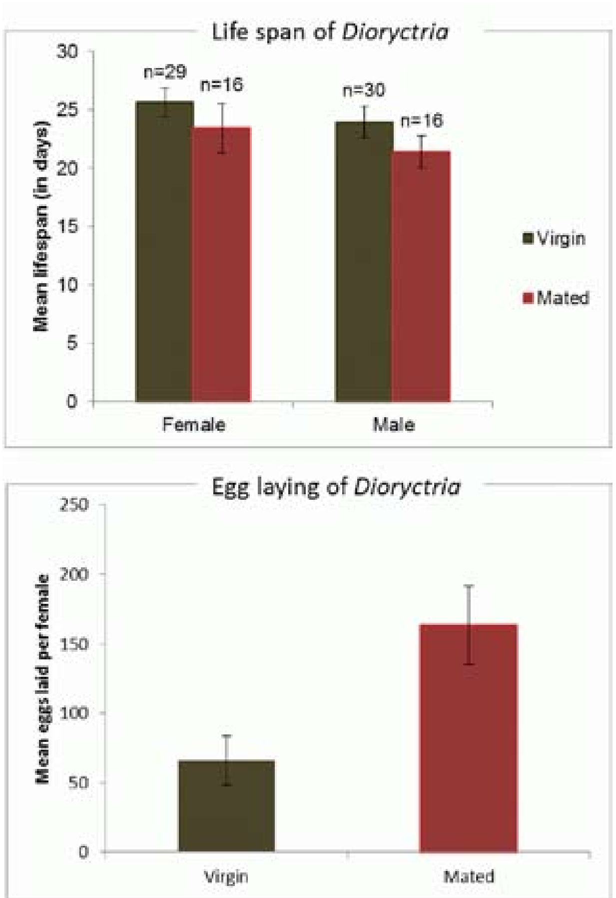

Figure 3. *Dioryctria* life span and egg laying.

- *Calling behaviour*. When females release pheromones into the air to attract males, it is termed "calling". Understanding this behaviour is important to a successful Mating Disruption program. Caroline measured calling behaviour with caged females in the lab and in the field. Females start calling as soon as they emerge from pupae, and call through their life, even if already mated. This again adds difficulty to using Mating Disruption. However, their calling is restricted to a 3-hour period before dawn. Thus in Mating Disruption, it would be possible to release pheromone during that 3-hour period only, thereby reducing the amount of pheromone needed.

Figure 4. Calling female *Dioryctria*.

Fir Coneworm females call and mate in the wee hours of the morning.

Fir Coneworm is not a good candidate for control by pheromone mating disruption.

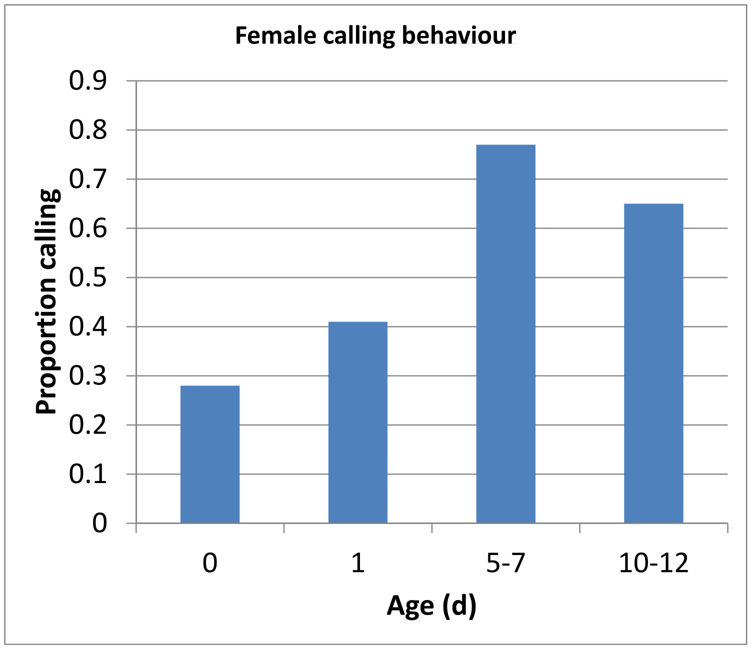

Figure 5. ***Dioryctria*** **female calling behaviour.**

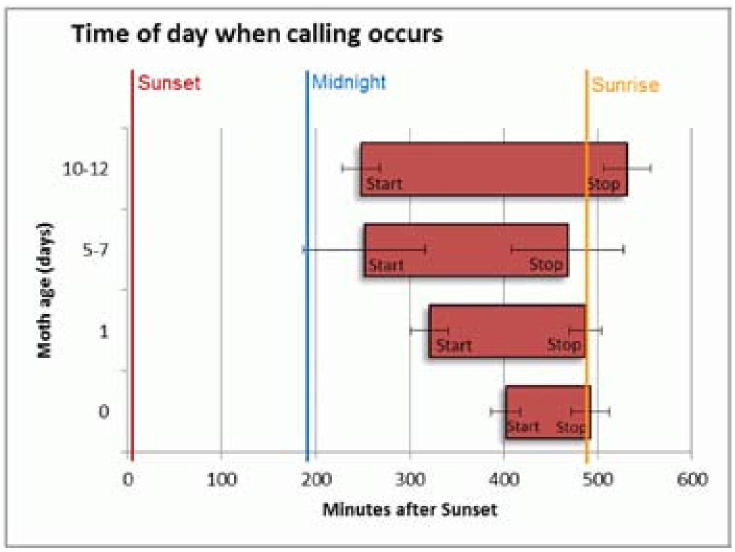

Figure 6. ***Dioryctria*** **- time of day when calling occurs.**

- *Mating frequency*. In some insect species, females mate once only, while in others they mate multiple times. Males inseminate females with a sperm packet which is visible in dissected females. By counting the number of sperm packets in females caught in her light traps, Caroline determined how many times each female had mated. She found that *D. abietivorella* mated up to 7 times, the average being 2.25. Other *Dioryctria* species mated fewer times.

Figure 7. ***Dioryctria*** **female reproductive organ.**

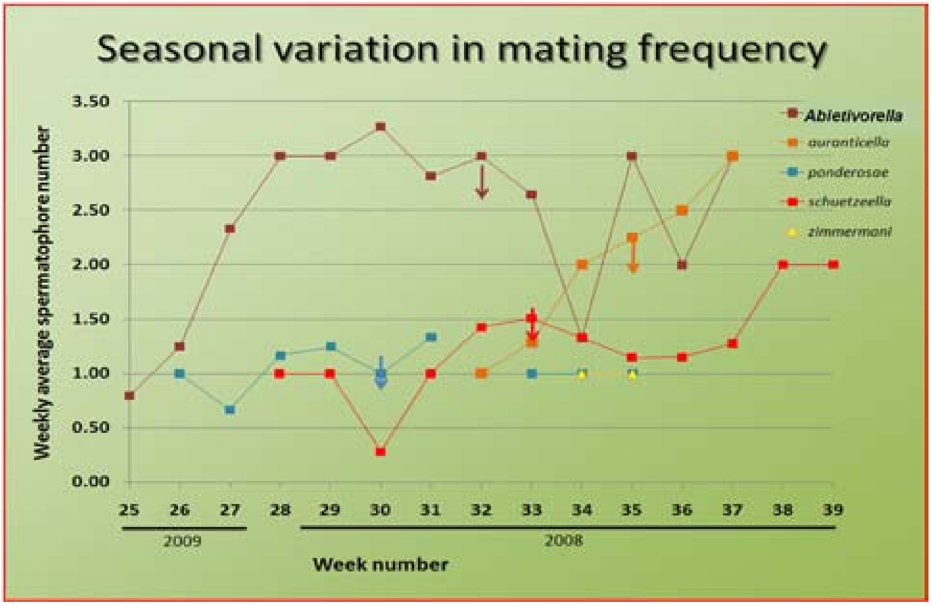

Figure 8. Dioryctria seasonal variation in mating frequency.

Conclusions. We have shown that *Dioryctria* has a long life span with multiple overlapping generations through the summer. Females mate multiple times and lay eggs throughout their lives. They are strong flyers, easily moving between seed orchards and wild stands. These factors all suggest that *Dioryctria* is not a good candidate for pheromone-based control techniques. We will not be pursuing this in the future.

Western Conifer Seedbug (*Leptoglossus occidentalis*) Preferred Clones study.

Graduate student: Tamara Richardson, UNBC.

Tamara's work with *Leptoglossus* focussed on a mark-release-recapture method to determine how they move within and between orchards, and to develop an economic threshold for decision-making. In the course of this work, she confirmed earlier reports that *Leptoglossus* prefer certain clones. Working in Orchard 307 at Kalamalka Seed Orchards, she discovered that 86% of all *Leptoglossus* counted throughout the summer of 2008 were found on only 10% of the clones. This pattern was also seen in 2009, with mostly the same clones involved.

To determine what about these clones was attractive (or what about the non-preferred clones was repellent), she examined cone size, temperature, and crop density. She then analyzed a sample of cones from each ramet for 33 terpenes. Terpenes are a class of chemicals that give conifers their resinous smell.

Tamara found that there was no consistent effect of crop size, though trees without cones held no *Leptoglossus*. However, the preferred clones had larger cones, and these cones were up to 5 °C warmer. Earlier this decade, our lab (in collaboration with Simon Fraser University) discovered that infrared radiation, emitted from warm cones, is used by *Leptoglossus* to find cones for feeding. Thus it is perhaps no surprise that preferred clones had warmer cones.

Most interesting was the discovery that cones of the preferred clones had a much different terpene profile than the non-preferred clones. Particularly, non-preferred clones had much higher levels of D-3-Carene and Bornylacetate, suggesting these are repellent to *Leptoglossus*.

Knowing why certain clones are preferred, and others avoided, can help us design lures for traps, and possibly repellent sprays. We hope to explore this more in the future.

Lodgepole pine clones favoured by seedbugs have distinctly different terpene profiles than unfavoured clones.

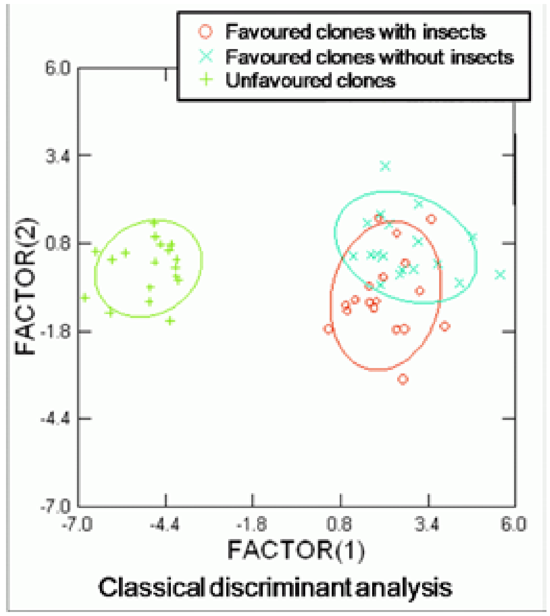

Figure 9. ***Terpene profiles of favoured versus unfavoured clones.***

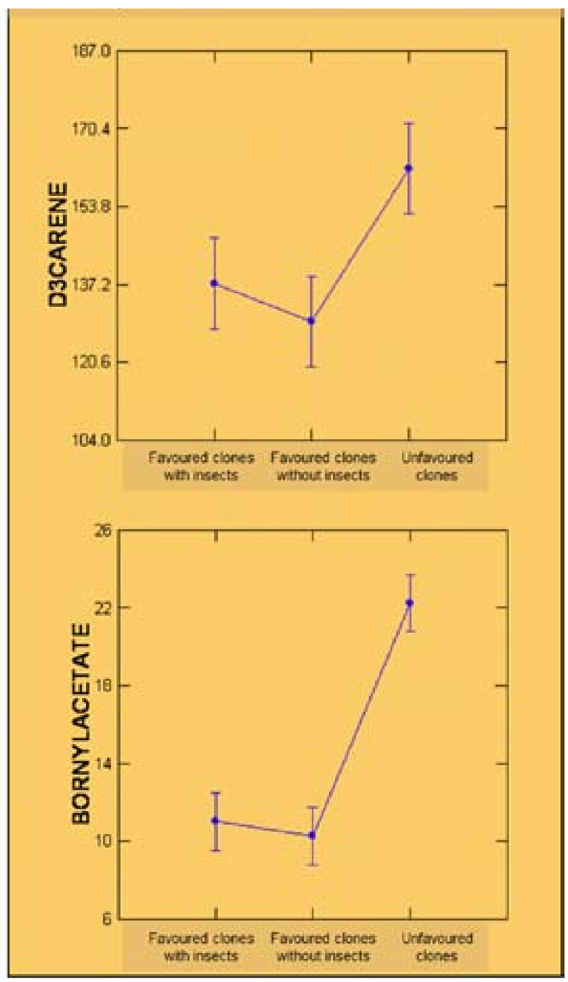

Figure 10.Two terpenes in favoured versus unfavoured clones..

Western Conifer Seedbug (*Leptoglossus occidentalis*) Egg Parasitoid Study.

Foreign Graduate student: Matteo Maltese, University of Palermo.

In 2003, Sarah Bates described an egg parasitoid of *Leptoglossus* for the first time. Egg parasitoids are tiny wasps that lay their eggs inside the eggs of another insect. The egg, larval, and pupal stages of the parasitoid develop entirely inside the host egg, and a new adult wasp emerges to start the cycle over. Sarah collected the parasitoid *Gryon pennsylvanicum* at the Kalamalka Forestry Centre in Vernon. About the size of a fruit fly, this species specializes on hosts in the genus *Leptoglossus*.

Meanwhile, *Leptoglossus* had been introduced into Italy, where it is causing huge losses to their pine nut industry. To reduce the seed losses, Italian researchers sought a biological control agent-- and ran across Sarah Bates' papers. They sent a graduate student, Matteo Maltese, from the University of Palermo to work at our lab during the summer of 2010. Matteo collected 3 species of egg parasitoids, of which *Gryon pennsylvanicum* was by far the most abundant. A laboratory colony is now undergoing tests in Italy to determine the safety and suitability of releasing it there.

A tiny parasitic wasp that attacks seedbug eggs could help provide control in seed orchards.

Figure 11*. Gryon pennsylvanicum* adult.

Figure 12. *Gyron* parasitizing *Leptoglossus* egg.

Figure 13. Parasization chambre.

Seed orchards have few nectar sources to support adults of the seedbug egg parasitoid.

I have established a colony of *Gryon* in our laboratory too, rearing them on eggs from a *Leptoglossus* colony. My goal is to understand the life history parameters of *Gryon* to try to determine whether it might be useful in our seed orchards. A full suite of experiments is more involved than I have time to conduct, but some things are coming to light. Between my work and Matteo's summer research, here's what we know so far.

• *High parasitism rates.* Matteo found that up to 93% of *Leptoglossus* eggs put in abandoned seed orchards were parasitized. *Gryon* can find and rapidly exploit high densities of their host.

• *Good host finding ability.* In California, *Leptoglossus* populations were so low that Matteo found only two eggs in 6 days of searching. Surprisingly, both were parasitized. It seems that *Gryon* can find very scattered, low-density host resources, suggesting it is able to maintain *Leptoglossus* at low densities.

• *Longevity.* These tiny insects live for a long time, up to 3 months in the lab. This is good for their ability to live long enough to search for new or low density populations of *Leptoglossus*.

• *Oviposition rate.* In the lab, *Gryon* have parasitized up to 8 *Leptoglossus* eggs per day; the upper limit has not been found. They also can parasitize eggs even when >2 months old. The number of eggs that can be parasitized in a lifetime has not been tested; maximum number so far is 36.

• *Reproductive system.* As with many types of wasps, *Gryon* females are capable of reproducing with or without mating. Unfertilized eggs develop into males; fertilized eggs develop into females. Therefore a female can parasitize *Leptoglossus* eggs even if she can't find a mate.

• *Storage of Leptoglossus eggs.* Host eggs stored at 9°C are suitable hosts for at least a month. Longer-term storage, possibly at different temperatures, has not been tested.

• *Storage of parasitized eggs.* Parasitized *Leptoglossus* eggs harbouring undeveloped *Gryon* have been stored for 10 days at 9°C. Longer-term storage, possibly at different temperatures, has not been tested.

•*Storage of adult Gryon*. Adults have been held in suspended animation at 9°C for as long as a month, though testing is not complete to ensure they can still successfully parasitize eggs afterwords. All of these storage methods could allow an accumulation of populations through the winter in order to release large numbers in spring.

• *Food and water requirements.* I have learned the hard way that *Gryon* needs to eat and drink every day, or they die. They need nothing more than honey and water, or nectar, to live their entire lifespan.

In summary, it looks like these egg parasitoids could have a significant impact on leptoglossus populations in seed orchards. Why, then, do they not seem to be doing anything out there? I think there are two reasons. First, the pesticides we apply for control of *Leptoglossus*, *Dioryctria*, and other pests probably wipe parasitoids out. Any successful use of these parasitoids would require a modified pesticide regime. Second, seed orchards are usually maintained with grass ground cover between rows, and bare earth within. In summer, the ground cover often dries right up. There is no source of nectar for the adult *Gryon* to live on. Thus seed orchards are an inherently hostile environment to these parasitoids. Enabling establishment of parasitoid populations would require flowering plants within the orchard. Perhaps drought-resistant plants like alfalfa, white clover, mustards, or yarrow would work.

Though much remains to be investigated, I am cautiously optimistic that *Gryon pennsylvanicum* and possibly other natural enemies might find a place in our seed orchards in the future.

Seed Orchard Pest Phenomena Occurring in the Season Following a Mast Seedling Event

submitted by Nancy van der Laan and Jim Corrigan

Mast seeding refers to the sporadic production of unusually large volumes of seed by plant populations. Among other functions, it is thought to be a mechanism to reduce herbivory on the seed produced during these events (Kelly, 1994).

How does mast seeding work to minimize losses caused by cone and seed herbivores?

'Normal' years, with no-low seed production, keep populations of obligate cone and seed herbivores at very low (endemic) levels. Under the predator satiation theory, these endemic populations are too small to 'catch up' sufficiently to exploit a one-year superabundance of seed resources. The reproductive potential of endemic herbivore populations is fully realized after attacking just a small portion of a bumper crop, so most seeds will escape attack during a mast seeding season (Kelly, 1994).

In four Interior hybrid spruce seed orchards located at the Kalamalka Forestry Centre, 2010 was a mast seeding year (Figure 1). Producing 475 kilograms of seed, these orchards contributed to the largest spruce crop ever harvested from the Kalamalka site. This crop experienced minimal pest damage; less than 5% losses were attributed to cone and seed insects in the 2010 growing season.

In 2011, two of the four spruce orchards (306, 620) that had produced bumper crops in 2010 had absolutely no cones on their ramets (Figure 1). Cones were developing on a few clones in Orchard 305, and Orchard 341 had a small but potentially harvestable cone crop. As part of routine spring monitoring, Nancy van der Laan collected cones from the latter two orchards at the beginning of June to be examined for in-cone pest species. Before a single cone had been dissected, it was clear that 2011 was going to be an atypical year for pest activity in these orchards.

While collecting samples in Orchard 305, Nancy photographed extremely high numbers of a parasitoid of the spruce cone axis midge, *Kaltenbachiola rachiphaga*, working cones (Figure 2). Females of the axis midge parasitoid, *Torymus azureus*, must drill through the scales to the cone axis in order to parasitize the midge larvae. While these parasitoid adults are commonly seen around spruce ramets in most growing seasons, Nancy had never before seen the numbers of females on cones as were observed in Orchard 305 in early June of 2011.

Figure 1. Typical Kalamalka spruce ramets in 2010 (left) and 2011 (right). (photos by Jim Corrigan)

Subsequent dissections revealed a reason for the unusually high numbers of parasitoids observed on these cones. An unprecedented number of the sampled cones contained axis midge larvae. The proportions of midge-infested cones in the 2011 samples were an order of magnitude higher than they had been in any sample taken from 2006 to 2010 (Table 1). Populations of the seedworm,

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Before a single cone had been dissected, it was clear that 2011 was going to be an atypical year for pest activity.

Figure 2. Large numbers of the axis midge parasitoid, *Torymus azureus*, probing spruce cones to find host larve to attack. (photo by Nancy van der Laan)

One year after a mast seeding season, the herbivore: host ratio had flipped completely in favour of the pests.

Cydia strobilella, another obligate cone and seed feeder, also were detected at much higher levels in 2011 than had been seen in any of the previous five years (Table 1).

At first, we felt that these large populations of cone-feeding specialists had 'come out of nowhere' in 2011 relative to the numbers usually found in our spruce seed orchards. However, when one considers the relative populations of both cones and cone pests from 2010 and 2011, the dramatic increases in attack rates can be explained.

Spruce Orchard	2006-2010		2011	
	Axis midge	*Cydia* seedworm	Axis midge	*Cydia* seedworm
305	0-8%	0-4%	84%	28%
341	0-4%	0-8%	52%	40%

Table 1. Proportions of dissected spruce cones that contained two species of obligate cone-feeding pests for the 2006-2010 and the 2011 growing seasons.

In 2010, there were incredibly high numbers of cones developing in the Kalamalka spruce seed orchards (Figure 1). As would be predicted by the predator satiation theory, pest losses of under 5% had little effect on the volume of seed produced from the Kalamalka spruce orchards in that year. However, an approximate 5% attack rate on this substantial crop resulted in the production of its own 'bumper crop' of pest insects that would carry over into the next growing season.

In 2011, the numbers of cones in the Kalamalka spruce orchards were reduced by well over 95%. Meanwhile, populations of overwintering pest insects coming from the 2010 season were much larger than those typically present in the seed orchards. Since obligate cone and seed herbivores must attack cones in order to reproduce, the few cones developing in Orchards 305 and 341 became the focus of the relatively large populations of cone and seed pests produced during the previous growing season. One year after a mast seeding season, the herbivore: host ratio had flipped completely in favour of the pest populations. In 2011, relatively large pest populations attacked greatly diminished host (cone) numbers, resulting in extremely high levels of pest activity (Table 1).

This result could have been anticipated. Commenting on pest damage after a mast seeding year, Knight & Heikenen (1980) state: "When a poor cone year follows a bumper cone crop ... the emerging increased insect populations will decimate what few cones and seeds exist."

This is exactly what occurred in the Kalamalka spruce orchards in 2011. Walkthrough inspections in late June revealed that virtually every cone had been attacked by one or several pest species. The damage was so extensive that we abandoned all attempts to manage either cone-bearing Kalamalka spruce orchard for a harvestable crop in the 2011 growing season.

The 2011 season revealed several other aspects of the ecology of the cone and seed feeding guild in these spruce orchards that had not been detected during normal cropping years.

1. Parasitoids of cone and seed herbivores go through their own boom-bust cycles in response to a mast seeding event. Like the obligate cone and seed herbivores that they attack, the parasitoids must find suitable hosts in order to reproduce. In a season when all activity is restricted to a very limited number of cones, the natural enemies of obligate seed and cone herbivores will be concentrated on them as well (Figure 2).

amount of feeding damage at the bases of the majority of early aborted cones (Figure 4). As well, several dead early-instar larvae of the spruce coneworn, *Dioryctria reniculelloides*, were found in association with this damage.

These attacks occurred fairly shortly after the spruce cones had been pollinated, and it took just a small amount of feeding at the base of a new cone to cause it to abort (Figure 4).

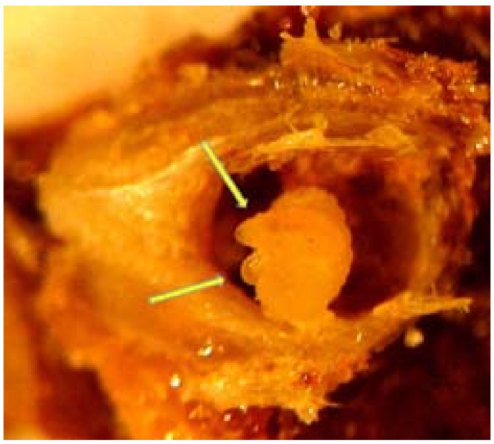

Figure 3. Two parasitoid larvae attacking an Axis midge larva (left) and a single parasitoid is seen on a *Cydia* seedworm larva (right). (photos by Jim Corrigan)

The operational implications of this phenomenon were detected in cone monitoring done in late June. Dissections of cone samples collected from Orchard 305 on June 24 revealed that most of the axis midge and seedworm larvae in the cones had been parasitized (Figure 3). For this reason, it was decided not to do sanitation picks, but to leave the 2011 cone crop in the orchards. Given the extremely high rates of parasitism observed on the herbivore larvae in these cones, we felt that leaving them in our orchards would provide a good reservoir of natural enemies for the 2012 growing season.

2. In most years, we have observed a small number of spruce cones that abort very shortly after being pollinated (Figure 4). No cause had ever been determined for these losses, as the number of cones killed in most years was not high enough to cause a great deal of concern.

Like other pest issues, the number of early-aborted cones skyrocketed in Orchard 305 in 2011 (Figure 4). Certain ramets had extensive losses while others apparently were not affected. Samples of aborted cones were examined to determine a cause for their lack of development. We observed a small

Because the young cones aborted so quickly in response to small amounts of feeding damage, an early instar spruce coneworm larva needed to attack a relatively large number of cones to support its growth and development. In normal years, the number of spruce coneworm larvae is small relative to the size of the cone crop, so only a scattering of cones are lost. Because of the high proportion of early aborted cones seen in the small 2011 crop, we were able to identify feeding by *Dioryctria reniculelloides*, as the one of the principal causes for these early season losses.

Conclusions

Our results from 2010 and 2011 illustrate an important difference between natural forest stands and seed orchards. When mast and post-mast seasons are taken together, pests cause minimal losses to total seed production in either environment. By far the largest volume of seed is produced in the mast seeding year – when few pest insects are present to attack the seeds. The small crop produced in the subsequent year likely will be wiped out by pests, but these losses occur on such a tiny proportion of the seed

Given the extremely high rates of parasitism observed on the herbivore larvae in these cones, we felt that leaving them in our orchards would provide a good reservoir of natural enemies for the 2012 growing season.

It must be recognized that extreme efforts likely will be needed to manage pest populations in a post-mast year, and that such efforts would be protecting a relatively small potential crop.

Figure 4. Early-aborted spruce cones in Kalamalka Orchard 306. Top left - Frass accumulation from feeding at the base of the cone by an early instar larva of the spruce coneworm. *Dioryctria reniculelloides*. Middle and bottom - Damage to bases of aborted cones caused by larval feeding. (photos by Jim Corrigan)

produced across both growing seasons that overall losses are minimal.

While the pest-filled aftermath of a mast seeding season should have little impact on the regeneration ecology of a natural forest stand, every year's crop is valuable in a seed orchard. Seed orchards are managed to optimize annual production rather than passively waiting for the occasional good harvest year in natural boom-bust cycles. That being said, it must be recognized that extreme efforts likely will be needed to manage pest populations in a post-mast year, and that such efforts would be protecting a relatively small potential crop. Seed orchard managers need to consider the cost-benefit ratio of trying to manage small crops in post-mast seeding years. As unpalatable as it may sound, the situation may arise when the cost-effective choice would be to let the pests have a small crop and save the costs associated with trying to protect it from heavy damage.

To end on a more optimistic note: The unfavourable pest: host ratios seen in a post-mast seeding year are unlikely to persist beyond that single season. Pest populations should collapse after this one year, because of: i) the greatly diminished number of cones available for them to attack in the post-mast season, and ii) the high rates of parasitism on the pest populations contained in these few cones. In the second year after a mast seeding season, cone production should be on the upswing, and populations of parasitoid species will be at the peaks of their own boom-bust cycles. Meanwhile, populations of cone and seed herbivores should be at their most depressed levels, and thereby present a minimal threat to the crop.

After taking our lumps in a post-mast year, let's hope that this rebound scenario describes a typical pattern for our conifer spruce seed orchards in 'post- post-' mast seeding seasons!

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Is the ponderosa pine coneworm, *Dioryctria auranticella*, a New Pest Species in Western White Pine and Lodgepole Pine Seed Orchards?

submitted by Judy Thomson and Jim Corrigan

In years when the western white or lodgepole pine seed orchards at Bailey Road are bearing commercially harvestable volumes of cones, monitoring is done to detect the proportion being attacked by *Dioryctria abietivorella*, the fir coneworm. Feeding damage caused by early-instar coneworm larvae is readily detected by observing small deposits of frass pellets on the surfaces of attacked cones (Figure 1). If alarming numbers of cones (i.e. 10% or more) are observed to be attacked, sprays of the systemic insecticide Dimethoate can be applied before the coneworm larvae destroy large portions of a crop.

Figure 1. Small frass pellets and damage produced by early-instar coneworm larvae feeding on a white pine cone – June 14, 2011. (photo by Jim Corrigan)

At the Bailey Road site of the Kalamalka Seed Orchards (located near Vernon, BC), pheromone-baited traps caught the first male *D. abietivorella* moth of the season on May 26, 2011. During monitoring done on June 14, we were very surprised to find cones on both western white and lodgepole pine ramets that were hosting large, late-instar coneworm larvae (Figure 2). Larval feeding by fir coneworms typically commences about 10-14 days after adult males are first caught in pheromone traps (Whitehouse *et al.*, 2011). On this basis, June 14 seemed too early in the growing season to be finding mature *D. abietivorella* larvae in our cones. We collected a number of white and lodgepole pine cones containing these large coneworm larvae and brought them into the lab for closer observation.

Two things were noted when examining the larvae in the lab. They appeared to be quite darkly pigmented and were henceforth christened the 'black *Dioryctria*' (Figure 2). As well, these individuals had a yellowish anal plate (Figure 3) that we could not recall seeing previously on fir coneworm larvae. Because we felt that something was atypical about these attacks, alerts were sent to all Interior operations asking them to check for coneworm feeding in their pine orchards. Meanwhile, cones holding 'black Dioryctria' larvae from Bailey Road were held in the lab to obtain adult specimens from them.

Figure 2. A late-instar 'black Dioryctria' larva found in a lodgepole pine cone on June 14, 2011. (photo Jim Corrigan)

Adult moths reared from these cones turned out to be *Dioryctria auranticella*, the ponderosa pine coneworm (Figure 3). This species has been reported to attack cones of both knobcone and ponderosa pines in North America (Furniss & Carolin, 1977; Hedlin *et al.*, 1980; Whitehouse *et al.*, 2011), but we could find no published records of individuals having been found in either western white or lodgepole pine cones. Prior to 2008, no specimens of *D. auranticella* reared from cones of the latter two pine species were present in the extensive insect collections held at the Canadian National Collection of Insects, the University of Alberta Strickland Museum of Entomology, the Royal BC Museum or in the Canadian Forest Service collections located at the Pacific Forestry Centre (J.F. Landry, Felix Sperling, Rob Cannings, Lee Humble, personal communications).

Adult moths reared from these cones turned out to be *Dioryctria auranticella*, the ponderosa pine coneworm (Figure 3).

In the summer of 2011, adult specimens of the ponderosa pine coneworm were reared from lodgepole pine cones collected at five different seed orchard locations.

In 2008, we had sent specimens of *D. auranticella* reared from white pine cones to these Museums and had retained several specimens reared from lodgepole pine cones in our own collection. To the best of our knowledge, these insects represented new host-rearing records for this species in North America. From a crop protection perspective, we felt that these new host records were of more academic than operational interest. However, monitoring work done in 2011 indicated that this moth species may represent a more serious threat to seed production coming from Interior pine orchards than was previously believed to be the case.

Figure 3. *Dioryctria auranticella*, the ponderosa pine coneworm. A late-instar larva showing its yellowish anal plate. Inset – the adult moth. (photos by Jim Corrigan)

In the summer of 2011, adult specimens of the ponderosa pine coneworm were reared from lodgepole pine cones collected at five different seed orchard locations: Bailey Road, Pacific Regeneration Technologies, Tolko-Eagle Rock, the Vernon Seed Orchard Company and the Sorrento Seed Orchards. As well, *D. auranticella* adults were reared out of cones collected from the white pine orchards at both Bailey Road and the Skimikin Seed Orchards. These rearing records indicated that the incidence of ponderosa pine coneworms successfully attacking lodgepole or white pine cones was much more widespread that had been suspected in 2008.

Judy Thomson did a whole-orchard survey for ponderosa pine coneworm attacks in Bailey Road lodgepole pine Orchard 340 on June 21, 2011. Of the approximately 2,200 ramets that comprise this orchard, 155 of them had some cones attacked by *D. auranticella*, and about 30 of these ramets had over 20% of their cones attacked by this coneworm species. While these results were below our spray threshold of 10% coneworm attack rates, Judy's survey indicated that attacks by the ponderosa pine coneworm in lodgepole pine seed orchards may be more than rare, isolated occurrences of the insects 'making a mistake' with their choice of host plant species.

Monitoring done by Judy in Bailey Road white pine Orchard 335 on July 14 indicated that about 16% of the observed cones were infested with ponderosa pine coneworms. This proportion was well above our spray threshold for coneworm feeding. Dimethoate sprays were applied to Orchard 335 on June 20-21 to limit the damage being caused by this coneworm species and by the fir coneworm. To the best of our knowledge, these sprays represented the first time that specific efforts were made to target *D. auranticella* in a conifer seed orchard in British Columbia. Unfortunately, a considerable amount of the damage caused by ponderosa pine coneworms in Bailey Road white pine 335 had already occurred by the time that these sprays were applied.

Why did we fail to detect early-instar attacks by the ponderosa pine coneworm through our routine monitoring procedures? Examinations of the life histories of both *D. auranticella* and the fir coneworm, *D. abietivorella*, reveal differences between them that have important operational implications (Table 1).

Ponderosa pine coneworms have a single generation per year, with the adults flying, mating and laying their eggs during midsummer (Whitehouse *et al.*, 2011).

	Generations per year	Early-instar larval ability to attack second-year cones	Overwintering life stage	Timing of post-overwintering attacks on second-year cones
D. auranticella **the ponderosa pine coneworm**	One	Next growing season	Early instar larva	Immediate on resumption of activity in spring
D. abietivorella **the fir coneworm**	Apparently continuous through summer	Immediate on hatching from egg	Post-feeding last instar larva	After pupation, adult emergence, mating, oviposition and egg hatch

Table 1. Life history attributes of *Dioryctria auranticella* and *D. abietivorella*.

Monitoring work done in September of 2011 by Judy Thomson detected early-instar ponderosa pine coneworm larvae on both lodgepole and western white pine ramets in the Bailey Road seed orchards. These larvae do a limited amount of feeding as they burrow into buds or conelets, where they pass the winter (Figure 4).

The operationally significant aspect of this life history is that ponderosa pine coneworm larvae are ready to attack cones as soon as the weather warms up during the following spring. On the other hand, fir coneworms overwinter as a fully grown last-instar larvae. In the spring, these individuals must pupate, eclose, pass through a pre-mating period (Whitehouse *et al.*, 2011), find a mate, copulate and oviposit. The resultant eggs must hatch, and only then are the new generation of fir coneworm larvae ready to start attacking cones.

Customarily, we do not begin to monitor cones for attacks by coneworms until 8-14 days after the first *D. abietivorella* males have been caught in pheromone traps. The difference between the two species with respect to when feeding activity starts in the spring is the reason why we missed observing early-instar larval feeding by *D. auranticella* in the pine orchards at Bailey Road in 2011. In 2012, we will start checking cones in our pine orchards for feeding damage much earlier in the spring (April) in an attempt to pinpoint the onset of larval feeding activity by ponderosa pine coneworms.

In Table 2, we offer several suggestions for how to determine the difference between attacks by *D. auranticella* and *D. abietivorella* in pine seed orchards. We are not yet sure if all of these apparent differences are diagnostic. If you do have samples of attacked cones, the surest way to identify the Dioryctria species responsible for the damage is to hold the cones in containers until adult moths emerge from them. The adults of the two species are very different in colour, and adult specimens will be easy to identify to species (Table 2). Observations of cone feeding occurring before any male fir coneworms have been caught in pheromone traps also would be indicative of attacks by the ponderosa pine coneworm.

On an orchard-wide scale, cones attacked by ponderosa pine coneworms tend to be clumped on certain ramets, while cones on surrounding ramets can be completely free of attacks by this species. Since they oviposit during the season before their larvae are going to develop inside second-year cones, *D. auranticella* females cannot target specific cones for their larvae to attack. Instead, they tend to deposit numbers of eggs on a particular ramet and none on others, resulting in a markedly clumped distribution of attacks across a pine seed orchard. Fir coneworms oviposit at the same time that the larval food resource is present on ramets, so they are thought to lay their eggs on or near specific second-year cones that their larvae will attack. Clonal preferences notwithstanding, cones attacked by fir coneworms tend to be more uniformly distributed across all ramets in a seed orchard, as the orientation of ovipositing fir coneworm females is to individual cones and not to whole ramets.

The operationally significant aspect of this life history is that ponderosa pine coneworm larvae are ready to attack cones as soon as the weather warms up during the following spring.

Figure 4. Early instar larva of *D. auranticella* found in its overwintering location inside a white pine conelet – September 15, 2011. Note frass at base of conelet in the left photo and the small larva with a yellowish anal plate on the right. (photos by Judy Thomson)

The surest way to identify the *Dioryctria* species responsible for the damage is to hold the cones in containers until adult moths emerge from them.

	D. auranticella, the ponderosa pine coneworm	***D. abietivorella***, the fir coneworm
Colour of mature larva (possibility for overlap exists)	Dark mahogany through gray to nearly black.	Reddish to dark mahogany.
Anal plate on larva	Dirty yellowish and lighter in colour than the rest of the body.	Not distinctively different in colour from rest of the body.
Timing of onset of cone feeding in spring	Feeding damage can be seen before any adult *D. abietivorella* males are caught in pheromone traps.	10-14 days after adult males are first caught in pheromone traps.
Distribution of attacked cones in orchard	Ramets with some-many attacked cones, surrounded by others with no attacked cones on them.	May be clonal effects, but attacks not overly clumped on particular ramets.
Adult coloration	Orange wings, off-white abdomen.	Gray wings, grayish abdomen.

Table 2. Differences between *Dioryctria auranticella* and *D. abietivorella* larvae, adults and their attacks on pine cones.

Conclusions

There never has been great concern about damage caused by the fir coneworm, *D. abietivorella*, in our lodgepole pine seed orchards, and we have not recorded a major loss to the fir coneworm on this host species (Gary Giampa, personal communication). At this time, we do not believe that the ponderosa pine coneworm will become an important pest species in lodgepole pine seed orchards either. However, observations of attacks by *D. auranticella* in Bailey Road lodgepole pine Orchard 340 have gone from two individual cones in 2008 to being seen on roughly 7% of the ramets in 2011. Clearly, monitoring must be carried out in our lodgepole pine orchards until we are sure that populations of the ponderosa pine coneworm are not increasing to the point that they will cause costly losses in these orchards.

The same cannot be said for western white pine seed orchards. Both Dioryctria species have been observed to attack cones at rates that have prompted chemical control measures to minimize significant crop losses. We suspect that some of the historic losses in white pine that were attributed to the fir coneworm actually may have been caused by ponderosa pine coneworms. Careful observations by Judy Thomson during our routine monitoring for fir coneworm in 2011 were largely responsible for detecting significant attack rates caused by this 'new' Dioryctria threat to our white pine seed crops. Armed with the knowledge that *D. auranticella* is capable of causing substantial economic losses in white pine, we plan to learn more about differences in early season biology between the two coneworm species. This knowledge should help us when dealing with both Dioryctria species in western white pine seed orchards in future years.

In closing, there will be a harvestable cone crop in the new ponderosa pine orchard (346) at Bailey Road in 2012. Given the amounts of damage that *D. auranticella* appears to be capable of causing in the white pine orchard at this location, we anticipate that the ponderosa pine coneworm will be a factor to consider when managing our ponderosa pine orchard for cone crops in future growing seasons.

Acknowledgements

We would like to thank Tia Wagner, Laura Whitney, Kris King, Onie Deardoff, Mo Fagan and Karen Turner for collecting coneworm-infested cones and/or rearing out Dioryctria adults from cones collected at their seed orchard locations. Chris Walsh and Gary Giampa are thanked for reviewing early drafts of this article.

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A workshop on "Adaptation of BC's Seed Transfer System for a Changing Climate: Developing a Road Map"

submitted by Lee Charleson

A one-day workshop, developed by Tree Improvement Branch (TIB) staff was held on February 24, 2011 bringing research and policy specialists in a variety of disciplines and backgrounds together support the development of a climate-based seed transfer system for BC. The twenty-eight participants spent a full day hearing presentations and discussing issues.

A number of research and policy initiatives are already underway in support of a climate-based seed transfer system. The workshop provided a day for dialogue and discussion about the work so far and an discussion of goals, objectives and strategy in the short and long term that are needed to achieve an effective and flexible climate-based seed transfer system for BC. The purpose of the workshop was to:

1. Follow-up and build upon the Seed Transfer and Climate Change workshop held on January 2008;
2. Share information on current research pertaining to the development of the scientific foundation for BC's Climate-Based Seed Transfer System;
3. Seek input from those working in policy development, climate change adaptation and disciplines related to climate based seed transfer e.g. ecology, biogeoclimatic ecosystem classification (BEC), and tree species selection;
4. Identify any gaps, concerns and issues pertaining to the scientific foundation, funding/resourcing, policy and/or decision support; and
5. Begin to articulate the development of a "Road Map" for undertaking work over the next 3 to 5 years.

Excellent reference material, composed of presentations made during the day and post-workshop synopsis, is available from the workshop. Eight presentations made during the workshop are posted on the following Tree Improvement Branch FTP server at http://www.for.gov.bc.ca/ftp/HTI/external/!publish/Archive/CBST_2011_Workshop/ . The presentations provide a snapshot of the status of the presenters' current work. Also, a summary document is available on the TIB website (see link, http://www.for.gov.bc.ca/hti/climate_based_seed_transfer/index.htm that includes highlights of each of the presentations, a capture of points raised during open forum to discuss issues and gaps, and points identified for developing a road map, and supporting, a climate-based seed transfer system.

To all of the presenters, thank you. And my thanks to the organizing committee composed of Diane Douglas, Leslie McAuley, Greg O'Neill, Barrie Phillips and Terje Vold for all their hard work, it was my pleasure to work with you on this workshop. It was a productive and successful day.

Reference material, composed of presentations made during the day and post-workshop synopsis, is available from the workshop.

An Introducton to the Whitebark Pine Ecosystem Foundation of Canada

submitted by Randy Moody

The Whitebark Pine Ecosystem Foundation of Canada (www.whitebarkpine.ca) was formed in 2011. Our mission is the promotion and conservation of whitebark pine ecosystems by supporting restoration, education and research projects that enhance the knowledge and stewardship of these valuable ecosystems.

Whitebark pine plays a vital ecological role and has been described as both a foundation and keystone species. Whitebark pine is well known as being an obligate mutualist of the Clark's nutcracker; forms an important food source for grizzly bears in some areas; and was traditionally used by First Nations. Whitebark pine numbers have been steadily declining due to the introduction of white pine blister rust, mountain pine beetle, fire suppression, and climate change. These collective threats have resulted in whitebark pine being blue-listed in British Columbia; listed as endangered by COSEWIC ; and recommended for an endangered listing under SARA. Despite its vital ecological role, little has been done to protect whitebark pine, in response to this we have formed the Whitebark Pine Ecosystem Foundation of Canada (www.whitebarkpine.ca). Our mission is the promotion and conservation of whitebark pine ecosystems by supporting restoration, education and research projects that enhance the knowledge and stewardship of these valuable ecosystems.

Our board of directors consists of seven individuals, six from BC and one from Alberta. Our board members include:

Judy Millar RPBio, Provincial Terrestrial Ecologist with the Ministry of Environment, BC Parks, Planning and Management Division. Judy has been a driving force behind whitebark pine work in Manning Park that includes seed collections, seedling planting, public outreach and ecosystem restoration planning.

Joyce Gould PhD is a conservation biologist with Alberta Parks and a member of the provincial recovery team for whitebark and limber pine. Joyce coordinates the conservation efforts for whitebark and limber pine for Alberta Parks and is actively involved in monitoring the health of populations and conducting research related to regeneration.

Michael Murray PhD is a forest pathologist for the Ministry of Forests, Lands, and Natural Resources located at the Kootenay Lake Forestry Centre in Nelson, BC. Michael is a Board Director of both the USA and Canadian Board of Directors for the WPEF. For his PhD he studied whitebark pine fire ecology-forest health.

Alana Clason is a PhD student at the University of Northern BC. She completed her MSc in summer 2010 at the University of Alberta, in collaboration with the Bulkley Valley Research Centre, working on whitebark pine ecology and resilience at the NW edge of its range. Catching the whitebark pine bug, she continues to persue whitebark pine research for her PhD, hoping to focus on the resilience of northern populations in both the coastal and Rocky Mountains under changing climate.

Joanne Vinnedge RPBio, is an ecosystem biologist working in the Ministry of Forests, Lands and Natural Resource Operations in Fort St James. She has been a keen advocate for the management of whitebark pine at the northern limit of its distribution in North America.

Don Pigott has worked in silviculture within BC, and internationally, for over 40 years and is the founder and owner of Yellow Point Propagation. Don has been involved in gene conservation of whitebark pine, and several other BC tree species considered to be priorities for both in situ and ex situ gene conservation.

Randy Moody RPBio is plant ecologist at Keefer Ecological Services Ltd. specializing in whitebark pine restoration, ecosystem mapping, and ecological restoration. For his graduate work, Randy worked on whitebark pine restoration in the Rocky Mountains and North Cascades.

Membership to the group is through our parent organization (www.whitebarkfound.org). Membership benefits include the semi-annual journal 'Nutcracker Notes,' that is dedicated to whitebark pine research and conservation.

To-date we have hosted two whitebark pine workshops, one in Lillooet in July 2011 and one in Vancouver in December 2011. The Lillooet workshop was attended by about 40 individuals and was co-hosted by the Lillooet Tribal Council and Lillooet Naturalists Club. The Forest Genetics Council supported the Lillooet event.

The Vancouver meeting was held in conjunction with the BC Protected Areas Research Forum in an attempt to bring the issues facing whitebark pine to a broader audience.

In early September 2012 we will be hosting the Whitebark Pine Ecosystem Foundation Annual Science Meeting in Kimberley BC. This meeting will consist of one day of research presentations followed by a field day to local whitebark pine stands. We are hoping to attract many researchers and practitioners from across the range of whitebark pine, so it is a great opportunity to learn about whitebark pine conservation from experienced individuals. See you there.

To-date we have hosted two whitebark pine workshops, one in Lillooet in July 2011 and one in Vancouver in December 2011.

Figure 1. Field tour to top of Poison Mountain, Whitebark Pine Ecosystem Foundation of Canada, Whitebark Pine: Science and Management Forum, Lillooet, July 2011. (photo by Ian Routley)

Journal Articles

Yousry El-Kassaby

Baltunis BS, JH Russell, A Van Niejenhuis, YA El-Kassaby. 2011. Genetic analysis and clonal stability of a yellow cypress clonal population from bulked seedlots using a post hoc reconstructed pedigree. Tree Genetics and Genomes (accepted with revision).

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Honour

Figure 1. Dr. Yousry El-Kassaby receives an honorary professorship in Dendrology and Forest Tree Breeding discipline. The ceremony was held at the University of Life Sciences, Prague, Czech Republic on October 17, 2011. It was followed by a meeting with the Minister of Environment and 2 TV interviews (one in English and the other in Czech).

Figure 2. Sheila Reynolds and Dr. Yousry El-Kassaby survey Sitka spruce crop at Nootka Seed Orchard in 1988.

Events

BC Seed Orchard Association (BCSOA) and Northwest Seed Orchard Manager's Association Joint Meeting (NWSOMA) – Port Angeles, WA and Victoria, BC June 26-27, 2012. http://www.for.gov.bc.ca/hti/events/bcoa.htm

Early September, 2012 Whitebark Pine Ecosystem Foundation Annual Science Meeting, Kimberley, BC. One day of research presentations followed by a field day to local whitebark pine stands. www.whitebarkpine.ca

Forest Nursery Association of BC Annual General Meeting, Campbell River – September 24 – 26, 2012. http://fnabc.com/

Forest Genetics 2013, Whistler BC, July 22-25, 2013. http://www.forestgenetics2013.ca/

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