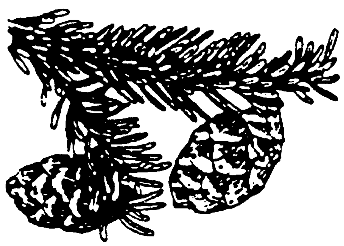
CANADIAN FOREST GENETICS ASSOCIATION
ASSOCIATION CANADIENNE DE GÉNÉTIQUE FORESTIÈRE



Tree Seed Working Group

NEWS BULLETIN

No. 49 July 2009

THIS ISSUE AT A GLANCE

Page	Article
3	Cone and Seed Pest Research Program: Research Update
6	Living in a Degree-day World in the Seed Orchards of British Columbia
7	Growing Degree Days and Seed Maturation
9	Abnormal Germinants
12	Fungal Assay Update
14	Processing Lodgepole Pine Collections in Multiple Portions
15	New Standards for Alberta
15	CFGA Meeting
16	Erratum
16	Upcoming Meetings
16	Recent Publications

CHAIR'S 'ARMCHAIR' REPORT

I hope everyone is having a good summer. It seems like the weather is just warming up and days are getting shorter already. From what I hear most areas of Canada have had a slow, cool spring and cone crops are behind their 'average' stage thus far. Let's hope for some hot dry weather to further these crops along and hopefully initiate some bumper ones for next year. Weather is an easy opener, but my motives are to steer our thoughts to crop development and especially the topic of growing degree days (or thermal units). Jim Corrigan, our EEE (Extraordinary Extension Entomologist) contributed a short article on a program he is spearheading in interior BC seed orchards to improve the precision of predicting the phenological status of cone and seed pests to increase the efficacy of control measures. I think that degree day summation also has great potential for seed orchard management in such diverse areas as collection timing, helping to explain crop quality variability between years, assisting in timing of induction treatments, and possibly improving precision of our effective population sizes (by helping to quantify potential and impossible clonal crosses within a given year?). The topic has a long history in agriculture and horticulture and there has been some work done on trees, primarily on *Picea* spp. in Canada. A short literature review is enclosed as well as a challenge to our readers to let us know what additional references exist for degree day summations and cone/fruit crop development. Look forward to hearing from you.

I expect budget reductions and gloomy scenarios are facing most of us today. In BC, with Mountain Pine Beetle we are somewhere between the expected 50% (2007) and 80% (2013) mortality of our merchantable pine[1]. Throw in a poor lumber market to our surplus of ready to harvest timber and we are in the 'middle' of declining harvest and planting levels. The small silver lining to all this tree mortality is that there was a canopy seed crop to collect from with the serotinous lodgepole pine cones. This has resulted in very large crops of lodgepole pine being collected year round to ensure a future seed supply. This has not gone without challenges and Debbie Picard outlines some of our challenges in her enclosed article. The scary part is what happens when the pests start hammering our crops without a seed bank! Hopefully an inventory exists and/or seed orchards are under full production – then we just have to adjust our deployment in light of climate change – interesting times indeed.

For me personally there has been a change in responsibilities as I have taken over leadership of our testing team in addition to my other duties. Included in this News Bulletin are a couple of articles updating the results from our fungal assay program (last presented in News Bulletin #41) and some new information related to the subject of abnormal germinants which hasn't received a great deal of attention, but can significantly impact the germination capacity of seedlots. Hopefully it will encourage others to contribute their experiences in dealing with the assessment of abnormal germinants. On that note, our upcoming 50th TSWG News Bulletin will have a theme of **Seed Testing** as this hasn't been a theme since edition 32 (December 2000). I can personally guarantee a few articles on the topic and the recent theme-less News Bulletins (#48 and #49) do not seem to attract more contributions. Thank you to everyone who contributed to this News Bulletin and everyone, please give some thought to an article for the upcoming 50th edition of the Tree Seed Working Group News Bulletin.

I decided to save the worst for last, although most people will already have heard. Shortly after publication of our last Newsbulletin, Dr. Kris Morgenstern passed away on December 31st, 2008 and his obituary can be found at this link:
http://www.legacy.com/can-ttawa/Obituaries.asp?Page=Lifestory&PersonId=122233575
This was a sad day as I personally worked for Kris and his students at UNB for two summers and he was my undergraduate thesis advisor. I strongly remember Kris' kind nature, wisdom, investigative mind, and his strong sense of practically integrating tree improvement into silviculture. He leaves behind a wealth of publications, wisdom, and many fond memories for those that knew him. Kris was one of the original Tree Seed Working Group members (see Newsbulletin #3) and I thought it would be appropriate to also honour our other original members who have passed on – Guy Caron, John Farrar, Clare Hewson, Don Levy, Jack Pitel, Stephen Ross, Betty Sommerfield, Oscar Sziklai, and Katherine Yakimchuk – gone, but not forgotten. Please let me know if I've missed anyone. Best wishes to you and your loved ones.

Dave Kolotelo
TSWG Chair

EDITOR'S NOTES

Welcome to another issue of the Tree Seed Working Group's News Bulletin. This is an 'open' Bulletin and hence a variety of articles courtesy of your colleagues from western Canada. As Dave has mentioned the theme of the next News Bulletin will be **Seed Testing**. I hope that many of you will feel led to share some of your thoughts, ideas, results, and anything else that is pertinent to this topic.

Ward Strong has written an interesting article, complete with some very nice pictures, about research on cone and seed pests. Other than the work that is being conducted in BC I have not heard much about this topic elsewhere in Canada. This is followed by two nice articles by Jim Corrigan and Dave Kolotelo on growing degree days for predicting development of cone and seed pests and when cones are mature for collection. Dave wrote about abnormal germinants and it is interesting to see how this varies among species. It would be nice to hear from others who test seeds how they assess abnormal germinants and if any synthesis has been done with the data. Dave has another article that provides an update on fungal assays conducted at the BC Tree Seed Centre and this issue is completed with an article by Debbie Picard about processing lodgepole pine cones. With all the salvage operations occurring due to mountain pine beetle there has been a steady flow of cones to the Seed Centre

I too wish each and every one of you a great summer!

Dale Simpson
Editor

[1] For more information see the Mountain pine beetle action Plan
http://www.for.gov.bc.ca/hfp/mountain_pine_beetle/actionplan/2006/Beetle_Action_Plan.pdf

TREE SEED WORKING GROUP

Chairperson
Dave Kolotelo
BC Ministry of Forests and Range
Tree Seed Centre
18793 - 32nd Avenue
Surrey, BC V3F 0L5
Tel.: (604) 541-1683 x 2228
Fax.: (604) 541-1685
E-mail: Dave.Kolotelo@gov.bc.ca

Editor
Dale Simpson
Natural Resources Canada
Canadian Forest Service
Atlantic Forestry Centre
P.O. Box 4000
Fredericton, NB E3B 5P7
Tel.: (506) 452-3530
Fax.: (506) 452-3525
E-mail: Dale.Simpson@nrcan.gc.ca

Comments, suggestions, and contributions for the News Bulletin are welcomed by the Chairperson and Editor.

CONE AND SEED PEST RESEARCH PROGRAM: RESEARCH UPDATE

What's brown and black and red all over? A *Leptoglossus* seedbug marked with fluorescent powder! While the yellow-marked ones were actually more visible (Fig. 1), we ended up using numbers written on painted marks on the bugs' backs (Fig. 2) for our Mark-Release-Recapture (MRR) project.

Figure 1. Seedbug marked with yellow fluorescent powder

Figure 2. Seedbug marked with paint on pronotum and felt-penned number.

The *Leptoglossus* MRR project, designed to determine dispersal and population dynamics characteristics of this serious seed orchard pest, is a part of the Cone and Seed Pest Research Program of the BC Ministry of Forests and Range (MoFR). This research program was established in 2006 with funding from the Forest Genetics Council of BC (FGC). The FGC also provides guidance and technical direction through the Pest Management Technical Advisory Committee, chaired by Dr. Robb Bennett, MoFR. I lead the research activities with a series of in-house projects, funded graduate student projects, and collaborative grants to universities.

Figuring out how to mark a seedbug was just a precursor to the current research program, which involves a graduate student from University of Northern BC (UNBC), partnership with University of British Columbia (UBC)-Okanagan, and fund-matching from MITACS (Mathematics of Information Technology and Complex Systems), a national program to encourage the use of mathematics in industry and technology. By using MRR with various mathematical models, we can deduce dispersal patterns and edge-effect build-up, absolute population densities, and construct economic thresholds for management of *Leptoglossus*.

The *Leptoglossus* research furthers the objective of the Cone and Seed Pest Research Program: to develop the background knowledge required to effectively manage our main pests in BC seed orchards. Little is known of the basic biology and ecology of many of our pests, hampering our ability to deal with them. Our research programs seek to fill in the knowledge gaps. The main areas of current research are described below.

- **Pesticide trials**.
  Collaborators: Robb Bennett and Jim

Corrigan, Tree Improvement Branch; CropHealth Advising and Research, Kelowna.

Using the large pressurized syringes of the Arborjet injection system (Fig. 3), we injected systemic insecticides into seed orchard trees in 2007 and 2008. Data from other systems showed that two chemicals, imidacloprid and emamectin-benzoate, could protect trees for more than one year from many types of insects. We managed to get very little uptake in the trees, possibly because the timing of injections had to be quite early in the spring, before high rates of transpiration. As a result, we found almost no effect of the stem injections on cone and seed pests. The technique was also very time-consuming and the pesticides expensive, making us think that operational adoption would be unlikely. Therefore in 2009 we scrapped injectable systemics and are trying foliar sprays of some promising new chemistries. These are:

- spinetoram (trade name Delegate, a spinosyn, derived from actinomycetes)
- methoxyfenozide (trade name Intrepid, a juvenile hormone analogue)
- chlorantraniliprole (trade name Altacor, very low mammalian toxicity)
- tebufenozide (trade name Confirm, an ecdysone agonist)
- spirotetramat (trade name Movento, a systemic lipid biosynthesis inhibitor).

Figure 3. Arborjet pesticide injection system.

- **Douglas-fir Coneworm Biology and Reproductive ecology**
  Collaborators: Maya Evenden, University of Alberta.
  Graduate student: Caroline Whitehouse, M.Sc. student, U of A.

Despite extensive visual searches, soil sifting, and ground emergence traps (Fig. 4), we are still trying to figure out where coneworms lay eggs, what stage(s) they overwinter in, and where the overwinter stages hang out. Using pheromones developed by the Cone and Seed Pest Research program, Caroline has confirmed that male moths fly all summer long, from early May through late September. Using light traps, she found that females fly from mid-June to mid-August, and nearly all females trapped were mated. Most females had mated multiple times. It's possible that unmated females do not disperse and that females die earlier in the autumn than males. Females call (release pheromone to attract males) in the night, and calling lasts between ½ and 9 hours. Young females (< 2 days old) call much less than older females. There are strong indications that cone volatiles must be present to stimulate oviposition. This information has strong implications for future development of pheromone-based control using either mating disruption or attract-and-kill technology.

Figure 4. Caroline Whitehouse's ground emergence trap: after overwintering in the soil, emerging insects are caught in the clear flask at the top.

• **Western Conifer Seedbug Mark-release-recapture**
Collaborators: Staffan Lindgren, UNBC; Sylvie Desjardins, UBC-Okanagan; MITACS.
Graduate student: Tamara Richardson, M.Sc. student, UNBC.

Using the marking techniques described above, Tamara has determined that edge effects develop quickly in the spring, and then dissipate as insects continue to move into an orchard. They tend to move to certain clones, accumulating in great numbers on certain ramets of these clones, while avoiding other clones altogether. This discovery led to an investigation of the reasons for clonal preference. This year Tamara will more thoroughly investigate her 2008 findings that seed content and cone number were unimportant, but that favoured clones had significantly larger cones, the cones were of intermediate temperature (39–40 ºC), and the cones had a specific terpene profile (Fig. 5), with significantly lower amounts of D-3-carene and β-phalendrine. Tamara is currently working on determining absolute population densities within an orchard; this information will be used to calibrate our visual monitoring system, eventually to create economic action thresholds.

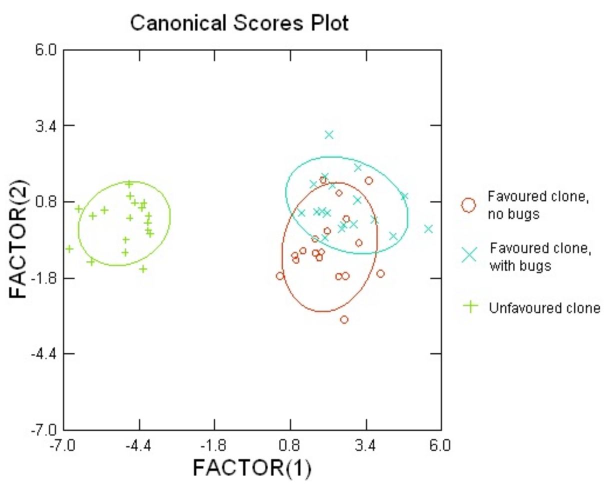


Figure 5. Principle Components analysis of terpene profiles for favoured vs. unfavoured clones. Favoured clones were further divided into ramets that harboured bugs and ramets that did not harbour bugs.

• **Western Conifer Seedbug host-finding mechanisms**
Collaborators: Gerhard Gries and Stephen Takacs, Simon Fraser University (SFU).
Graduate student: Tracy Zaradnik, Ph.D. student, SFU.

The Gries lab is working to put to use their discovery that *Leptoglossus* finds cones by "seeing" infrared radiation (IR). They are currently determining the range of IR that *Leptoglossus* is most sensitive to, the optimum size of objects that attract the insects, and the most attractive visual-spectrum colour. They have determined that medium-sized objects are more attractive than smaller or larger ones, and that certain hues of green are highly attractive. We are hoping to develop a trap based on infrared (Fig. 6) for monitoring and possibly control. Their lab has also recently found that another major cone pest, *Contarinia oregonensis*, is attracted to infrared; confirming suspicions that using IR as a host-finding mechanism may be widespread in cone-feeding species. They are also collaborating with the preferred-host studies conducted by Tamara Richardson (above).

Figure 6. Trial of traps for *Leptoglossus*; the black prototype emits high IR while white emits low IR.

• **Douglas-fir cone gall midge pheromone production system**
Collaborators: Gerhard Gries and Robert Britton, SFU.

This project is designed to develop a new method of producing *Contarinia oregonensis* pheromone. This pheromone, discovered by the Gries lab and the Cone and Seed Pest group in the 1990s, offers potential for monitoring, decision-making, and control of gall midges (Fig. 7). However, the production method is inefficient, making production of large quantities prohibitively expensive. Dr Britton has devised a new, more efficient synthesis pathway that will be tested with this project. Plans for future research with gall midge pheromone await the successful outcome of the new synthesis method.

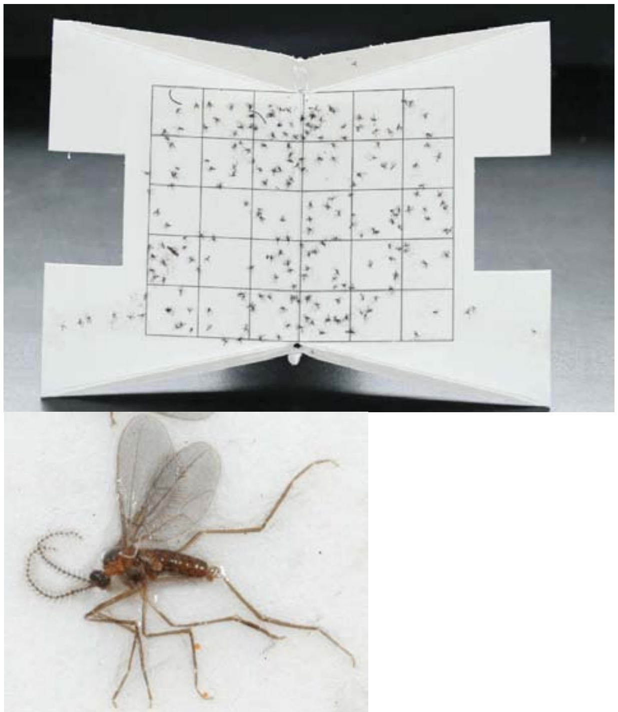


Figure 7. Catches of *Contarinia oregonensis* in a pheromone trap with the Gries-lab synthetic pheromone as a lure.

Combined with several smaller in-house trials, these research projects cover the most pressing cone and seed pest issues in BC. That brown and black and red-all-over seedbug will eventually result in better yields for BC seed orchards.

Ward Strong
BC Ministry of Forests and Range
Research Branch
3401 Reservoir Road
Vernon, BC V1B 2C7
E-mail: Ward.Strong@gov.bc.ca

LIVING IN A DEGREE-DAY WORLD IN THE SEED ORCHARDS OF BRITISH COLUMBIA

Because insect development is temperature dependent, any measurements of population-level processes that depend upon either physiological development or behaviour are best measured in terms of the number of degree days required rather than time. (Beresford and Sutcliffe 2009).

Most insect pests encountered in conifer seed production are poikilothermic (commonly called 'cold-blooded') organisms, in that there is an inverse linear relationship between temperature and the time it takes them to reach important developmental milestones (e.g., post-winter emergence, egg hatch, commencement of larval feeding, pupation, adult eclosion, mating, and oviposition). For these species, higher ambient temperatures experienced during non-diapausing life stages will accelerate their rates of development.

In the field, the recording of accumulated heat units, often called Growing Degree Days (GDD), along with good knowledge of the developmental biology of pest species, can lead to more precise prediction of their developmental phenology. Accurate prediction of the seasonal biology of pest species is one of the fundamental pillars of modern integrated pest management, as it allows for precise application of control measures at the ideal time to affect the pest population.

Monitoring and prediction of pest biology on a GDD basis is a widely used technique in many areas of agricultural pest management. We believe that similar programs could be equally valuable in the conifer seed orchards of British Columbia. In 2008, temperature and GDD recording equipment was installed at each of ten conifer seed orchard locations in the Interior of British Columbia. The HOBO Micro Stations record temperature on an hourly basis and calculate GDD accumulations for each 24 hour period (http://www.onsetcomp.com/products/data-loggers/h21-002). The model employed to calculate GDD accumulations is the Actual Temperature Method with horizontal cutoffs, which are set at a 5°C lower threshold and a 35°C upper threshold. The resultant datasets are being used to develop seasonal GDD profiles for each seed orchard location (Fig. 1).

GDD profiles need to be combined with close observation of the important pest species at each seed orchard location. Orchard staff will monitor for events such as post-winter emergence, mating activity, and the initiation of larval feeding. The date that each event is observed will be recorded throughout the growing season. By comparing these field monitoring records with the GDD accumulations to that date, GDD values can be associated with the timing of important developmental events in the life cycles of most of our important cone and seed pest species.

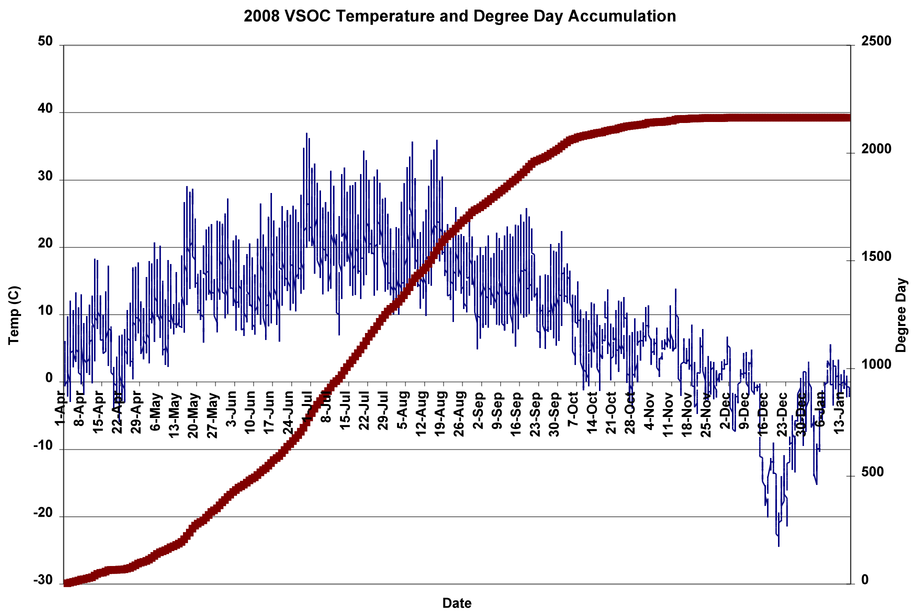


Figure 1. Graph of 2008 hourly temperatures (left axis) and cumulative GDD data (right axis) from HOBO sensor located at the Vernon Seed Orchard Company, Vernon, BC. Graph prepared by Tia Wagner, Pest Biologist, VSOC.

Each location will have a unique GDD seasonal profile which will be refined over multiple years of temperature recording and on-the-ground pest monitoring. Over time, site and pest specific GDD records will become increasingly finely tuned and will become stronger predictive tools for onsite pest management.

Reference

Beresford, D.V.; Sutcliffe, J.F. 2009. Sampling designs of insect time series data: are they all irregularly spaced? OIKOS 118:115–121.

Jim Corrigan
Ministry of Forests and Range
Tree Improvement Branch
3401 Reservoir Road
Vernon, BC V1B 2C7
E-mail: Jim.Corrigan@gov.bc.ca

GROWING DEGREE DAYS AND SEED MATURATION

Here is a listing of articles related to degree-day summations and cone crop development. It isn't a thorough literature review, but a capture of references readily available in my files. Please forward any additional references and we'll include them in the next News Bulletin. In Table 1, I've tried to summarize the pertinent information from these references related to growing degree days (GDD) and seed development including the minimum GDD accumulation for normal seed development, the starting point, threshold used, and basis of accumulation. Most of the references used a similar method of calculating GDD using the daily mean temperature and a threshold of 5°C, but not all studies used the same starting point.

Most of the articles deal with white or black spruce indicating we have very little information available on GDD requirements for other tree species. The date to start accumulation of GDD was the least consistent variable and explains a large part of the different minimum GDD estimates for white spruce between the Zasada (1973) and Mercier and Langlois (1999) paper. The latter paper is interesting as it uses fireweed

Table 1. Minimum growing degree day accumulation, starting point, threshold used, and basis of accumulation for tamarack and several spruce and pine species.

Reference	Species	Minimum GDD	Starting Point	Threshold / basis
Smith 1981	*Larix laricina*	1100–1150	?	?
Mercier and Langlois 1999	*Picea glauca*	1276 ± 112 **1943 ± 155 <u>TU</u>**	temperature >0°C	> 5° C / daily mean **Thermal Units**
Meunier et al. 2007	*Picea mariana*	800–940	temperature >5°C	> 5° C / daily mean
Mosseler 1992	*Picea mariana* *Picea glauca*	900 1100	after pollination	> 5° C / daily mean > 5° C / daily mean
Mosseler et al. 1993	*Picea mariana* *Picea glauca*	800 900	after pollination	
Smith 1983	*Picea glauca*	1350–1400	?	> 5° C / daily mean
Sirois 2000	*Picea mariana*		temperature >0°C in growing season	> 5° C / daily mean
Noland et al. 2006	*Pinus strobus*	1996 period – 321 2000 period – 356	April 1 to June 15	> 5° C / daily mean
Sirois et al. 1999	*Picea mariana*	800–944	starting June 6th	> 5° C / daily mean
Tanaka and Cameron 1979	*Pinus ponderosa*	1310	starting June 1st	> 5° C / daily mean
Winston and Haddon 1981	*Picea glauca*	1222–1275	Starting May 22 (pollen shed)	> 5° C / daily mean
Zasada 1973	*Picea glauca*	681–751	after pollination	> 5° C / daily mean
Zasada 1987	*Picea glauca*	670–700 for 75% embryo growth	after pollination	> 5° C / daily mean

as an indicator plant to integrate environmental factors together. Mercier and Langlois (1999) found the strongest correlation between germination and fireweed capsule bursting (r = 0.92), followed by thermal units (TU) (r = 0.88), and then GDD (r = 0.84). In terms of temperature accumulation it appears that thermal units are worthy of further exploration. Previous studies have suggested other variables (i.e., solar radiation, precipitation, latitude, humidity, and wind) may interact with GDD to influence seed maturation and should be considered further (Zasada 1973, Winston and Haddon 1981). Fortunately a variety of programs are available today that can provide additional climate variables to assist in this type of exploration (i.e., Climate BC[1]). Lastly, I'll draw your attention to Figures that illustrate megagametophyte and embryo development across GDD in Sirois et al. (1999 – Figure 21) and Meunier et al. (2007 – Figure 2). Imagine those images integrated with the initiation of cone attack on cone phenology images presented in Turgeon and DeGroot (1992) and you have a very powerful extension and planning tool.

References

Mercier, S.; Langlois, C.-G. 1993. Relationships between *Epilobium angustifolium* phenology and *Picea glauca* seed maturation. For. Ecol. Manage. 59:115–125.

[1] Climate BC - http://www.genetics.forestry.ubc.ca/cfcg/climate-models.html

Meunier, C.; Sirois, L.; Begin, Y. 2007. Climate and *Picea mariana* seed maturation relationships: A multi-scale perspective. Ecol. Monogr. 77(3):361–376.

Mosseler, A. 1992. Seed yield and quality from early cone collections of black spruce and white spruce. Seed Sci. Technol. 20:473–482.

Mosseler, A.; Johnsen, K.H.; Tricco, P. 1993. Growth performance in seedlings derived from premature cone collections from natural populations of black spruce and white spruce. Seed Sci. Technol. 21:537–544.

Noland, T.L.; Parker, W.C.; Morneault, A.E. 2006. Natural variation in seed characteristics of eastern white pine (*Pinus strobus* L.). New For. 32:87–103.

Sirois, L. 1998. Female gametophyte and embryo development of black spruce along a shore-hinterland climatic gradient of a recently created reservoir, northern Quebec. Can. J. Bot. 77:61–69.

Sirois, L. 2000. Spatiotemporal variation in black spruce cone and seed crops along a boreal forest – tree line transect. Can. J. For. Res. 30:900–909.

Smith, R.F. 1981. How early can tamarack cones be collected? Environ. Can., Can. For. Serv., Maritimes For. Res. Cent., Tech. Note 35, 4 p.

Smith, R.F. 1983. How early can white spruce cones be collected? Environ. Can., Can. For. Serv., Maritimes For. Res. Cent., Tech. Note 92, 2 p.

Tanaka, Y.; Cameron, P.C. 1979. Maturation of Ponderosa pine seeds in southern Oregon. Pages 218–225. *In* F.T. Bonner, ed. Proc. Flowering and Seed Development in Trees. 15–18 May 1978. USFS South. For. Exp. Sta., Starkville, MS.

Turgeon, J.J.; DeGroot P. 1992. Management of insect pests of cones in seed orchards in eastern Canada. For. Can. and Ontario Min. Nat. Res. 98 p.

Winston, D.A.; Haddon, B.D. 1981. Effects of early cone collection and artificial ripening on white spruce and red pine germination. Can. J. For. Res. 11:817–826.

Zasada, J.C. 1973. Effect of cone storage method and collection date on Alaskan white spruce (*Picea glauca*) seed quality. IUFRO Working Party S2.01.06 International Symposium on Seed Processing "Seed Problems". Vol. 1 Paper 19. 10 pp.

Zasada, J.C. 1988. Embryo growth in Alaskan white spruce seeds. Can. J. For. Res. 18:64–67.

Dave Kolotelo

ABNORMAL GERMINANTS

In the estimation of the germination capacity (GC) of a seedlot only the normal germinants are included in the calculation. A normal germinant is generally defined as a germinating seed showing the potential to develop into a normal seedling under favourable conditions. If we have normal germinants, then we must have abnormal germinants (simply called abnormals hereafter) and this relatively scarce group is the subject of this article. Abnormals are defined by the Association of Official Seed Analysts (AOSA 2006) as "all seedlings that cannot be classified as normal seedlings" and by the International Seed Testing Association (ISTA 2007) in terms of specific defects defined in section 5.2.5.A. Of particular interest to us are defects of the primary root (I), hypocotyl (II) or the entire seedling (VII), but descriptions of defects to the cotyledons, primary leaves, and terminal bud are also included.

At the BC Ministry of Forests and Range Tree Seed Centre (TSC) we have been recording number of abnormals by test replicate using a set of standard abnormal types. Data from a total of 24 511 standard germination tests, performed since 1994, were analyzed for the occurrence of abnormals. Some seedlots are included multiple times in this analysis and all species presented were based on at least 100 germination tests. Across all species and germination test types, each germination test has an average of 2.8% abnormals identified (equals an average of 11.2 total abnormals identified in a 400-seed germination test). A listing of our abnormal types, a brief description, and their proportional contribution to the 2.8% is presented in Table 1 clearly showing that stunted radicles are the most common type of abnormal. The four most common abnormal types account for roughly 94% of the identified abnormals. The remaining six types, accounting for 6% of the abnormals, will be grouped together as 'Other' to simplify comparisons across species.

The occurrence of abnormals varies greatly by species and Fig. 1 presents the proportions of the top four abnormal types and "Other" across our BC tree species[1]. Western hemlock (Hw) clearly has the highest proportion of abnormals (9.2%) and is also the species with the highest proportion of stunted radicles (90%). Other species averaging above 5% abnormals are mountain hemlock (Hm = 6.0%), western redcedar (Cw = 6.0%), and Grand fir (Bg = 5.1%) and the only other species exhibiting above average abnormal counts are western larch (Lw = 4.0%), Noble fir (BP = 3.8%), and Amabilis fir (BA = 3.7%). All of the remaining species average below 2.4% abnormals per germination test. Stunted radicles account for more than 50% of the abnormals in all species except subalpine fir (Bl = 32%), western larch (Lw = 47%), western white pine (Pw = 23%), yellow pine (Py = 44%), interior spruce (Sx = 48%), and yellow-cedar (Yc = 32%).

Table 1. The abnormal germinant classes and their relative contribution to the total of abnormals across all species and test types.

Classification	Description	Proportion
Stunted Radicle	Radicle emergence, but failure to reach length of 4X seed coat. Tip often blunt and darkened.	63.1%
Rotten	Tissues have become decayed.	11.4%
Reversed	Cotyledons emerging first.	10.2%
Weak	Radicle emergence, but failure to reach length of 4X seed coat. Radicle may be thin and spindly displaying low vigour or extremely small for species of interest.	9.0%
Megagametophyte Collar	Megagametophyte restricting normal radicle emergence, often appearing as a collar or extremely swollen tissues.	2.2%
Pregermination	Germination prior to pre-treatment completion	1.8%
Other	Assessed as not able to produce a viable seedling, but failing to clearly fit a category (i.e., emergence of two embryos).	1.3%
Twisted	Hypocotyl tightly twisted (360°), germinant unlikely to form a normal seedling.	0.2%
Stunted Hypocotyl	Radicle may appear normal or absent, but hypocotyl is short or blunt for species of interest.	0.2%
Thickened Hypocotyl	Radicle appears normal, but hypocotyl is thickened in comparison to radicle.	0.2%

Abnormal germinants are present in virtually all seedlots and therefore have an impact on a seedlots' estimated germination capacity. Some classes are easily identified (i.e., Reversed,

[1] The BC Tree Code List can be found at this link http://www.for.gov.bc.ca/hre/becweb/Downloads/Downloads_SpeciesList/treecode_45.doc

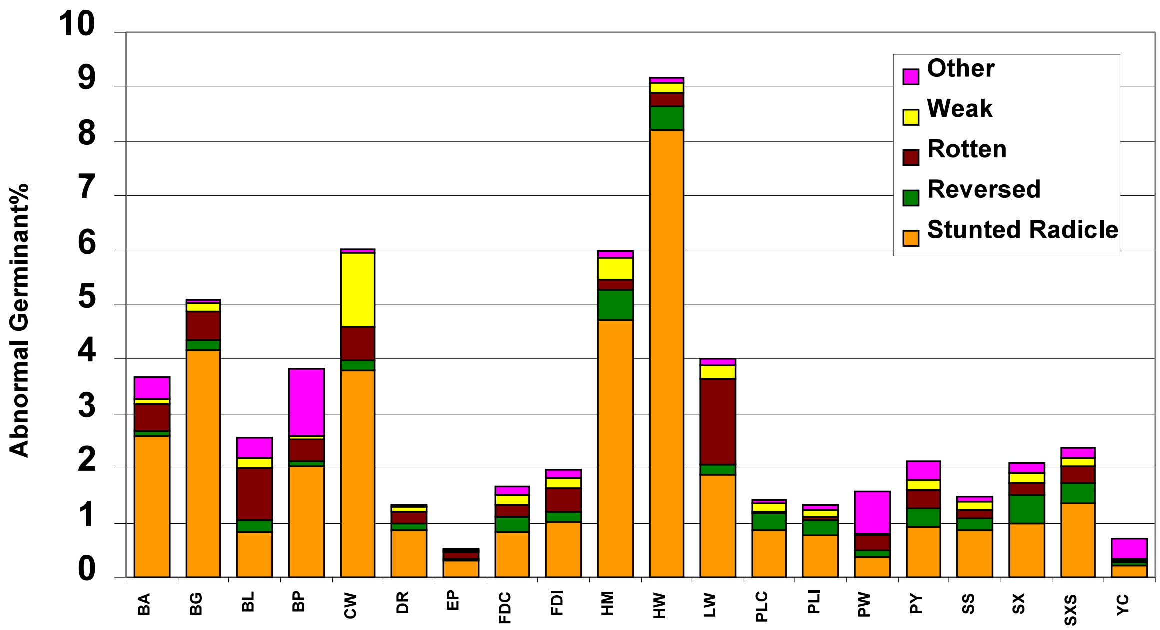


Figure 1. The percentage of abnormal germinants presented by species and abnormal germinant class.

Rotten), yet some of the classes can be quite subjective such as Weak, Twisted, and Other. In addition to quantifying the frequency of abnormal germinants, we will also be creating an abnormal germinant classification guide to assist with standardization. Stunted radicles are especially interesting due to their frequency and somewhat mysterious origin. I think that at least some of these stunted radicles are simply due to damage to the root apical meristem allowing existing cells to expand, but not permitting cell division to continue. We are hoping to perform some histological examinations to confirm this.

The other pertinent question is whether our assessment of abnormal germinants corresponds to the fate of those seeds in the nursery (i.e., inability to produce a viable seedling)? This is not an easy question to definitely answer, but the generally good correspondence between test and nursery germination for western hemlock (Hw), mountain hemlock (Hm), and western larch (Lw) is reassuring[2]. Large differences between germination tests and the nursery exist for western white pine (Pw), red alder (Dr), and subalpine fir (Bl), but these species have below average numbers of abnormal germinants. It is possible we are underestimating abnormals in these species, but there are a variety of other factors (i.e., actual duration of stratification, seed treatment, germination conditions, and culling standards) that can play as large a role in the production of acceptable seedlings.

I'd be interested to hear how other jurisdictions deal with the assessment of abnormal germinants and their frequency. It's a great opportunity to contribute to our 50th edition of the News Bulletin in December.

References

AOSA. 2006. AOSA Rules for testing seeds. Assoc. Off. Seed Anal. Stillwater, OK.

ISTA. 2007. International rules for seed testing. Edition 2007. International Seed Test. Assoc. Bassersdorf, Switzerland.

Dave Kolotelo

[2] 2008 Sowing Request Quality Assurance Results – Dave Kolotelo, TicTalk, December 2008 http://www.fgcouncil.bc.ca/tictalk_2008-final2-web.pdf

FUNGAL ASSAY UPDATE

The BC Ministry of Forests and Range Tree Seed Centre (TSC) continues to fund a fungal assay program as a critical and cost-effective step to direct integrated pest management (IPM) practices and improve seed-use efficiency. Information regarding the presence of a pathogen and its contamination or infection levels should influence seed sanitation, sowing, and germination practices. This article is an update of information related to our fungal assay program which has also been reporting in News Bulletin #41 (June 2005).

The results presented in Tables 1–3 are based on all 6532 tests performed, although some seedlots have expired since testing. To conserve table space, the BC species codes are used to identify species[1]. The cells identified in **Red** indicate a high testing priority and **Blue** indicate a medium testing priority. Variables presented are described below with an emphasis on differentiating pathogens that are contaminants of the seed coat (i.e., *Fusarium* sp.) that can be reduced through surface seed sanitation techniques and the pathogens which are infections (*Caloscypha* and *Siroccoccus*) in which other IPM practices need to be employed.

Following is a description of the various table headings:
#T = the number of tests performed for this tree seed/pathogen combination
MeanI or MeanC = the average infection or contamination of ALL tests performed for this tree seed*pathogen combination
%I or %C = the % of seedlots showing an infection or contamination level > 0.0% for this tree seed*pathogen combination
AveI or AveC = the average infection level of seedlots showing an infection or contamination > 0.0% for this tree seed*pathogen combination
MaxI or MaxC = the maximum infection or contamination found for this tree seed*pathogen combination.

I think it is important to present several variables as only the mean of all tests or the average of tests > 0.0% only presents part of the story. The terminology used can be confusing and alternate suggestions are welcome. An example is probably helpful, so let's look at the results for coastal Douglas-fir (Fdc) for *Fusarium* testing. There have been 458 tests performed with a 1.6% average level of *Fusarium* estimated. The probability of a seedlot being contaminated is 56.1% and for those contaminated seedlots, the average contamination level is 2.9%. The worst case scenario was an 84% contamination level providing an indication of how bad the situation can be.

A common question is at what level is a fungal assay result significant? This is not an easy question to answer as other factors such as the germination environment, seed treatment, and moisture content can have a significant impact on actual disease occurrence. For *Fusarium* spp. and *Caloscypha fulgens* a level of 5% or more is considered significant, but for *Sirococcus conigenus* a level of 1% is considered significant as this pathogen can spread to adjacent seedlings quite rapidly. Pathologists were less comfortable assigning a specific significance level to *Fusarium* as disease incidence could be significantly influenced by actual *Fusarium* species (assays to species level are currently cost prohibitive), variability in bulking-up rates for stratified seed, and differences between tree species. Fusarium levels under 5% can still lead to diseases under specific conditions and greater due diligence on a seedlot level is required with this pathogen.

[1] The BC Tree Code List can be found at this link http://www.for.gov.bc.ca/hre/becweb/Downloads/Downloads_SpeciesList/treecode_45.doc

Table 1. Results of the BC Ministry of Forests and Range, Tree Seed Centre fungal assay program for *Calosypha fulgens* (Infection).

Sp.	# T	MeanI	%I	AveI	MaxI
Ba	208	0.5	14.4	3.6	22.0
Bg	43	0.7	14.0	5.1	12.4
Bl	214	1.7	35.5	4.7	32.8
Bn	22	0.1	4.5	2.0	2.0
Cw	4	0.0	0.0	0.0	0.0
Fdc	59	<0.1	1.7	0.4	0.4
Fdi	131	0.1	8.4	1.6	4.4
Hm	9	0.0	0.0	0.0	0.0
Hw	54	<0.1	7.4	0.4	0.4
Lw	16	0.0	0.0	0.0	0.0
Plc	5	0.0	0.0	0.0	0.0
Pli	50	0.0	0.0	0.0	0.0
Pw	87	0.1	5.7	1.8	4.8
Py	20	0.5	10.0	5.2	10.0
SS	84	0.7	10.7	7.0	37.6
Sx	384	0.2	11.2	2.1	16.0
SxS	61	0.6	26.2	2.3	16.0
Yc	6	0.0	0.0	0.0	0.0
Total	1457				

Table 2. Results of the BC Ministry of Forests and Range, Tree Seed Centre fungal assay program for *Fusarium* spp. (Contamination).

Sp.	# T	MeanC	%C	AveC	MaxC
Ba	287	0.4	33.1	1.2	14.0
Bg	64	0.6	43.8	1.4	7.0
Bl	247	0.2	32.0	0.6	2.8
Bn	22	0.5	50.0	1.0	2.0
Cw	298	0.7	48.3	1.5	20.4
Fdc	458	1.6	56.1	2.9	84.0
Fdi	558	1.0	57.2	1.8	42.0
Hm	31	<1.0	12.9	0.2	0.2
Hw	169	0.2	30.8	0.7	4.8
Lw	227	1.6	63.4	2.5	43.2
Plc	12	<0.1	8.3	0.1	0.1
Pli	542	<0.1	6.5	0.3	1.2
Pw	126	1.5	60.3	2.6	29.0
Py	221	1.1	49.8	2.1	35.8
SS	96	0.3	20.8	1.2	6.4
Sx	653	0.5	26.6	1.7	39.8
SxS	60	0.2	20.0	1.2	4.6
Yc	22	0.1	27.3	0.4	0.8
Total	4093				

Table 3. Results of the BC Ministry of Forests and Range, Tree Seed Centre fungal assay program for *Sirococcus conigenus* (Infection).

Sp.	# T	MeanI	%I	AveI	MaxI
Ba					
Bg	1	0.0	0.0	0.0	0.0
Bl					
Bn					
Cw					
Fdc	4	0.0	0.0	0.0	0.0
Fdi	6	0.0	0.0	0.0	0.0
Hm					
Hw	81	<0.1	7.4	0.3	0.5
Lw	47	0.1	19.1	0.5	1.4
Plc	7	0.0	0.0	0.0	0.0
Pli	23	0.0	0.0	0.0	0.0
Pw	3	0.3	33.3	0.9	0.9
Py					
SS	99	0.1	19.2	0.3	1.5
Sx	665	0.1	16.7	0.7	7.8
SxS	46	0.3	34.8	0.7	2.4
Yc					
Total	982				

Dave Kolotelo

PROCESSING LODGEPOLE PINE COLLECTIONS IN MULTIPLE PORTIONS

British Columbia is currently experiencing a mountain pine beetle (MPB) epidemic throughout the range of lodgepole pine (Pli) which has resulted in increased collections received at the Ministry of Forests and Range, Tree Seed Centre (TSC) for cone and seed processing. Over the past 2 crop years, the TSC has processed over 22 000 hl of natural stand Pli representing 248 collections. This volume represents over 52% of the TSC's processing totals during the past 10 collection years.

Diminishing collection sources has resulted in collections with increasing volumes of older cones. This decrease in cone quality has resulted in increased processing demands to accommodate the increase in cone debris and proportion of deteriorated seed. Modifications to routine Pli screening and de-winging activities were implemented to address the increased volumes of debris noted during cone tumbling/seed extraction. The following provides a brief overview of further quality assurance measures taken to pre-determine the presence of deteriorated seed to effectively manage seed processing with appropriate resources

To determine the relationship between cone characteristics and the presence and percentage of deteriorated seed, the following occurred: 1) cone and seed evaluations at the TSC classified cones by degree of surface weathering and within these, quantified any scale separation, 2) cones were submitted by these cone classes for moisture content determination, and 3) individual longitudinal seed bisections (cuts) were completed by cone classification. As the potential viability on cuts at storage moisture (4.9 – 9.9%) became more difficult, cuts of imbibed seed were implemented as a routine part of seed assessments throughout seed processing. For further information on lodgepole pine cone classifications, please refer to: http://www.for.gov.bc.ca/hti/pinebeetle/Pli_Bulletin05.pdf

Our goal in cone and seed processing is to submit a 100% potentially viable product with no or negligible discard of potentially viable seed. At final seed separation (after de-winging and prior to blending), using specific gravity techniques, an experienced seed technician attempts to remove deteriorated and empty seed from potentially viable seed. For challenging seedlots, where a significant portion of deteriorated seed cannot be completely removed, separation assessments warrant submission for testing, (i.e., purity, moisture content, seeds per gram, and germination) in multiple portions: the best portion identified as A - Good portion. The B - Poor portion consists of both viable and deteriorated seed, determined by extensive cutting tests of separated portions. This B portion is too poor to re-blend with the A portion yet too significant to discard. Additional separation is undertaken in an attempt to further increase the potential viability of the B portion, which in some cases has resulted in a third C portion.

Once germination tests are complete, a suitable plan is selected for the separated portion(s) with client consultation. Options available for consideration are: 1) new seedlot(s) created for the additional portions, 2) separated portion(s) re-blended and new testing initiated for solely one seedlot, or 3) in some cases poorer portions are approved for discard.

This portioning of seedlots from MPB impacted areas, subsequent testing, and additional information management is driven by TSC commitment to recover maximum potential seedlings, meeting client expectations for excellence in cone and seed services.

In the past, lodgepole pine seedlots submitted in A and B portions were few and limited to high elevation collections where embryo immaturity was present. The 2007 collection year identified four seedlots completed in multiple portions and in 2008 and 2009, 92 seedlots were submitted with A and B portions and 5 seedlots with A, B, and C portions. Current germination results between the good and poorer portions show an average difference of 9.4%, ranging from 3 to 24%.

Client support for cone and seed processing efforts has resulted in new seedlot identifications generated for over 95% of the multiple portions.

Debbie Picard
BC Ministry of Forests and Range
Tree Seed Centre
18793 - 32nd Avenue
Surrey, BC V3F 0L5
E-mail: Debbie.Picard@gov.bc.ca

NEW STANDARDS FOR ALBERTA

Alberta Sustainable Resource Development's "Standards for Tree Improvement in Alberta" has been replaced with the newly revised "Alberta Forest Genetic Resources Management and Conservation Standards" (FGRMS). The name change more accurately reflects the overall scope of the document as it sets rules for the production, deployment, and conservation of reforestation materials from controlled parentage programs as well as the collection and use of wild reforestation materials. Many additional changes were made throughout the standards to improve clarity and consistency and to make the intent of the standards more specific where needed. Two major changes affecting tree seed are the inclusion of seed testing standards and the requirement that seed testing must be conducted in a Department approved facility. The FGRMS became effective June 30, 2009 and can be found on the Alberta Sustainable Resource Development's website at: http://srd.alberta.ca/forests/managing/manuals.aspx

Donna Palamarek
Alberta Sustainable Resource Development
Tree Improvement and Seed Centre
PO Box 750
Smoky Lake, AB T0A 3C0
E-mail: Donna.Palamerek@gov.ab.ca

CFGA MEETING

The Canadian Forest Genetics Association's biennial meeting, Forest Genetics and Adaptive Management: Strategies and Approaches on the Ground, will be held on 20–22 July 2010, at the Valhalla Inn, Thunder Bay, Ontario. Mark your calendars!

This conference will bring together researchers in forest genetics and climate with forest managers, to bring new knowledge and theoretical data to the field. Plan to attend and learn and share the latest information about climate change and adaptive variation, seed source, and policy ramifications. You will meet some of Canada's brightest thinkers and practitioners in forest genetics and genetic resource management, share ideas and strategies, and come away better prepared to apply this information in your work.

Additional meetings of CON**FOR**GEN and CFGA Working Groups are being planned and will be announced at a later date.

Please watch www.fgo.ca for further details as they are available.

Kathie Brosemer
Forest Genetics Ontario
510 Queen Street East, Suite 24
Sault Ste. Marie, ON P6A 2A1
E-mail: kbrosemer@fgo.ca

ERRATUM

In Bulletin 48 "Storage and Germination Behaviour of Hybrid Maple (*Acer freemannii*) Seed" Table 1. The germination percentage for 'brown' colored seed coats should be 16%. The '3' is a reference to footnote 3.

UPCOMING MEETINGS

Seed Orchards
Sep 8–11, 2009 Jeju Island, Republic of Korea
http://www-genfys.slu.se/staff/dagl/Index.htm
Contact: Kyu-Suk Kang
kangks@forest.go.kr

Whitebark Pine Science and Management Workshop
Sep 10–11, 2009 Nelson, BC
http://www.whitebarkfound.org/annual-meeting.html
Contact: Michael Murray
Michael.Murray@gov.bc.ca

SISCO Summer Workshop
(Southern Interior Silviculture Committee)
Sep 14–16, 2009 Williams Lake, BC
http://www.siscobc.com/

FNABC/NSC Summer Workshop (Forest Nursery Association of BC / Northern Silviculture Committee)
Sep 28– 29, 2009 Prince George, BC
Contact: Steve Kiiskila or Anna Monetta
Steven.Kiiskila@gov.bc.ca
Anna.Monetta@gov.bc.ca

Canadian Forest Genetics Association
July 20–22, 2010 Thunder Bay, ON
www.fgo.ca
Contact: Kathie Brosemer
kbrosemer@fgo.ca

Recent Advances in Seed Research and *ex situ* Conservation
Aug 15–21, 2010 Taipei, Taiwan
Contact: Tannis Beardmore
tbeardmo@nrcam.gc.ca

RECENT PUBLICATIONS

Conklin, J.R.; Sellmer, J.C. 2009. Flowering, fecundity, seed germination, and seed viability of *Viburnum opulus* L. cultivars. J. Environ. Hort. 27(1):31–36.

Daigle, B.I.; Simpson, J.D. 2009. Collecting and processing Salicaceae seeds. Native Plants J. 10:48–51.

Darbah, J.N.T.; Kubiske, M.E.; Nelson, N.; Oksanen, E.; Vapaavuori, E.; Karnosky, D.F. 2008. Effects of decadal exposure to interacting elevated CO_2 and/or O_3 on paper birch (*Betula papyrifera*) reproduction. Environ. Pollut. 155:446–452.

Kalemba, E.M.; Janowiak, F.; Pukacka, S. 2009. Desiccation tolerance acquisition in developing beech (*Fagus sylvatica* L.) seeds: the contribution of dehydrin-like protein. Trees 23:305–315.

Koenig, W.D.; Knops, J.M.H.; Carmen, W.J.; Sage, R.D. 2009. No trade-off between seed size and number in the Valley Oak *Quercus lobata*. Am. Nat. 173:682–688.

Li, Q.; Hou L.; Duan X.; Liu G.; Ma F. 2009. Effects of ultra-dry treatment on vigor and physiological characteristics of *Pinus tabulaeformis* seeds. For. Res. 22:124–128.

Marsico, T.D.; Hellmann, J.J.; Romero-Severson, J. 2009. Patterns of seed dispersal and pollen flow in *Quercus garryana* (Fagaceae) following post-glacial climatic changes. J. Biogeogr. 36: 929–941.

Munck, I.A.; Stanosz, G.R. 2009. Quantification of conidia of *Diplodia* spp. extracted from red and jack pine cones. Plant Disease 93:81–86.

Packham, J.R.; Thomas, P.A.; Lageard, J.G.A.; Hilton, G.M. 2008. The English Beech masting survey 1980–2007: Variation in the fruiting of the common beech (*Fagus sylvatica* L.) and its effects on woodland ecosystems. Arbor. J 31:189–214.

Poncet, B.N.; Garat, P.; Manel, S.; Bru, N.; Sachet, J.-M.; Roques, A.; Despres, L. 2009. The effect of climate on masting in the European larch and on its specific seed predators. Oecologia 159:527–537.

Simpson, J.D.; Daigle, B.I. 2009. Five years' storage of seeds from three willow species. Native Plants J. 10:63–67.

Slavov, G.T.; Leonardi, S.; Burczyk, J.; Adams, W.T.; Strauss, S.H.; Difazio, S.P. 2009. Extensive pollen flow in two ecologically contrasting populations of *Populus trichocarpa*. Mol. Ecol. 18:357–373.