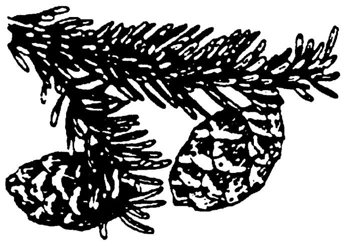
CANADIAN FOREST GENETICS ASSOCIATION
ASSOCIATION CANADIENNE DE GÉNÉTIQUE FORESTIÈRE



Tree Seed Working Group

NEWS BULLETIN

No. 48 December 2008

THIS ISSUE AT A GLANCE

CHAIR'S 'ARMCHAIR' REPORT

Happy Silver anniversary to the Tree Seed Working Group News Bulletin. It was 25 years ago today, Ben Wang and others taught the seedy guys and gals to play, it's been going in and out of style, but guaranteed to raise an eye….

The first News Bulletin was published in December 1983 establishing the broad objective of "promoting tree seed science and technology" for the working group and we are still on that same long and winding road. The News Bulletin has provided a forum for the timely exchange of information on tree seeds at both the operational level, high tech research level, and everything in between. It is truly amazing that a volunteer Newsletter could survive for this long and it is a testament to all of those involved. The editors deserve much of the credit and we have had some dedicated Editors over our 25-year history (edition numbers in brackets) – George Edwards (1 to 3), Hugh Schooley (4 to 23), Ron Smith (24 to 35), and our current scribe Dale Simpson (36 to 48 and counting) – Thank you all. Every edition of the News Bulletin is available as a pdf document at the following webpage http://www.for.gov.bc.ca/hti/treeseedcentre/tsc/tswg.htm . Enjoy!

We had a successful workshop in Quebec City – thank you to Fabienne Colas and her team for putting it together. For those who haven't heard, we are now a working group of the Canadian Forest Genetics Association (CFGA) due to the Canadian Tree Improvement Association changing its name. The workshop covered a variety of topics from strategic seed orchard planning, reviews of seed production systems, genetic conservation, water activity, and work on improving clonal production systems through rooted cuttings and somatic embryogenesis. In BC, we are looking forward to participating in future work on 'water activity' as a method of maximizing storage longevity of seeds and pollen. I'm sure you'll be hearing more about this in the future.

The BC Forest Service Tree Seed Centre celebrated its 50th Anniversary this past year with a variety of functions including an appreciation event for those who contributed significantly to the TSC, a family and friends event, a variety of specialized tours, and the Seed Use Efficiency meeting that formed the bulk of July's News Bulletin. The Abstracts and Powerpoint presentations (as pdf documents) from this workshop are now online and can be accessed at: http://www.for.gov.bc.ca/hti/treeseedcentre/tsc/workshops&presentations/seed-use-efficiency/index.htm. There is also a similar webpage for the 2007 Tree Seed Workshop in BC: http://www.for.gov.bc.ca/hti/treeseedcentre/tsc/workshops&presentations/treeseedworkshop2007/index.htm.

In addition to the CFGA meeting, I was also fortunate to attend the Tree Seeds 2008 meeting at the University of Sussex in England. You can read a brief meeting report on page 20. A highlight of the trip was spending a wonderful sunny (believe it or not) day in Kew Gardens wandering through the gardens and glass houses. A must see for all those with a botanical interest.

Last, but certainly not least, we can also celebrate the printing of the 2008 version of the Woody Plant Seed Manual – all 1223 pages! See the article on page 19, but this really is a must-have for your bookshelf and there is an online version as well. A great reference.

We'll also keep the next News Bulletin as an open forum and, as is customary, I'll encourage, grovel, and whine to try and get submissions. What is happening with tree seed in your province? Are you going through legislative changes to its use? Considering adapting seed transfer to climate change? Performed some interesting tree seed research? Attended an interesting seed-related meeting? These are all topics of interest for the News Bulletin, please contribute to its continued success. Thank you.

Wishing everyone the very best over the holiday season.

Dave Kolotelo
TSWG Chair

EDITOR'S NOTES

Well, this is indeed a milestone! We all owe Ben Wang a debt of gratitude for germinating the idea for a Tree Seed Working Group and a newsletter. As they say "the rest is history". Ben Wang was the first Chairman of the working group and he has kindly provided an article on his perspective and retrospective of the group and the News Bulletin.

Speaking of Chairman, the Working Group has been blessed with six exceptional Chairmen over the past 25 years. They were: Ben Wang (1983–1985), Yves Lamontagne (1985–1987), Graham Powell (1987–1991), Guy Caron (1991–1997), Howard Frame (1997-2000), and Dave Kolotelo (2000–present). These gentlemen have done a great job leading the Working Group and providing their perspective on many issues dealing with tree seed. Their commitment and involvement has kept the Working Group and its activities alive.

As Dave pointed out, this is an open issue with a good variety of articles. As well, there are two summaries from the Seed Use Efficiency workshop that did not make it into the last News Bulletin (better late than never).

I too wish each and every one of you a joyous holiday season.

Dale Simpson
Editor

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 228
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.

CONGRATULATIONS TO THE TREE SEED WORKING GROUP

Happy 25th anniversary to the Tree Seed Working Group and its continuous publication and expanded distribution of the News Bulletin (48 issues). The Working Group was formed based on my frequent discussions with Doug Skeates of the Ontario Ministry of Natural Resources Research Group in Maple, Ontario. Originally, we considered forming an independent group of some kind of association, but we felt it would be too small a group for tree seed workers and users. Eventually, we decided to form the group under the umbrella of the Canadian Tree Improvement Association (CTIA). At the 1983 CTIA meeting in Toronto, we proposed forming the Tree Seed Working Group and received the approval of the membership of the Association. I was honoured to be elected as the first chair and Dr. George Edwards of the Pacific Forestry Centre was the Editor of the proposed News Bulletin. We have been growing and thriving for 25 years! We owe our success and accomplishments to the sponsorship and encouragement of the Canadian Forest Service; leadership of the successive chairs and editors; CTIA for allowing our group to hold workshops in conjunction with its biennial meetings; and strong interest, enthusiasm, and support of the Working Group members.

Despite the decrease in funding for tree seed research and development in Canada over the years, keen interest in readership of our group's News Bulletin remains high. I sincerely hope that our Working Group will continue to serve the forestry community as there are more tree seed problems to be resolved and more research is required. As a seed researcher for all my life, I would like to offer a word of caution to future tree seed research. It is important to include various seed lots from different provenances of different crop years in the experimental designs. My experience suggests that some of the published information with a single seed lot from one area of one seed crop year often could not be reproduced.

Ben Wang
Natural Resources Canada
Canadian Forest Service
Petawawa Research Forest
P.O. Box 2000
Chalk River, ON K0J 1J0
E-mail: bwang@nrcan.gc.ca

SEEDLING PRODUCTION IN QUEBEC: A SUCCESSFUL INTEGRATION OF THE MULTIDISCIPLINARY RESEARCH APPROACH!

For 40 years, the Research Division (Direction de la recherche forestière - DRF) of the Quebec Ministry of Natural Resources and Wildlife (ministère des Ressources naturelles et de la Faune - MRNF) has managed an avant-garde research and development program in the fields of genetic tree improvement for commercial species and the production of forest seedlings and seeds, while integrating new *in vitro* techniques for the multiplication of coniferous species. To fully profit from the genetic gains arising from these studies, each of the steps in the seedling production chain, from seed harvest through planting, had to be optimised in harmony with the others. Diversified, complementary, and highly skilled expertise constitutes the strength of our multidisciplinary group of researchers. Our work focuses on improving the morpho-physiological and genetic quality of seedlings destined for reforestation, while respecting the environment and genetic diversity.

DRF researchers in the fields of genetic improvement and seed and seedling production work in close collaboration with several universities and the Direction générale des pépinières et des stations piscicoles (DGPSP, MRNF), as well as the six provincial government forest nurseries. In addition to the work being done at the tree seed centre and at the DGPSP's mass cutting propagation and somatic embryogenesis centres, research is also being conducted in some of the 18 private forest nurseries that make up l'Office des producteurs de plants forestiers du Québec (OPPFQ). This unique multidisciplinary integration of several projects constitutes the powerful force necessary to respond to the current preoccupations in Quebec forestry. This collaboration also facilitates the rapid diffusion of scientific advances and new technologies flowing from the research projects, as well as their integration into daily operations under forest nursery conditions. This technology transfer extends from seed production, through seedlot management at the provincial tree seed centre in Berthierville, to the production of seedlings by conventional techniques, mass cutting propagation, or somatic embryogenesis.

This report presents a brief overview of the principal recent advances that have been integrated into the seedling production chain in Quebec in recent years.

Genetics and Tree Breeding

The work undertaken in the field of tree improvement in Quebec over the past 40 years has principally concentrated on commercial coniferous species, notably white spruce (*Picea glauca*), black spruce (*P. mariana*), Norway spruce (*P. abies*), jack pine (*Pinus banksiana*), tamarack (*Larix laricina*), and certain exotic larches (*L. decidua*, *L. kaempferi*, *L.* x *marschlinsii*). Of the broadleaved species, certain varieties of hybrid poplar (*Populus* spp.) have been selected for reforestation purposes; the list of recommended clones is revised periodically. More recently, studies have been conducted on red oak (*Quercus rubra*) and white ash (*Fraxinus americana*). The principal objective of the different improvement programs is to increase plantation yield (Rainville et al. 2003). As a result of this work, Quebec now has a sizable network of first- and second-generation seed orchards as well as four propagation centres for the vegetative multiplication of varieties obtained from controlled crossings. Overall, the 141 seed sources that are in place provide more than 85% of the demand for seedling production (Savary et al. 2008). The knowledge gained in the 40 years of tree improvement research has permitted us to define transfer rules for the various seed sources, obtain significant gains in terms of growth and quality of the reforestation stock, develop models to predict the effects of climate change on plantation yield (Andalo et al. 2005, Beaulieu and Rainville 2005), and acquire knowledge on wood quality of plantation-grown trees (Beaulieu et al. 2006, Daoust and Mottet 2006, Mottet et al. 2006). The MRNF has invested in clonal forestry of white spruce by emphasizing the installation of clonal tests. A large number of clones, produced by somatic embryogenesis, are planted each year for evaluation. In the future, tree breeders will also benefit from new genetic tools presently being developed within the framework of Arborea (2008), a tree genomics research consortium. These resources will be beneficial for selecting breeding stock as well as assuring better management of genetic resources.

Seed and Pollen

Research and development, principally being done with coniferous species, has permitted the creation of a pollen bank, now managed operationally using the methods we developed to evaluate pollen quality and conservation (Mercier 1995, Colas and Mercier 2000). To increase seed orchard yield for the different commercial species, a system of mass pollination with an electrostatic pistol (Mercier and Périnet 1998) was adapted from the model developed by Philippe and Baldet (1997). In response to the increasing demand for hybrid larch seedlings, we developed a concept of sheltered seed orchards enabling hybrid larch seeds to be successfully produced despite harsh northern climatic conditions and unsynchronised flowering of different larch species (Colas et al. 2006, 2008a). The progressive use of water activity measurements in collaboration with Cemagref (2008), a French research centre (Baldet et al. 2007, 2008; Colas et al. 2008b), will facilitate quality control of the seed and pollen used in reforestation programs. In the near future, we would like to integrate water activity measurements in the ISTA (International Seed Testing Association) rules. Finally, we plan on incorporating somatic embryogenesis (SE) into seed orchard management (refer to SE section).

Mass Cutting Propagation

Vegetative multiplication by mass cutting propagation permits controlled crosses exhibiting superior productivity to be reproduced, without the use of genetic modification. For cuttings of white, black, and Norway spruce, the stock plants are produced from controlled crosses, while hybrid larch stock plants are grown from seeds produced by mass pollination in sheltered seed orchards.

In Quebec, the MRNF began producing seedlings by mass cutting propagation at an operational scale in the early 1990's, with the development of the *Bouturathèque* system for rooting black spruce cuttings (Vallée and Noreau 1990, Tousignant et al. 1996). In 1998, a complementary second system (double-walled rooting enclosures) was developed to facilitate the propagation of hybrid larch. With time, this system was refined and has now replaced the *Bouturathèques* for the rooting of all coniferous species in the program (Tousignant and Rioux 2002, Rioux et al. 2008). The rooting percentage reaches 75 to 90% in 12 weeks, depending on the species. In 2008, the total production of coniferous species via mass cutting propagation in the four provincial nurseries (DGPSP, MRNF) surpassed four million seedlings (Tousignant et al. 2008a).

Rooted cuttings are transplanted, either to bareroot beds or into larger containers, to complete their growth in the nursery. After two more growing seasons, they are delivered to reforestation sites as large-size seedlings. Seedlings originating from cuttings must meet 25 rigorous quality standards established for seedlings by the MRNF (Direction générale des pépinières et des stations piscicoles 2008), including those for root system architecture and foliar nitrogen concentration.

In response to the large family and clonal variability observed in white spruce (Lamhamedi et al. 2000), we significantly modified the cultural techniques specific to the production of stock plants of this species. The use of a mix of seeds from many controlled crosses for stock plant production has given rise to important differences in germination, growth, shoot architecture, as well as the number of cuttings (yield) that can be harvested from the stock plants. To achieve the mass cutting propagation objectives, each cross is now subjected to morpho-physiological evaluations at different points of the production chain: seed size and quality, stock plant growth and cutting yield, rooting ability, tissue nutrient status, etc. (Lamhamedi et al. 2005a, 2005b, 2007a; Tousignant et al. 2008b).

In an effort to optimise the rooting of cuttings taken from 75 half-sib white spruce families, a recent study found that the average family heritability for root length and root mass was 0.64 and 0.63, respectively, at the end of the rooting phase (Grenier et al. 2008). The average family heritability for root mass at the end of the first growing season was 0.74. This clearly shows that we can improve rooting capacity of cuttings by selecting the best families, while still preserving genetic diversity.

To reduce production costs and increase the multiplication rate from improved seeds, we are progressively integrating the use of hardwood (dormant) cuttings into our cultural scenarios. Other efforts are being invested in the integration of somatic embryogenesis into seedling production (Tremblay et al. 2007), as a complement to mass cutting propagation, using somatic seedlings as stock plants (Lamhamedi and Tousignant 2008). The use of this combination of vegetative propagation techniques paves the way for clonal forestry and genetic gains that are superior to those that have been achieved to date.

Somatic Embryogenesis

The DGPSP has chosen to integrate somatic embryogenesis (SE) into the seedling production chain. The early studies, beginning in 1990, permitted the optimisation of different steps in the SE process and established the framework of clonal tests for black spruce, white spruce, and hybrid larches (Tremblay and Lamhamedi 2006). In 2001, SE was implemented at an operational scale at the Saint-Modeste forest nursery (MRNF) as a pilot project. White spruce was the first species considered for SE because its genetic improvement program was the most advanced. The development and adaptation of a unique acclimatization technique (without misting) (Lamhamedi et al. 2003), guarantees survival rates of over 98% for commercial species under forest nursery conditions. Since 2004, the SE program has used controlled crosses recommended by forest geneticists. Between 2004 and 2007, 1154 clones from 41 unrelated families have been conserved by cryopreservation (Tremblay et al. 2008). The identification of the best selected clones through clonal testing and their subsequent multiplication by SE will maximize genetic gains while maintaining genetic diversity. The scaling-up of SE techniques to an operational level is presently underway. These studies focus on the development of bioreactors and techniques for *ex vitro* sowing of somatic embryos.

During the same period, the MRNF initiated an original study to utilize the full potential of SE in the forest seedling production chain. Morpho-physiological characterization, specific to each clone produced for the clonal tests, was conducted under nursery conditions (Lamhamedi et al. 2000). This was followed by a systematic characterization of the clones at each stage of the SE process under laboratory conditions. Laboratory results will be correlated to those obtained in the nursery to determine early selection criteria for desired characteristics, in order to identify the best-performing clones before establishing clonal tests. The rooting ability of the clones was also evaluated. This will permit the MRNF to integrate the somatic stock plants in the cutting propagation program and reproduce the best-performing clones at minimal cost.

Quebec has the oldest clonal tests in Canada. Since 2001, production of seed and pollen cones by somatic black spruce clones has been observed as early as four years after planting. Our early results showed that somatic black spruce clones produced normal seed and pollen flowers. At maturity, the seed cones contain high quality seed, capable of germinating and producing seedlings with good morpho-physiological characteristics (Colas and Lamhamedi 2006). The seeds and seedlings produced by somatic clones are similar in quality to those produced by grafting or by standard seedling production techniques. Our objective is to integrate the best somatic clones in controlled crossings, as well as using them as seed trees in future seed orchards. We have conducted the same studies with white spruce somatic clones, in order to accelerate the genetic improvement of both species and significantly increase the genetic gain of their seed orchards (Colas and Lamhamedi 2006).

Seedling Production

Although seedlings planted on reforestation sites in Quebec are of the highest quality, the production scenarios associated with new seedling stock sizes are very complex. Seedling producers must comply with strict environmental norms and adapt to the recurrence of extreme climatic conditions, especially in winter, in response to climate change. This calls for the continuous adjustment of cultural techniques and a judicious choice of genetic resources, which also must be adapted to climate change. Recent studies have permitted us to refine the computerized management of cultural practices in forest nurseries, including defining irrigation and fertilization regimes which optimize the morpho-physiology of white and black spruce seedlings, while at the same time, reducing the leaching of mineral nutrients (Langlois and Gagnon 1993; Gagnon and Camiré 1996, 2001; Gagnon and Girard 2001; Girard et al. 2001; Larocque et al. 2002; Lamhamedi et al. 2002, 2006; Carles et al. 2008). Other innovative research with nursery-grown hybrid poplar clones has been concerned with cultural techniques and the early selection of clones for desired characteristics such as growth, stem form, carbon sequestration, frost tolerance, and drought resistance (Lamhamedi et al. 2007b). Research conducted by the DRF, showed that under forest nursery conditions, the application of short-day treatments resulted in a significant increase of 20% in the percentage of tunnel grown (1+0) black spruce seedlings conforming to the established norms for sufficient rooting, thus reducing the number of seedlings rejected at delivery (Lamhamedi et al. 2007c). This simple approach will make a tangible contribution to improving the profitability of forest nurseries. Other work, conducted in close collaboration with Université Laval, has clarified the effect of genetics and cultural regime on root growth of white spruce seedlings (Carles et al. 2007).

Conclusion

In summary, the 40 years of research and development invested by the DRF in genetic improvement and the production of seeds and seedlings has been, and will continue to be, fruitful. The integration of all the steps in the seedling production chain, from seed to plantation, is unique to Quebec and allows for efficient technology transfer. The numerous innovations resulting from this research have translated into substantial benefits. Quebec is among the leaders in seed and forest seedling production. Quality seedlings significantly contribute to increasing the productivity and yield our forest plantations.

These benefits will become increasingly important with the reform of Quebec's forest policy, in which the provincial government will be investing in an intensive silviculture strategy. Reforestation with both traditional and fast growing species will be prioritized to increase forest productivity, allowing the expansion of the land area dedicated to conservation, without affecting the overall productivity of Quebec's forest land base.

References

Andalo, C.; Beaulieu, J.; Bousquet, J. 2005. The impact of climate change on growth of local white spruce populations in Québec, Canada. For. Ecol. Manage. 205:169–182.

Arborea. 2008. www.arborea.ulaval.ca

Baldet, P.; Colas, F.; Bettez, M. 2008. Measurement of water activity on forest tree seeds: an efficient tool for seed bank management. Int. Seed Test. Assoc., For. Tree Shrub Seed Wkhp, 12–14 June 2008, Peri, Verona, Italy, 42 p. (http://www.corpoforestale.it/CNBFPeri/Workshop-/moisture/Measurement%20of%20water%20activity%20on%20forest%20tree%20seeds%20.ppt#1)

Baldet, P.; Colas, F.; Bettez, M. 2007. Water activity: a new paradigm for seed and pollen management. Can. Tree Imp. Assoc., Tree Seed Work. Grp. News Bull. 46: 10–12. (http://www.mrnf.gouv.qc.ca/publications/forets/connaissances/recherche/Colas-Fabienne/CTIA-News-Bulletin-46-10-12.pdf)

Beaulieu, J.; Zhang, S.Y.; Yu, Q.; Rainville, A. 2006. Comparison between genetic and environmental influences on lumber bending properties in young white spruce. Wood Fibre Sci. 38(3): 553–564. (http://www.mrnf.gouv.qc.ca/publications/forets/connaissances/recherche/Rainville-Andre/Wood-Fiber-Sc-38-3-553-564.pdf).

Beaulieu, J.; Rainville, A. 2005. Adaptation to climate change: Genetic variation is both a short- and a long-term solution. For. Chron. 81(5):704–709.

Carles, S.; Lamhamedi, M.S.; Stowe, D.C.; Margolis, H.A.; Bernier, P.Y.; Veilleux, L.; Fecteau, B. 2008. Frost tolerance of two-year-old *Picea glauca* seedlings grown under different irrigation regimes in a forest nursery. Scand. J. For. Res. 23:137–147. (http://www.mrn.gouv.qc.ca/publications/forets/connaissances/recherche/Lamhamedi-Mohammed/Scand-jour-for-reseach-23-137-147.pdf)

Carles, S.A.; Lamhamedi, M.S.; Beaulieu, J.; Colas, F.; Stowe, D.C.; Margolis, H.A. 2007. Génétique et architecture des racines des plants d'épinette blanche produits en pépinière forestière. Recueil des résumés - Colloque de transfert de connaissances - Des plants aux plantations : techniques, technologies et performances. 19 sep 2007. Québec, Qc, p. 19–23. (http://www.mrnf.gouv.qc.ca/publications/forets/connaissances/recherche/Lamhamedi-Mohammed/Recueil-PlantsPlantations-19-23.pdf)

Cemagref. 2008. www.cemagref.fr

Colas, F.; Mercier, S. 2000. Évaluation et maintien de la viabilité des pollens utilisés dans le programme d'amélioration des arbres. Gouv. Québec, Forêt Québec, Direction de la recherche forestière, mémoire de recherche forestière nº135, 78 p.

Colas, F.; Lamhamedi, M.S. 2006. Quality of seeds produced from different black spruce (*Picea mariana*) somatic clones. Page 63. *In* T.L. Beardmore and J.D. Simpson, eds. Proc. IUFRO Tree Seed Symp.,Recent Advances in Seed Physiology and Technology. IUFRO Res. Grp. 2.09.00., 18–21 July 2006, Fredericton, NB. (http://www.mrnf.gouv.qc.ca/publications/forets/connaissances/recherche/Colas-Fabienne/Resume-affiche-IUFRO-quality-seeds.pdf).

Colas, F.; Perron, M.; Tousignant, D.; Bettez, M. 2006. New approach for the production of hybrid larch seeds in a sheltered orchard. Page 62. *In* T.L. Beardmore and J.D. Simpson, eds. Proc. IUFRO Tree Seed Symp.,Recent Advances in Seed Physiology and Technology. IUFRO Res. Grp. 2.09.00., 18–21 July 2006, Fredericton, NB. (http://www.mrnf.gouv.qc.ca/publications/forets/connaissances/recherche/Colas-Fabienne/Resume-affiche-IUFRO-Tree-seed.pdf)

Colas, F.; Perron, M.; Tousignant, D.; Parent, C.; Pelletier, M.; Lemay, P. 2008a. A novel approach for the operational production of hybrid larch seeds under northern climatic conditions. For. Chron. 84(1):95–104. (http://www.mrnf.gouv.qc.ca/publications/forets/connaissances/recherche/Colas-Fabienne/For-Chron-84-1-95-104.pdf).

Colas, F.; Baldet, P.; Bettez, M. 2008b. Water activity: a new tool for moisture management of seedlots in tree seed centres. Tree Seed Wkshp, IUFRO – CTIA 2008, Adaptation, Breeding and Conservation in the Era of Forest Tree Genomics and Environmental Change, 25–28 Aug 2008, Quebec, QC. (http://www.mrnf.gouv.qc.ca/activite/iufro-acaa/pdf/colas-resume.pdf)

Daoust, G.; Mottet, M.-J. 2006. Impact of the white pine weevil (*Pissodes strobi* Peck) on Norway spruce plantations (*Picea abies* [L.] Karst.) Part 1: Productivity and lumber quality. For. Chron. 82(5):745–756.

Direction générale des pépinières et des stations piscicoles (DGPSP). 2008. Guide terrain : Inventaire de qualification des plants résineux cultivés en récipient. Document de travail, livraison 2008. Gouv. du Québec, Ministère des Ressources naturelles et de la Faune, 131 p.

Gagnon J.; Camiré, C. 1996. Effets de la fertilisation azotée sur la croissance de plants à racines nues 2+2 et sur la lixiviation des nitrates en pépinière. Actes du Colloque international « L'eau souterraine en région agricole (ESRA'96) », Poitiers, France, 9–12 sep 1996 : S4-37 à S4-40.

Gagnon, J.; Camiré, C. 2001. *In vitro* urea transformations in a soil of forest tree nursery. Pages 447–448. *In* J. Lefèvre and V. Dazin, eds. 11th Nitrogen Workshop, Reims, France, 9– 12 sep 2001.

Gagnon, J. Girard, D. 2001. Bilan des pertes saisonnières de nitrates (NO_3^-) et d'eau sous une culture d'épinette blanche 2+0 produite dans le récipient 25-350A. Gouv. du Québec, Ministère des Ressources naturelles, Direction de la recherche forestière. Rapport interne n° 466, 36 p.

Girard, D.; Gagnon, J.; Langlois, C.-G. 2001. PLANTEC : un logiciel pour gérer la fertilisation des plants dans les pépinières forestières. Gouv. du Québec, Ministère des Ressources naturelles, Direction de la recherche forestière. Note de recherche forestière n° 111, 8 p. (http://www.mrnf.gouv.qc.ca/publications/forets/connaissances/recherche/Gagnon-Jean/Note111.pdf).

Grenier, J.G.; Lamhamedi, M.S.; Beaulieu, J.; Carles, S.; Margolis, H.A.; Rioux, M.; Stowe, D.C.; Lapointe, L. 2008. Utilization of family genetic variability of white spruce (*Picea glauca*) to improve rooting of plant cutting root systems. IUFRO – CTIA 2008 Joint Conference - Adaptation, Breeding and Conservation in the Era of Forest Tree Genomics and Environmental Change, 25–28 Aug 2008, Québec, QC. (http://www.mrnf.gouv.qc.ca/activite/iufro-acaa/pdf/Gravel-Grenier-affiche.pdf).

Lamhamedi, M.S.; Chamberland, H.; Bernier, P.Y.; Tremblay, F.M. 2000. Clonal variation in morphology, growth, physiology, anatomy and ultrastructure of container-grown white spruce somatic seedlings. Tree Physiol. 20:869–880. (http://www.mrn.gouv.qc.ca/publications/forets/connaissances/recherche/Lamhamedi-Mohammed/Tree-physiology-20-869-880.pdf)

Lamhamedi, M.S.; Renaud, M.; Margolis, H.A. 2002. La réflectométrie dans le domaine temporel : une technique d'optimisation de l'irrigation et de réduction du lessivage en pépinières forestières au Québec. Cahiers Agricultures 11:275–283.

Lamhamedi, M.S.; Chamberland, H.; Tremblay, F.M. 2003. Epidermal transpiration, ultrastructural characteristics and net photosynthesis of white spruce somatic seedlings in response to *in vitro* acclimatization. Physiol. Plant. 18:544–561. (http://www.mrnf.gouv.qc.ca/publications/forets/connaissances/recherche/Lamhamedi-Mohammed/Physiologia-Plantarum-118.pdf)

Lamhamedi, M.S.; Colas, F.; Tousignant, D. 2005a. Caractérisation de la croissance des pieds-mères d'épinette blanche issus de croisements dirigés: 1- Approche méthodologique. Gouv. du Québec, Ministère des Ressources naturelles et de la Faune, Direction de la recherche forestière. Avis technique. 10 p. (http://www.mrnf.gouv.qc.ca/publications/forets/connaissances/recherche/Colas-Fabienne/Avis-techn-caracterisation.pdf)

Lamhamedi, M.S.; Colas, F.; Tousignant, D. 2005b. Vers une nouvelle optimisation de l'utilisation des croisements dirigés pour la production des pieds-mères en bouturage. Des plants et des hommes 8(1):21–26.

(http://www.mrnf.gouv.qc.ca/publications/forets/connaissances/recherche/Colas-Fabienne/DesPlants-des-Hommes-8-1-21-26.pdf)

Lamhamedi, M.S.; Labbé, L.; Margolis, H.A.; Stowe, D.C.; Blais, L.; Renaud, M. 2006. Spatial variability of substrate water content and growth of white spruce seedlings. Soil Sci. Soc. Am. J. 70:108–120. (http://www.mrnf.gouv.qc.ca/publications/forets/connaissances/recherche/Lamhamedi-Mohammed/Soil-Sci-Soc-Am-J-70-108-120.pdf).

Lamhamedi, M.S.; Colas, F.; Tousignant, D.; Rioux, M. 2007a. Characterization and multi-criteria selection of families for the mass cutting propagation of white spruce (*Picea glauca*) in Québec. Page 64. *In* T.L. Beardmore and J.D. Simpson, eds. Proc. IUFRO Tree Seed Symp.,Recent Advances in Seed Physiology and Technology. IUFRO Res. Grp. 2.09.00., 18–21 July 2006, Fredericton, NB.

Lamhamedi, M.S.; Renaud, M.; Desjardins, P.; Veilleux, L. 2007b. Effets du traitement de jours courts sur la croissance des racines, la tolérance au gel et la nutrition minérale des plants d'épinette noire (1+0) produits en pépinière forestière. Recueil des résumés - Colloque de transfert de connaissances - Des plants aux plantations : techniques, technologies et performances. 19 sep 2007, Québec, Qc. (http://www.mrnf.gouv.qc.ca/publications/forets/connaissances/recherche/Lamhamedi-Mohammed/Recueil-PlantsPlantations-25-31.pdf).

Lamhamedi, M.S.; Renaud, M.; Desjardins, P.; Veilleux, L. 2007c. Early selection and clonal variation of hybrid poplar clones in a Québec forest nursery. Pages 51–53. *In* Conf. Hndbk, 2007 Ann. Meet. Poplar Council of Canada, Poplar culture: a collaborative effort from clone to mill. 16–21 Sep 2007, Rivière du Loup and Quebec, QC. (http://www.mrnf.gouv.qc.ca/publications/forets/connaissances/recherche/Lamhamedi-Mohammed/Conference-Handbook-

CPC-Early-51-53.pdf).

Lamhamedi, M.S.; Tousignant, D. 2008. Clonal variations in *Picea abies* stock plants produced by somatic embryogenesis and their use in cutting propagation programs. IUFRO – CTIA 2008 Joint Conference - Adaptation, Breeding and Conservation in the Era of Forest Tree Genomics and Environmental Change, 25–28 Aug 2008, Québec, QC. (http://www.mrnf.gouv.qc.ca/activite/iufro-acaa/pdf/Lamhamedi-Tousignant-affiche.pdf).

Langlois, C.-G.; Gagnon, J. 1993. A global approach to mineral nutrition based on the growth needs of seedlings produced in forest tree nurseries. Pages 303–306. *In* N.J. Barrow, ed. Plant nutrition: from genetic engineering to field practice. Kluwer Academic Publishers, Dordrecht, Netherlands.

Larocque, M.; Banton, O.; Gagnon, J.; Camiré, C. 2002. Using models to manage soil inorganic nitrogen in forest tree nurseries. Soil Sci. Soc. Am. J. 66:602–612. (http://www.mrnf.gouv.qc.ca/publications/forets/connaissances/recherche/Gagnon-Jean/Soil-Sci-Soc-Am-J-66-602-612.pdf)

Mercier, S. 1995. The role of a pollen bank in tree genetic improvement program in Québec (Canada). Grana 34:367–370.

Mercier, S.; Périnet, P. 1998. The second generation seed orchard project at the Direction de la recherche forestière in Québec. For. Chron. 74(2):181–184.

Mottet, M.-J.; Daoust, G.; Zhang, S.Y. 2006. Impact of the white pine weevil (*Pissodes strobi* [Peck]) on Norway spruce (*Picea abies* [L.] Karst.) plantations Part 2: Lumber properties. For. Chron. 82(6):834–843.

Philippe, G.; Baldet, P.; 1997. Electrostatic dusting : an efficient technique of pollination in larch. Ann. For. Sci. 54:301–310.

Rainville, A.; Desponts, M.; Beaudoin, R.; Périnet, P.; Mottet, M.-J.; Perron, M. 2003. Tree Improvement in Québec: a Tool for Industrial and Environmental Productivity. XII[th] World Forestry Congress, Québec, QC. Ministère des Ressources naturelles, de la Faune et des Parcs du Québec. Research Note No. 127. 11 p.

(http://www.mrnf.gouv.qc.ca/publications/forets/connaissances/recherche/beaudoin-roger/Note127.pdf)

Rioux, M.; Tousignant, D.; Lamhamedi, M.S. Colas, F. 2008. Cutting propagation of coniferous forest trees in Québec. Int. Plant Prop. Soc. 57:26–33.

Savary, A.; Deshaies, A.; Lévesque, D. 2008. Zoom in on the seed production in Québec. Tree Seed Wkshp, IUFRO – CTIA 2008, Adaptation, Breeding and Conservation in the Era of Forest Tree Genomics and Environmental Change, 25–28 Aug 2008, Quebec, QC. (http://www.mrnf.gouv.qc.ca/activite/iufro-acaa/pdf/savary-resume.pdf)

Tousignant, D.; Lamhamedi, M.S.; Rioux, M. 2008a. Using the conifer cutting propagation pathway to increase forest productivity in Québec. IUFRO – CTIA 2008 Joint Conference - Adaptation, Breeding and Conservation in the Era of Forest Tree Genomics and Environmental Change. Pre-congress field tour: Pépinière de Berthier, 24 Aug 2008. Ministère des ressources naturelles et de la faune, Direction de la recherche forestière. 4 p. (http://www.mrnf.gouv.qc.ca/activite/iufro-acaa/pdf/cutting-propagation.pdf)

Tousignant, D.; Lamhamedi, M.S.; Colas, F.; Rioux, M. 2008b. Seed size and family effects on vegetative propagation rates of stockplants for the mass cutting propagation of white spruce (*Picea glauca*) in Québec. Tree Seed Wkshp, IUFRO – CTIA 2008, Adaptation, Breeding and Conservation in the Era of Forest Tree Genomics and Environmental Change, 25–28 Aug 2008, Quebec, QC. (http://www.mrnf.gouv.qc.ca/activite/iufro-acaa/pdf/tousignant-resume.pdf)

Tousignant, D.; Rioux, M. 2002. Le bouturage des résineux à la pépinière de Saint-Modeste (Québec, Canada) : 10 ans de recherche, de développement et d'innovations. Pages 65–86. *Dans* M. Verger, ed. Multiplication végétative des ligneux forestiers, fruitiers et ornementaux. Actes [CD-ROM]. Montpellier, France : CIRAD-INRA. Troisième rencontre du groupe de la Sainte-Catherine, 22-24/11/2000, Orléans, France.

Tousignant, D.; Périnet, P.; Rioux, M. 1996. Black spruce cutting propagation at the Pépinière de Saint-Modeste. Gouv. du Québec, Ministère des Ressources naturelles. RN96-3004. 33 p. (http://www.mrn.gouv.qc.ca/publications/forets/connaissances/recherche/Tousignant-Denise/Rapport-Black-spruce-cutting.pdf).

Tremblay, L.; Lamhamedi, M.S.; Colas, F.; Rainville, A.; Guay, J.Y. 2008. An integrated approach to preserve and multiply improved material of white spruce by somatic embryogenesis. Tree Seed Wkshp, IUFRO – CTIA 2008, Adaptation, Breeding and Conservation in the Era of Forest Tree Genomics and Environmental Change, 25–28 Aug 2008, Quebec, QC. (http://www.mrnf.gouv.qc.ca/activite/iufro-acaa/pdf/tremblay-resume.pdf)

Tremblay, L.; Lamhamedi, M.S.; Colas, F.; Beaulieu, J. 2007. Utilisation de l'embryogenèse somatique en foresterie multiclonale au Québec. Pages 13–16. *Dans* Recueil des résumés - Colloque de transfert de connaissances - Des plants aux plantations : techniques, technologies et performances. Ministère des Ressources naturelles et de la Faune, Direction de la recherche forestière, Québec, Québec, 19 sep 2007. ISBN 978-2-550-50669-0. (http://www.mrn.gouv.qc.ca/publications/forets/connaissances/recherche/Tremblay-Laurence/Recueil-PlantsPlantations-13-16.pdf)

Tremblay, L.; Lamhamedi, M.S. 2006. Embryogenèse somatique au ministère des Ressources naturelles et de la Faune du Québec : Du laboratoire au site de plantation. Des plants et des hommes 9:6–11. (http://www.mrnf.gouv.qc.ca/publications/forets/connaissances/recherche/Lamhamedi-Mohammed/DesPlants-des-Hommes-9-3-6-11.pdf)

Vallée, G.; Noreau, R. 1990. La "Bouturathèque" : système de bouturage compact hors serre. Ministère de l'Énergie et des Ressources, Direction de la recherche forestière. Note de recherche N° 41, 6 p.

Fabienne Colas[1], Mohammed S. Lamhamedi[1], Denise Tousignant[1], Laurence Tremblay[1,2], André Rainville[1] and Jean Gagnon[1]

[1] Ministère des Ressources naturelles et de la Faune (MRNF)
Direction de la recherche forestière (DRF)
2700, rue Einstein
Quebec, QC G1P 3W8
E-mail: fabienne.colas@mrnf.gouv.qc.ca

[2] MRNF
Direction générale des pépinières et des stations piscicoles (DGPSP)
Pépinière forestière de Saint-Modeste
410, rue Principale
Saint-Modeste, QC G0L 3W0

HOT CONES ON COOL CONIFERS ATTRACT SEED-FEEDING INSECTS[1]

Leptoglossus occidentalis seed bugs have long been the bane of conifer seed orchard production in British Columbia. Not only are they difficult to control, it has proven nearly impossible to monitor seed bug population levels effectively and just about as difficult to accurately estimate the extent of seed damage they cause. The Insect Communication Ecology lab at Simon Fraser University (SFU) shares with the BC Ministry of Forests and Range a long history of collaborative research aimed at increasing our understanding of seed bug biology and developing innovative, effective ways to manage populations in conifer seed orchards. Over the years, we have learned much about *L. occidentalis* but, until recently, have made little progress in improving our abilities to manage them.

Recent new research by the SFU group has provided not only a significant breakthrough for management of *L. occidentalis* but also a dramatic new development in our understanding of the way some plant-feeding insects perceive the world around them. As CBC Radio's Bob MacDonald suggested during an interview aired on "Quirks and Quarks", seed bugs effectively have developed their own version of night-vision goggles with which they hunt down seed cones.

Between 2006 and 2007, experiments developed by technician Steve Takács, director Gerhard Gries, and others at the SFU lab demonstrated that conifer seed cones emit infrared (IR) light wavelengths and that seed bugs perceive this light from a considerable distance and use it to home in on cones for feeding. First, using a combination of temperature recording thermocouples, IR imaging techniques, and cone-bearing trees at Canadian Forest Products' Sechelt (BC) Seed Orchard site, Takács *et al.* demonstrated that seed cones are consistently warmer than needles or other parts of a conifer tree and that the resultant IR radiation differential causes the cones to glow brightly against their surroundings (Fig. 1).

Then, using a novel experimental lab set-up, the SFU group established that seed bugs are strongly, positively attracted to IR light. Armed with this information, they built simple traps using short lengths of black plastic pipe and placed these in pairs (one empty, the other filled with ice water to serve as sources of high and low IR light respectively) among cone-bearing trees at the Sechelt site. Seed bugs were attracted to the high IR source in very significant numbers but only one bug landed on the low IR source.

The most difficult part of the research came next: discovering how *L. occidentalis* seed bugs perceive IR light. Exhaustive examination by environmental scanning electron microscopy of the body surface of live seed bugs revealed possible IR receptor organs on the sides of each abdominal segment (Fig. 2).

Insertion of microscopic electrodes into these tiny patches of scaly cuticle revealed that they consistently respond when exposed to pulses of IR light. Covering the scaly patches with silica-based paint (impermeable to IR) completely shut down the micro-electronic response. Fitting the last piece of the puzzle required demonstrating that the IR receptors are actually components of the seed bug nervous system. This was proven conclusively through delicate microsurgical and tissue staining procedures.

In conclusion, this fascinating work has demonstrated, for the first time, that developing conifer cones emit IR and that *L. occidentalis* seed bugs exploit this as a cue when foraging for food resources. The implications of this with respect to the foraging behaviour of other plant-feeding insects are now being explored. More importantly, as far as conifer seed production is concerned, we finally have a real tool with which to develop an effective seed bug population monitoring and management program. Work is continuing at the Gries lab.

Figure 1. Paired photographic and thermographic images of western white pine cones at Sechelt Seed Orchards. Image credits: Jane Gale, Stephen Takács

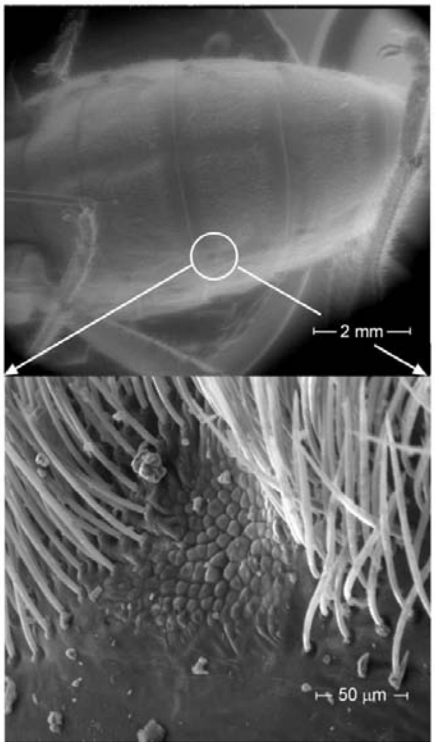


Figure 2. Environmental scanning electron micrographs of ventral abdominal surface of a western conifer seed bug (upper) and close up view of one infrared receptor site (lower). Image credits: James Drummond

The full text of the peer-reviewed publication resulting from this work is available at http://journals.royalsociety.org/content/0315t4k222526v81/fulltext.html. The Quirks and Quarks audio segment can be downloaded from http://www.cbc.ca/quirks/archives/08-09/qq-2008-10-25.html#4

[1] (Stephen Takács, Hannah Bottomley, Iisak Andreller, Tracy Zaradnik, Joseph Schwarz, Robb Bennett, Ward Strong, and Gerhard Gries. 2008. *Infrared radiation from hot cones on cool conifers attracts seed-feeding insects.* Proceedings of the Royal Society B. published on-line. DOI: 10.1098/rspb.2008.0742)

Robb Bennett
BC Ministry of Forests and Range
Saanichton, BC
V8M 1W4
E-mail: Robb.Bennett@gov.bc.ca.

STORAGE AND GERMINATION BEHAVIOUR OF HYBRID MAPLE (*Acer freemannii*) SEED

Freeman maple (*Acer freemannii*) is a hybrid between silver maple (*Acer saccharinum*) and red maple (*Acer rubrum*). The hybrid occurs naturally and is distributed along stream and river banks in the Upper Ottawa Valley (Latitude 45˚–46˚N), Ontario. As a result of a miscalculation in proper collection time, seeds from a tree growing at the Petawawa Research Forest had already dispersed in June 2008. They were scattered on the ground over a large area where micro-environments (i.e., grass, bare soil, pot holes, and shallow depressions, etc.) may have contributed to the variation in the moisture content of the seed. The objective of this preliminary, simple trial was to evaluate germination and obtain an indication of storage ability of hybrid maple seed as one of its parents, red maple, exhibits orthodox storage behavior and the other parent, silver maple, is classified as being recalcitrant.

From the appearance of the seed it could not be determined how long they had been on the ground or how much moisture has been lost. It was decided to remove the pericarp in order to evaluate the freshness of the seed based on seed coat colour. After the pericarp was removed, the seeds were roughly classified into three categories based on the colour of the seed coat: greenish, brownish, or blackish. About 10 seeds from each category were taken for moisture content (fresh weight basis) determination by the oven-dry method of 103˚C for 17 hours. Moisture content for each category of seed was as follows: greenish seed coat – 5.9%, brownish seed coat – 7.1%, blackish seed coat – 7.3 %, and samara alone (without seed) – 9.3%.

Seed of each category: 56 seeds with greenish seed coat, 71 with brownish seed coat, and 29 seeds with blackish seed coat were germinated on moist Kimpak in a Petawawa germination box on a laboratory bench at room temperature varying from 19˚ to 25˚C in daylight for 13 days. Germination results are presented in Table 1.

Table 1. Germination percentage of hybrid maple seed for three categories of seed coat colour.

Seed coat colour	Germination (%)		
	7 days[1]	10 days[2]	13 days
Green	50	80	80
Brown	10	20	16[3]
Black	0	4	7

[1] All germinants exhibited radicle emergence
[2] Germinants had seed coat partially or fully shed with true leaves
[3] Four germinants dead

Morphologically, hybrid maple seed looks very similar to one of its parents, silver maple, except for size (Fig. 1). Its germination behaviour was also like silver maple because the non-dormant seed completed germination in 10 days (Figs. 2 and 3). However, hybrid maple seed could tolerate drying to a moisture content of 6% (embryo and cotyledons). That means its storage behaviour could belong to the orthodox or intermediate category. If this is the case, then hybrid maple seed may have the capability of being stored at sub zero temperatures. However, the results of this trial are based on only a small seed sample from one parent tree in one seed crop year. Further study is required to confirm these results.

Figure 1. *Acer freemannii* seed.

Figure 2. Germination of *Acer freemannii* after seven days.

Figure 3. Germination of *Acer freemannii* after ten days.

Ben Wang
Natural Resources Canada
Canadian Forest Service
Petawawa Research Forest
P.O. Box 2000
Chalk River, ON K0J 1J0
E-mail: bwang@nrcan.gc.ca

DO YOU KNOW YOUR NAP?

The NAP (Niveau d'Amélioration des Produits) is a new indicator of the level of genetic improvement for seedlings produced by the Quebec Ministry of Natural Resources (MRNF).

For nearly 40 years, the Ministry of Natural Resources has invested in forest genetic improvement. Over the years, more than one hundred sources of genetically improved material have been identified by researchers for the main tree species used for reforestation. Today 85% of the seed used for reforestation comes from 1st and 2nd generation seed orchards. The remaining proportion comes primarily from black spruce and jack pine natural stands growing in the northern regions of the province.

We also produce high quality seeds from controlled crosses, which constitute the "crème de la crème" of our forest seeds which are used to produce plants by cuttings. Since 2006, we have scaled up the operational technology to produce seedlings from somatic embryogenesis. We hope in the next 5 to 10 years to be producing highly improved reforestation materials with this technique.

In order to inform our customers about the level of genetic improvement of our products, forest managers use a new information tool nicknamed "NAP". The NAP is represented by 4 levels of genetic gain of the seed source: none, low, intermediate, and high. Table 1 shows the description of each level and the related production for 2007.

Since 2008, this tool has become an indicator of the strategic plan of the MRNF. The information, conveyed on documents and labels, becomes available at the beginning of the plant production schedule starting with the allocation of seeds and following through to the delivery of the planting stock. The customer is able to determine the NAP of the seedlings that will be grown and shipped by consulting the information system PLANTS. This allows him to deploy the higher NAP planting stock to the bests sites.

Finally, the proportion of plants supplied for each NAP category becomes the indicator of the increased genetic gain of plants shipped for reforestation. In 2007, 69% of the plants delivered had an intermediate NAP and 3% a high NAP. The labels accompanying the plants contain NAP information as shown in the figure on the next page.

Table 1. Levels of genetic gain (NAP) for reforestation species and proportion of seedling production in 2007 for each level.

NAP	Approximate genetic gain in height (%)	Species	Proportion of seedlings produced in 2007(%)
None	0	All	17
Low	3	All	11
Intermediate	3 – 15	Spruce (black, Norway, red and white), Pine (jack, red and white), Larch (European, Japanese and hybrid), red oak, black walnut, and, white ash.	69
High	≥ 15	Spruce (black, Norway and white), Pine (jack and white), hybrid larch and, poplar.	3

Anne Savary
Ministry of Natural Resources
Direction générale des pépinières et stations piscicoles
880 chemin Sainte Foy
Quebec, QC G1S 4X4
E-mail: anne.savary@mrnf.gouv.qc.ca

ASH SEED COLLECTIONS FOR GENETIC CONSERVATION

Introduction

Emerald ash borer (EAB), an exotic insect, poses an economic and environmental threat to the ash resource in Canada. Since EAB is a non-native insect, ash trees have not had the opportunity to evolve defense mechanisms to mitigate the insect's impact. If EAB continues to spread it is likely that the ash resource will be decimated.

Since EAB was discovered in Windsor in 2002 it has spread rapidly in southwestern Ontario probably due to movement of infested materials such as firewood. This has resulted in five counties and the City of Toronto being regulated by the Government of Canada to control (prevent) movement of infested materials such as firewood, logs, nursery stock, etc. However, in 2008 the insect was discovered at several more locations in and adjacent to Toronto, in Ottawa, Sault Ste. Marie, north of Sarnia, as well as the Montérégie region southeast of Montreal. It is obvious that the spread of this insect is difficult to control.

There is an opportunity now, while the ash resource is still relatively intact, to initiate an *ex situ* conservation strategy by collecting seed from throughout the ranges of the ash species and storing the seed to preserve the germplasm thereby conserving as much of the natural genetic variation as possible. This germplasm is invaluable and has numerous uses: 1) provides a means to mitigate species extinction, 2) provides a means for storing germplasm that may be resistant to the insect and otherwise lost due to aggressive sanitation programs, 3) provides a valuable source of material that may be utilized in developing resistance to the insect through either conventional or non-conventional (e.g., cloning) breeding, 4) provides a resource for endangered, rare, threatened, and species of concern for plant research, and 5) provides a source of seed to use for future restoration projects in order to re-establish ash species after the insect has swept through.

Ash seed is classified as orthodox and can be dried to a moisture content of less than 10% and stored at -20˚C. Results of testing seed in storage at -20˚C at the National Tree Seed Centre (NTSC) showed that 27-year-old white ash (*Fraxinus americana*) seed had average germination of 76%, 10-year-old red ash (*F. pennsylvanica*) seed exhibited 66% germination, and 15-year-old black ash (*F. nigra*) seed had average viability of 78%. This demonstrates that ash seed can be effectively stored for many decades.

Ash Species Targeted for Seed Collection

There are six ash species native to Canada. The four major species are black, green (*F. pennsylvancia* var. *subintegerrima*), red and white ash but there are two other species, blue ash (*F. quadrangulata*) and pumpkin ash *(F. profunda*), occurring in a few small, isolated populations in

Ontario. Blue ash is rated “special concern” by COSEWIC (Committee on the Status of Endangered Wildlife in Canada). It is important to collect seed from blue and pumpkin ash because they occur at the northern limit of their species ranges and they are adapted to growing in these environmental conditions.

Status of Seed Collections

The preferred type of seed collection is from individual trees and seed is collected from a minimum of 15 trees in a stand or population. Seed collected from individual trees is most advantageous for research such as determining genetic variation, characterizing seed quality, evaluating storage protocols, developing resistance, etc. Stands and populations are selected so as to cover the range of ecological and climatic conditions that occur within a species’ range. Seed can be collected by pulling down seed-bearing branches, removing seed-bearing branches with pole pruners, climbing trees, or shaking trees to dislodge seed that falls onto a tarpaulin spread underneath. Seed must not be collected from the ground because they may be of poor quality and could originate from adjacent trees.

Seed undergo some processing before storage. Coarse debris such as leaves, leaf rachis’s, and stems the seed were attached to is first removed. Green, red, and white ash seed are de-winged whereby about 50% of the samara is removed. The seed are then put into an aspirator which allows for the debris to be blown off as well as most empty and insect damaged seed. The additional advantage of these processing treatments is to reduce the volume of seed to store. Black ash seed cannot be de-winged in this manner so they are stored fully intact.

Seed quality of each collection is determined by conducting a viability test which indicates if an embryo is alive and capable of germinating. Results from viability tests can be obtained within 14 days whereas germination tests may require 4 to 12 months to complete, depending on the species, due to treatments required to alleviate seed dormancy. To conduct viability tests the seed is removed from the pericarp and placed in water at 3˚C for 96 hours. The purpose of this treatment is to soften the seed coat and allow the seed to absorb moisture making it easier to process. After soaking, the embryo is removed by making a longitudinal incision the length of the seed coat and placing the embryo on germination medium in a germination box. Three replications of up to 25 seed each are prepared. The germination box is placed in a germination cabinet set at 25˚C with a daily light duration of 8 hours. After 14 days the embryos are assessed. An embryo is viable if it remains at the same color as it was when excised or one or both cotyledons turn green, and/or the radicle starts to develop.

Seed are stored under two categories. About 2,000 seed per collection are stored for genetic conservation and an average of 3,000 seed (ranging from 100 to 35 000) are stored for research. Seed is primarily stored in glass containers in a walk-in freezer at -20˚C. Information about each seedlot such as provenance, geographic coordinates, and test data is stored in a database.

The NTSC started collecting ash seed for genetic conservation in 2004. Progress has been slow but steady due to availability of seed crops and assistance provided by others to collect seed. The table below shows the number of collections for each species.

Table 1. Number of ash seed collections in storage at the National Tree Seed Centre, 2008

Species	Number of collections
Black ash	137
Blue ash	1
Green ash	14
Pumpkin ash	1
Red ash	105
White ash	215

The NTSC has taken the lead in Canada in making seed collections for conservation. The majority of the collections are from the Maritime provinces with some seed collected in Quebec, Ontario, and Manitoba. Because the EAB is rapidly expanding its range in Ontario and it is now in Quebec it is important that seed collections be made while trees are still alive. It is hoped that provincial governments and other agencies or groups will cooperate to collect seed.

Considerations

It is apparent that EAB is here to stay. It is dispersing rapidly, often as a result of human activity. Steps must be taken to conserve the genes of our native ash species before the resource is destroyed. Storing seed is an effective means for genetic conservation. Such an effort should begin now but is dependent upon good seed production years. During years of poor seed production suitable natural stands and populations of ash can be identified and located so that when the time comes, efforts can be concentrated on seed collection. Cooperation among agencies is crucial in order to achieve success. The NTSC will collect seed whenever it is fiscally and operationally possible. NTSC seeks the involvement of provincial governments, agencies and people to identify and locate ash stands and populations and when necessary to collect or assist with collecting seed.

Dale Simpson and Bernard Daigle
Natural Resources Canada
Canadian Forest Service
Atlantic Forestry Centre
P.O. Box 4000
Fredericton, NB E3B 5P7
E-mail: dsimpson@nrcan.gc.ca

BENEFITS OF THERMAL PRIMING AND OTHER SEED HANDLING PRACTICES

Nurseries play a large role in ensuring that seed is used “efficiently”. Often it is thought that the relationship of seed efficiency at the nursery pertains primarily to how the seed is dispersed in the nursery (quantitative use of seed based on seeds sown per cavity and oversow decisions made at the nursery). Thermal priming of seed in the nursery, prior to sowing, demonstrates that the “nurturing” practices in a nursery can have a large impact on germination rates and vigour. Up to two weeks reduction in germination time can be successfully achieved through this practice. This can contribute to both efficient use of energy and efficient use of seed and increased seedling health. This benefit has been consistently achieved without the use of genetic manipulation.

Efficient use of seed becomes more important as the genetic worth of seed, both in terms of cost of production and potential silvicultural gain, increase. In this sense the concept of “priming” seed (or achieving full benefit of prime seed) is broadened beyond just the concept of thermal priming and becomes a more generalized and universal goal.

If we have truly committed to the development of “prime” seed is it reasonable that we would extend this effort to the development of “prime” growing conditions, “prime” seedlings, and “prime” forests. While we all purport to want this it is not always clear through our behaviour that we act in ways that reflect this objective. Short term economic decisions may be posing some dysfunctional constrictions on our long term objectives.

It has been clearly demonstrated in the past that the development of genetically improved seed is worthwhile. It has been demonstrated that planting larger stock types contributes to more rapid free to grow status. It has been demonstrated that good nurturing practices can enhance the growth of seedlings in the nursery. It is our belief that there is a good business case for collaborating to produce “prime” seedlings from “prime” seed in order to reach the common objective of developing “prime” forests. Growing trees that have been engineered for “prime” performance and growth, enhancing the seed’s performance in the nursery, and subsequently restricting the growth potential by choosing to grow in ever smaller containers may not be conducive to our collective goal of enhancing field performance. Might this be the equivalent of forcing the gene-(y) back into the bottle or binding the feet of our genetically superior progeny?

Robin Dawes
K&C Silviculture Ltd.
33664 HWY 97 South
Oliver, BC V0H 1T0
E-mail: robin@silviculture.com

SEED AND SEEDLING COSTS OVER TIME

Seedling costs are based on the prices paid on competitive award contracts for seedlings grown for Ministry of Forests and Range programs over the previous ten years. Because of the large variety of species and container types, the two prevalent interior and coastal species with their predominant container types were chosen. Interior examples – lodgepole pine 112’s and 160’s, interior spruce 77’s and 112’s. Coastal examples – coastal Douglas fir 77's and 112's, western redcedar 77's and 112's. These examples account for slightly more than 70% of all of the reforestation crops grown in the province over the last 10 years. In spite of a constantly rising "BC Consumer Price Index", seedling prices have remained remarkably constant over the last decade, ranging from about $.11 for pine 160's to about $.33 for fir 77's.

Seed costs are based, for the most part, on the 'Surplus Seed' prices posted on the Tree Seed Centre website. These have been quite consistent with Ministry seed costs. However, some adjustments need to be made, particularly in the case of lodgepole pine and some updated pine and interior fir prices have been calculated by Lee Charleson, Tree Improvement Branch. For pine, spruce, and fir seed costs have risen over the past 10 years as a result of the increasing use of seed orchard seed. As well, the increased cost of pine collections due to the escalating costs of helicopter collections has driven pine seed prices up.

Total seedling cost, comprised of the proportionate cost of nursery and seed in overall seedling costs, varies with species and container sizes. In coastal Douglas-fir, the seed price can be 30% of the overall seedling cost and in small container pine, it can be 25%. In terms of western redcedar in large containers, it is as low as 8%.

Nursery costs have remained very stable over the last 10 years in spite of dramatically rising fuel costs and the shortage of nursery space in 2006 and 2007 and so it's likely that they will remain fairly constant. Some seed however, is becoming increasingly valuable and represents a larger portion of the total seedling cost. Depending on species, it's becoming more important that nursery and seed costs are taken into account to ensure that seed is used as efficiently as possible

Al McDonald
Ministry of Forests and Range
727 Fisgard St.
Victoria, BC V8W 9C2
E-mail: Allan.McDonald@gov.bc.ca

J.D. IRVING, LIMITED PARKINDALE SEED ORCHARD

We are celebrating 20 years of cone collecting and seed cleaning at the Parkindale Seed Orchard. The first grafts were planted in 1983 and by 1991 we had over 40 000 grafted trees established in the orchard. Species are: white spruce, black spruce, Norway spruce, red spruce, jack pine, white pine, and eastern larch. Our present total is 29 000 grafts. All of the early first-generation blocks have been rogued to 50% occupancy.

The first cones were collected from first-generation eastern larch and white and black spruce in 1988. The seed plant was purchased in the same year, from BCC in Sweden. We only collected the seed we needed from our orchard blocks, sometimes leaving part of the crops behind. Better quality seed was available as we removed more and more of the lower ranked clones.

Table 1. Summary of cones collected and seed extracted at J.D. Irving, Limited Parkindale Seed Orchard during 20 years.

Species and generation	Volume of cones (L)	Number of seed (million)
Tamarack, 1st gen.	7460	14.7
Jack pine, 1st gen.	23690	37.3
Jack pine, 2nd gen.	8975	35
White spruce, 1st gen.	92010	332.4
Black spruce, 1st gen.	35725	105.8
Black spruce, 2nd gen.	27350	68.9
Norway spruce, 1st gen.	52905	52.6
Red spruce, 1st gen.	2110	5
White pine, 1st gen.	8480	3.1
Total	258705	654.8

Hart Kunze
J.D. Irving, Limited
Sussex Tree Nursery
181 Aiton Road
Sussex, NB 4G 2V5
E-mail: Kunze.Hartmut@jdirving.com

WOODY PLANT SEED MANUAL

The Woody Plant Seed Manual is available in printed form and can be obtained through the National Seed Lab website http://www.nsl.fs.fed.us/ which provides a link to the Government Printing Office. It is USDA Forest Service Agriculture Handbook number 727, July 2008 and is 1223 pages in length. The manual is an updated and expanded version of the classic 1974 Seeds of Woody Plants in the United States (Figure 1). The cost of the publication is $144.20 in Canadian dollars and considering it is 1223 pages, (full letter size pages) it is quite a good deal. We've just received our copy and it weighs in at just under 4.3 Kg!

The introductory sections covering "Principles and general methods of producing and handling seeds" have been retained and updated with a slight adjustment to the titles. These chapters have been reduced from 163 to 145 pages in the latest edition. The area of expansion was with the genera as now 236 genera are discussed compared to 188 in the 1974 version. Most of these new genera are tropical trees grown in Hawaii or one of the US territories (i.e., Puerto Rico) and a variety of shrubs that have increased in value for wildlife or restoration purposes.

The right margin has a letter index with specific genus indicated at the bottom of each page allowing you to quickly find the genera of interest. For those unable to purchase the manual or wanting to check on some seed details on the road, one can always access the online version, produced in April 2008, at the following link http://www.nsl.fs.fed.us/nsl_wpsm.html. The manual indicates that they plan to use this site to set up a system to update and add to the 236 genera.

Specific to British Columbia, one of the nine pioneers to which the book is dedicated is George S. Allen retired from the Canadian Forestry Service and the University of British Columbia. The other BC participant is George Edwards who provided the chapter on *Abies*, which is the first genera chapter coming in at 50 pages. Overall a great resource and I highly recommend it to those dealing with seeds of woody plants.

Figure 1. A comparison between the 1974 and 2008 USDA Agriculture Handbooks dealing with Seeds of Woody Plants.

Dave Kolotelo

NARINDER DHIR RETIRES

Dr. Narinder Dhir has retired after more than 30 years of guiding the progress of tree improvement in Alberta. Narinder was hired by the Alberta Forest Service, Timber Management Branch in 1975 to develop a genetics and tree improvement program for the province. At the program's inception, he was the only staff member and had no facilities. Under his direction, Alberta's tree improvement program has become very well-established. Both government and industry led programs are making good progress; a network of field test sites, both government and co-operative, has been established across the province; and several seed orchards are now producing improved seed for reforestation. Currently, most of the program delivery is done from the Alberta Tree Improvement and Seed Centre, a complex of greenhouses and laboratories with 50 ha of irrigated field space dedicated to clone banks, field trials and experimental orchards. It is also home to the reforestation seed bunker which houses Alberta's supply of reforestation seed. During his tenure, the Alberta Forest Genetics Resource Council was established to promote dialogue between government, industry and other stakeholders; the Standards for Tree Improvement in Alberta, which regulate management of tree gene resources on provincial Crown lands, came into effect; the Genetics and Tree Improvement Unit took over management of reforestation seed storage and registration; and the Forest Genetic Association of Alberta was inaugurated to address the needs of smaller forest companies lacking the resources to carry out tree improvement and research work. Through all the administrative and scientific challenges over the years, Narinder was always the strongest and most determined advocate for maintaining a viable tree improvement program within the Alberta provincial government. We wish Narinder the very best and trust his retirement will be as productive as his career was with Alberta Sustainable Resource Development.

Alberta Tree Improvement and Seed Centre Staff

TREE SEEDS 2008

I was fortunate to attend the Tree Seeds 2008 meeting held in England from September 22–25 that focused on "**Trees, Seeds and a Changing Climate**". The meeting's theme was recommended at the 2006 IUFRO meeting in Fredericton, NB and its importance and profile have only grown since then. Participants travelled from diverse locations such as Australia, Brazil, South Africa and there was even one from North America – me. Most of the participants (roughly 60%) were from the United Kingdom and many associated with Kew Gardens and their various programs. The meeting organizers: Hugh W. Pritchard, Kate Hardwick and M.M. Daws are commended for their efforts in organizing a very informative, diverse, and entertaining conference.

Daily registrations ranged from 25 to 35 people with different program themes on each day. The sessions on the first and third day were at the University of Sussex and Day 2 was at Wakehurst Place. A listing of the meeting sponsors and the abstracts can be found at: http://www.kew.org/msbp/tree-seeds-2008/Abtract_leaflet.pdf. Day 1 was dedicated to "**Climate Change: Predicted and Observed Impacts**" with four invited and four volunteer presentations. Perhaps most striking was the estimate that approximately 50 000 tree species worldwide are threatened by climate change. Horse chestnut (*Aesculus hippocastanum*) received a great deal of love and appeared to be the meeting poster tree taking over from *Juglans cinerea* in 2006 and *Castanea dentata* in 2003.

Day 2 was dedicated to "**Forest Fragmentation and Restoration**" with seven volunteer papers covering practical issues with restoration, fragmentation, and seed supply, mostly from the tropical forest tree perspective. There was a tour of the Millenium Seed Bank Project facilities including their vaults and their production and research laboratories. The day was rounded out with a few hours to explore the wonderful gardens at Wakehurst Place. Day 3 focused on "**Tree Seed Science**" with two invited speakers and seven volunteer papers. Seed storage behaviour and cryopreservation were the most common topics and probably seed science's highest priorities in light of climate change, environmental degradation, and the need to conserve genetic diversity.

The plan for the meeting was to present gifts to the two best volunteer presentations, but three presentations were considered Excellent. The award recipients were Eila Tilman-Sutela, Steve W. Adkins, and David Blakesly - Congratulations. Each recipient received a signed copy of either the "Seeds: - Capsules of Life" or "Fruit: Edible, Inedible, Incredible" by Wolfgang Stuppy and Rob Kesseler. More information about these glorious books can be found at http://www.kew.org/msbp/scitech/publications/books.htm

After our last dinner we ventured into Lewes for a pub night with Harveys brewery pumping its product from across the road. It was a good, intimate meeting of people from different continents, disciplines, and species interests with one common thread– tree seeds. Although not confirmed Taiwan appears to be the leading candidate location for the next IUFRO Seed Physiology and Technology Research Group meeting – stay tuned.

Dave Kolotelo

UPCOMING MEETINGS

ISTA Tropical Tree and Shrub Seed Workshop
Purity, Moisture Content, Germination, Storage, Tetrazolium
April 7–10, 2009 Curitiba, Brazil
Contact: Antonio Medeiros
medeiros@cnpf.embrapa.br

ISTA Annual Meeting
June 15–18, 2009 Zurich, Switzerland
Contact: www.seedtest.org

RECENT PUBLICATIONS

Beardmore, T.; Scheer, G.; Penner, M.; Wang, B.S.P. 2008. Effects of seed water content and storage temperature on the germination parameters of white spruce, black spruce and lodgepole pine seed. New For. 36(2):171–185.

Bilir, N., Kroon, J.; Lindgren, D.; Prescher, F. 2008. Variation in cone and seed characters in clonal seed orchards of *Pinus sylvestris*. New For. 36(2):187–199.

Castro, J.P.; Reich, B.; Sánchez-Miranda, Á.; Guerrero, J.D. 2008. Evidence that the negative relationship between seed mass and relative growth rate is not physiological but linked to species identity: a within-family analysis of Scots pine. Tree Physiol. 28(7):1077–1082.

Climent, J.; Prada, M.A.; Calama, R.; Chambel, M.R.; Sánchez de Ron, D.; Alía, R. 2008. To grow or to seed : Ecotypic variation in reproductive allocation and cone production by young female Aleppo pine (*Pinus halepensis*, Pinaceae). Am. J. Bot. 95(7):833–842.

Doerksen, T.K.; Herbinger, C.M. 2008. Male reproductive success and pedigree error in red spruce open-pollinated and polycross mating systems. Can. J. For. Res. 38(7):1742–1749.

Fowler, C. 2008. The Svalbard seed vault and crop security. Bioscience 58(3):190–191.

Honda, Y. 2008. Ecological correlations between the persistence of the soil seed bank and several plant traits, including seed dormancy. Plant Ecol. 196(2):301–309.

Jetton, R.M.; Dvorak, W.S.; Whittier, W.A. 2008. Ecological and genetic factors that define the natural distribution of Carolina hemlock in the southeastern United States and their role in *ex situ* conservation. For. Ecol. Manage. 255(8-9):3212–3221.

Kong, L.; Abrams, S.R.; Owen, S.J.; Graham, H.; Von Aderkas, P. 2008. Phytohormones and their metabolites during long shoot development in Douglas-fir following cone induction by gibberelin injection. Tree Physiol. 28(9):1357–1364.

Kormutak, A.; Vookova, B.; Manka, P.; Salaj, J.; Camek, V.; Gömöry, D. 2008. Abortive embryogenesis in hybrid swarm populations of *Pinus sylvestris* L. and *Pinus muga* Turra. Trees 22(5):657–662.

Kuparinen, A.; Schurr, F.M. 2008. Assessing the risk of gene flow from genetically modified trees carrying mitigation transgenes. Biol. Invasions 10(3):281–290.

Lombardo, J.A.; McCarthy, B.C. 2008. Silvicultural treatment effects on oak seed production and predation by acorn weevils in southeastern Ohio. For. Ecol. Manage. 255(7):2566–2576.

Masaki, T.; Suzuki, W.; Osumi, K.; Oka, T. 2008. Geographical variation in climatic cues for mast seeding of *Fagus crenata*. Popul. Ecol. 50(4): 357–366.

Moriguchi, Y.; Prescher, F.; Lindgren, D. 2008. Optimum lifetime for Swedish *Picea abies* seed orchards. New For. 35(2):147–157.

Moya, D.; Saracino, A.; Salvatore, R.; Lovreglio, R.; de Las Heras, J.; Leone, V. 2008. Anatomic basis and insulation of serotinous cones in *Pinus halepensis* Mill. Trees 22(4):511-519.

Peña, E.; Hidalgo, M.; Langdon, B.; Pauchard, A. 2008. Pattern of spread of Pinus contorta Dougl. Ex. Loud invasiuon in a natural reserve in Southern South America. For. Ecol. Manage. 256(5):1049–1054.

Provan, J.; McLaughlin, E.; Preston, S.J.; Wilson, S.; Beatty, G.E.; Hunter, A.M.; McDonald, R. A. 2008. Restricted gene flow in fragmented populations of a wind-pollinated tree. Conserv. Genet. 9(6):1521–1532.

Pullman, G.; Buchanan, M. 2008. Identification and quantitative analysis of stage-specific carbohydrates in loblolly pine (*Pinus taeda*) zygotic embryo and female gametophyte tissues. Tree Physiol. 28(7):985–996.

Ranta, H.; Bondestam, K.; Oksanen, A.; Laukkanen, L.; Hokkanen, T.; Linkosalo, T. 2008. Male flowering of birch: Spatial synchronization, year-to-year variation and relation of catkin numbers and airborne pollen counts. For. Ecol. Manage. 255(3-4):643–650.

Stoehr, M.; Yanchuk, A.; Xie, C-Y.; Sanchez, L. 2008. Gain and diversity in advanced generation coastal Douglas-fir selections for seed production populations. Tree Genet. Genome. 4(2):193–200.

Takács, A.; Bottomley, H.; Andreller, I.; Zaradnik, T.; Schwarz, J.; Bennett, R.; Strong, W.; Gries, G. 2008. Infrared radiation from hot cones on cool conifers attracts seed-feeding insects. Proc. R. Soc. B., 7 p.

Terskikh, V.V.; Zeng, Y.; Feurtado, J.A.; Giblin, M.; Abrams, S.R.; Kermode, A.R. 2008. Deterioration of western redcedar (*Thuja plicata* Donn ex D. Don) seeds: protein oxidation and *in vivo* NMR monitoring of storage oils. J. Exp. Bot. 59(4):765–777.

Tillman-Sutela, E.; Kauppi, A.; Karppinen, K.; Tomback, D.F. 2007. Variant maturity in seed structures of *Pinus albicaulis* (Engelm.) and *Pinus sibirica* (Du Tour): key to a soil seed bank, unusual among conifers. Trees 22:225-236.

Vieira, D.L.M.; de Lima, V.V.; Sevelha, A.C.; Scariot, A. 2008. Consequences of dry-season seed dispersal on seedling establishment of dry forest trees: Should we store seeds until the rains? For. Ecol. Manage. 256(3):471–481.

Williams, C.G. 2008. Aerobiology of *Pinus taeda* pollen clouds. Can. J. For. Res. 38:2177– 2188.