Tree Seed Working Group News Bulletin

Canadian Forest Genetics Association
l'Association canadienne de génétique forestière

74
October 2023

40th ANNIVERSARY

Featured in this Issue:

Banner photo of the Forest Genetics 2023 field tour to a western larch progeny trial, July 14, 2023.

Armchair Report No. 74

Fall greetings to all – I hope everyone had a great summer. We are finally getting a little rain, which may seem odd coming from Vancouver, but it was a very dry summer. Usual rainfall from May to September is 146 mm, and we received 91 this year, and the drought even greater for May and June (36 mm vs. 106 mm normal) when we usually receive most of our summer rainfall. British Columbia was under a state of emergency order for about a month until it was lifted on September 14th. However, various communities still have emergency orders in place, and there are still 125 fires burning in northern BC! Unfortunately, this fire season has also resulted in some fatalities to firefighters. May our thoughts be with them and their families. This is the worst fire season on record in Canada. It's been a hard summer, and hopefully it is not the new normal.

On a brighter note, I am encouraged by the obvious investments being made in tree seed facilities, ranging from the new Vernon Seed Orchard Company cone and seed processing facility, the approval of funding for Washington State to build a new processing and storage facility; upgrades to facilities run by Mast Reforestation and the province of Quebec and last, but not least the construction of new freezer and cooler facilities at our BC Tree Seed Centre. After many permitting delays, we finally broke ground on September 18th and hopefully, in 9 months, we will have the new facilitates operational. The illustration below is an artistic rendering of our new layout, with the red line showing the new section that will be added. The other photo shows the work on day 1 to prepare for the new roadway around the addition.

It looks like live meetings and conferences are finally back! You will find reviews of many meetings enclosed in this edition, just a few highlights here. We finally had the CFGA conference in Vernon, BC, initially scheduled for 2021 until COVID took over. It was a full week for those who participated in both field tours, the Tree Seed

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Deadline for Issue No. 75: January 26, 2024

We welcome any comments, suggestions and article submissions and will solicit active, subscribing members for content. Submissions may be edited for length. Authors are responsible for the accuracy of the material in their submitted content. The mention of commercial products in this publication is solely for the information of the reader, and endorsement is not intended by the Canadian Forest Genetics Association (CFGA). All issues of the News Bulletin are freely available here.

The Tree Seed Working Group News Bulletin is published biennially. The Group's principle aim is to promote tree seed science and technology through:

1. Seed research from bud initiation to seed utilization
2. Identification of seed problems relating to tree improvement and forest management
3. The exchange of information on seed-related problems
4. Advising on implementation practices

Top: Artist's rendering of the BC Tree Seed Centre freezer and cooler expansion project (new additional space underlined in red). Bottom: Breaking ground, September 18, 2023.

Workshop and the two days of concurrent indoor sessions. It always takes a village, but high praise to Brian Barber and Nick Ukrainetz, who bore the lion's share of the work organizing this conference. The Tree Seed Workshop and the concurrent conference sessions were not offered virtually, but most presentations will be made available on the CFGA YouTube site – stay tuned for more details. The CFGA AGM will be held virtually later this fall to allow for maximum participation.

I was also fortunate to participate in the Tree Seed Summit in Eatonville, WA, hosted by Mast Reforestation and the Society for Ecological Restoration, with the goal of strengthening the seed supply chain. Although the entire reforestation pipeline was topical, a major emphasis was placed on collecting cone crops. Please see their meeting summary for resources and links.

The Whitebark Pine Ecosystem Foundation of Canada (WPEFC) is hosting a science and management conference with the theme of "Pines & People: Human Impacts on 5-Needle Pines" in Revelstoke, BC from October 11–14. More details can be found here: https://whitebarkpine.ca/conferences/. Hopefully, we will have meeting summaries for this and the joint Forest Nursery Association of BC (FNABC) and Western Forestry and Conservation Association (WFCA) meeting that recently occurred in Portland, OR in the next News Bulletin in early 2024.

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Editor's Notes

Happy 40th anniversary TSWG (1983–2023)! With the persistent activity and meetings since No. 73, I'd say the TSWG spirit feels alive and well. I hope this momentum continues, so we can fortify our ranks with skilled expertise and long-term support. There are more big shoes due empty soon and no substitute for adequate mentorship time with them. Repeat after me: we shalt not reinvent any wheels!

Special thanks to new and long-standing members who helped this issue go from sparse to jam-packed since the Vernon workshop. As a dividend of international meetings, this is the first Bulletin with views from both Sweden and Portugal. In research extension, Patrick von Aderkas and Rob Vaughn provide insights on cone induction and seed dormancy with managed and natural regeneration implications. Conservation archives and resistance breeding programs are pushing ahead in the Great Lakes region, with range-wide black ash research reaching across borders, and the RNGR team branching into urban forestry seed needs. One notable meeting Richard Sniezko alerted me to that will publish material later was the July 25–27th USFS geneticists' applied resistance breeding workshop, held in Cottage Grove, OR. After finally meeting Richard in person, I fully understand his *infectious* energy for this cause.

To allow more research, publications and operational news to roll in, I've set the next deadline into the New Year. In the meantime, please post jobs, events and more urgent news to the TSWG [Google Groups] or [LinkedIn]. Dave and I are brainstorming more reasons to get together online, but reach out anytime if you've got a good idea or seed problem.

Views and vines from Vernon: myself (left in both) with Kristen Sandvall (left), Victoria Lei (middle) and Richard Sniezko (right).

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2023 TSWG Workshop

Melissa and I were pleased to be able to provide a full day tree seed workshop on July 10th at the most recent CFGA meeting in Vernon, British Columbia. The workshop was presented live but also recorded; videos will be available on the CFGA YouTube site soon. There were approximately 60 people who attended the workshop and the consolidated program is provided in Table 1.

I was excited that we were able to provide several talks on reproductive biology. I strongly believe this is an area we do not invest in enough, especially with ambitious tree planting goals and increasingly greater dependence on seed orchard crops. Our first speaker, Dr. Graham Powell, was Chairman of our working group from August 1987 to August 1991. Graham was actually the first person to hire me into a forestry job assisting graduate students (Kathy Tosh and Guy Caron) with their research on crown architecture, pollen and seed production. Graham's prerecorded lecture demonstrated what should proceed normally in a typical balsam fir (*Abies balsamea*) reproductive cycle, including his foundational research on phenotypic and interannual variation. Patrick then provided a great overview of what can go wrong and when in the longer reproductive cycle of *Pinus* species. Robert provided an overview of the impact of soil characteristics on lodgepole pine seed production at the Skimikin seed orchard. I was especially excited by Stephen and Courtney's talks on controlled mass pollination as I thinks this is a viable tool for BC, especially in the production of specialized seedlots focusing on pest resistance traits from a subset of orchard parents without having to create a new seed orchard.

Victoria provided an overview of seed testing practices at the BC Tree Seed Centre and spoke to equipment used during the afternoon demonstration session. I followed this with some suggestions and cautionary remarks on interpreting research results and common pitfalls (see also "Publication Perils" in Bulletin No. 59). Melissa's talk on handling and testing exceptional (non-orthodox) species at the Atlantic Forestry Centre was voluntarily withheld to allow networking time at lunch, and will be posted to YouTube.

In the afternoon, several talks focused on genetic conservation from an overview of the status of the BC program and inherent protected areas to the development of a tree seed

Table 1. Summary of the Tree Seed Workshop presentations and demonstrations, held July 10, 2023 in Vernon, BC.

Presentation	Speaker
Welcome & Introductions	Dave Kolotelo
TSWG Membership Needs & OECD Tree Seed Demand Update	Melissa Spearing
Reproductive Biology and Seed Orchard Practices	
Reproduction in Balsam Fir (recorded presentation)	Dr. Graham R. Powell
Gametic Selection During Reproduction: Whatever Could Go Wrong?	Dr. Patrick von Aderkas
Lodgepole Pine Seed Yields from Two Orchard Soil Types	Robert Taylor
Controlled Mass Pollination (CMP) in the Southeastern USA	Stephen Goodfellow
JD Irving's Controlled Mass Pollination with White Spruce	Courtney McDonald
Seed Testing and Use	
Testing, Testing 1, 2, 3!	Victoria Lei
Seed Research Interpretations & Pitfalls	Dave Kolotelo
Dealing with Exceptional Species at the Atlantic Forestry Centre	Melissa Spearing
Genetic Conservation and Restoration	
Update on Genetic Conservation of Trees in BC	Dr. Tongli Wang
Whitebark Pine: Initiatives to Restore an Endangered Species	Francis Iredale and Stephen Joyce
Genetic Conservation Projects in Southern Ontario: Challenges and Opportunities	Kristen Sandvall
Towards an Ontario Tree Seed Genetics Archive	Dr. Lahcen Benomar
Low Tech Tools and Techniques	
Seed Orchard Monitoring: From Low to High Tech	Geoff Bradley
Demonstrations • Protecting Seeds & Seedlings - Cages, Guards, Deterrents and More • BC Tree Seed Centre Germination Testing Set-Up • Digital Moisture Monitoring Tools + Mini Seed Banks • Good Microscopes & Photography Tools	
Closing Remarks	Dave Kolotelo and Brian Barber

Prerecorded lecture on reproduction in balsam fir by Dr. Graham R. Powell, Professor Emeritus from the University of New Brunswick. Click to watch the YouTube recording.

archive in Ontario. In between, the unique and progressive program to restore the endangered whitebark pine (*Pinus albicaulis*) to the landscape and challenges with southern Ontario's programs to conserve unique Canadian species were featured.

Geoff provided an overview of seed orchard monitoring and how technology is helping inform decision making for orchard management – "Data to Decisions" being his mantra. Several people brought low tech tools for show and tell, which were set up on tables for previewing all day and demonstrated concurrently in the final session. Melissa gathered supplementary material to share as the audio was not recorded. Please contact those below to learn more:

- Evolution of whitebark pine cone cage construction. Instructional how-to in Nutcracker Notes No. 35: https://drive.google.com/file/d/1uewT-_g2Zx2oG-bOddka9ziC6LYrQAte/view. Contact Stephen Joyce: info@whitebarkpine.ca
- Wire hanger pheromone trap and pole insertion technique for use in seed orchards; short demonstration video: https://photos.app.goo.gl/RzfoWVvJLSEGPwcw7. Contact Geoff Bradley: Geoff.Bradley@gov.bc.ca
- Gopher cages to protect new orchard grafts and seedlings: https://gopherbasket.com. Contact Robert Taylor: Robert.1.Taylor@gov.bc.ca
- Demonstration on how the BC Tree Seed Centre sets up routine germination tests. A supplier list with current

costs is here: https://docs.google.com/spreadsheets/d/1ym63otUyzNUaQMGGl0kueRzby_1GQ6ZeyJf5tB0JaQk/edit#gid=0. Contact Victoria Lei: Victoria.Lei@gov.bc.ca

- Digital moisture monitoring tools included Kestrel D2 Bluetooth data loggers (https://kestrelinstruments.com/kestrel-drop-d2-humidity-logger) and a FLIR ONE® Pro thermal imaging smartphone camera and application. Given interest in the latter, see Melissa's article to follow.

- Mini seed bank: Melissa brought a ULINE gamma-sealed 5-gallon bucket kit with orange-green indicating silica gel beads, a Bluetooth serving as a humidity-controlled storage or transport system for small collections (see also National Tree Seed Centre webinar here: https://youtu.be/mu0jTd5ahCc?si=qXnFV0H8qk5zo_ov&t=1739). Contact Melissa below.

- Good microscopes for seed dissection and photography included the National Tree Seed Centre's Dino-Lite USB digital microscope (Model AF4115ZT, 20–220× magnification, 1.3MP images; newer models up to 8MP) and Vernon Seed Orchard Company's basic Fisher Scientific digital stereo microscope (Model 11350134, 10–40× magnification) with a built-in 3.0MP camera. Melissa also brought a Xenvo Pro macro lens kit for high-quality smartphone field photography: https://www.xenvopro.com/pdp/pro-lens-kit/. Contact Tia Wagner (tia@vsoc.ca) or Melissa below.

This final session also provided a good opportunity for networking within the seed community.

We look forward to our next tree seed workshop in 2025 and the location will be finalized at our online CFGA AGM and Business Meeting in the fall. Thank you to everyone who contributed in making this workshop a success.

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Low-Cost Thermal Imaging Cameras for Seed Handling

At the July 10th TSWG workshop, I demonstrated a FLIR ONE® Pro thermal infrared (IR) imaging smartphone camera and app for real-time seed moisture visualization ($570, Gen 3 $305 CDN). Given the potential applications for research and practical users, I wanted to expand and build on the TSWG knowledge base here. Check out the full suite of FLIR cameras: https://www.flir.ca/browse/professional-tools/thermography-cameras/.

My brother first introduced me to this plug-and-play unit in 2017, as it gained widespread use with insurance inspectors looking for potential energy, electricity, and water issues. I found it immediately useful for monitoring seed drying areas during busy collection periods, as it quickly reveals any damp lots or spots not yet in equilibrium (Fig. 1). Newer models can auto-capture the warmest and coolest surface temperatures in an image up to 400°C, which could be useful for live trouble-shooting seed extraction and nursery mechanical systems. I have only used the app in basic point-shoot-and-save mode, but FLIR's Thermal Studio desktop software offers more data analysis pipelines and customizable reports.

Scanning recent literature, a review by Zambrano et al. (2020) listed IR smartphone technology as a globally accessible technology for small-scale farmers to assess stable seed moisture content in harvested crops prior to long-

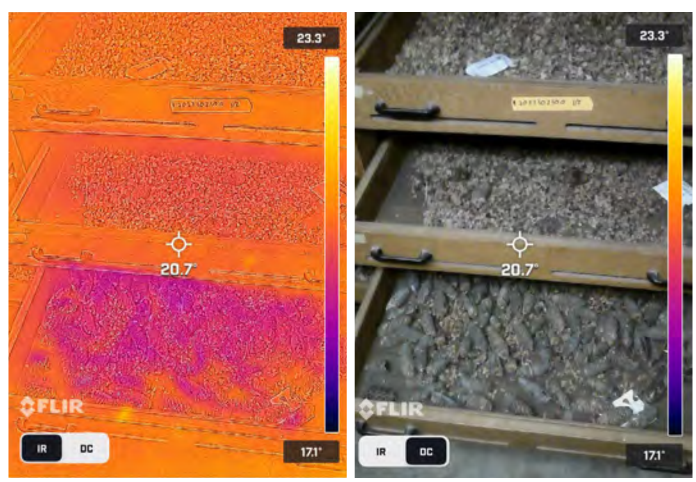

Figure 1. A mobile thermal camera application that captures both the infrared (IR) and digital camera (DC) modes (FLIR ONE Pro). The bottom tray shows a fresh *Abies balsamea* cone lot releasing moisture on a day with >80% relative humidity.

term storage. Liu et al. (2020) demonstrated thermal decay signatures in assessing seed vigor of aged Chinese elm (*Ulmus pumila*) and rice seedlots, as well as other agricultural crop tested. See other reviews by Michelon et al (2023) and Wen et al. (2023) in Recent Publications.

Long-time readers may also recall inversely-colored images in Bulletins No. 48 (Robb Bennett) and No. 61 (Mike Crawford), based on the fascinating study by Takács et al. (2009) that determined the infrared honing mechanism of the western conifer bug to warmer-than-ambient developing cones. From 2014–2016, the US Bureau of Land Management (BLM) was interested in testing drone-based thermography to rapidly survey Douglas-fir orchard crops, though camera weight limitations were an issue. Now FLIR's military drone suite includes a nano-UAV less than 33 grams, and I noted in Mast Reforestation's TSS Newsletter #1 IR images taken with Nick Kunz' DJI Mavic unit. A question posed after the workshop I couldn't answer was whether IR can determine seed readiness for picking. Similarly, I'm curious how well IR could distinguish seed quality and quantity of broad-leaf seeds hanging under the leaves.

Has anyone else been using or thinking of infrared thermal cameras for seed handling or research?

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Lodgepole pine cone production: new sites unleashed with $GA_{4/7}$ and BA when used in a tree-sensitive manner

One way to boost seed production in orchards is to induce more cones. In lodgepole pine (*Pinus contorta*), male and female cone buds initiate in the long-shoot bud. Within this bud, there are branch buds, leaf needle fascicle buds, as well as male and female cone buds. The cone buds are spatially restricted such that female cones develop at the distal end and male cones at the proximal end (O'Reilly and Owens, 1987). Typically, two to three female cones and twenty or more male cones develop within a long-shoot bud.

Methods such as root pruning, shoot pruning, and application of plant growth regulators (PGRs) have been used to increase female cone yield in coniferous species (Kong and von Aderkas, 2007). Exogenously applied gibberellins are not the only PGRs to influence cone numbers; cytokinins are able to induce cones. Stem injection of cytokinin in combination with $GA_{4/7}$ produced many more cones than injection of either type of PGR on its own in lodgepole pine (Kong et al., 2018). Results of cone induction via stem injection in lodgepole pine vary by genotype (Wheeler et al., 1980, Kong et al., 2018). Little information is available about the factors that may be involved in such genotype-specific responses following the application of exogenous PGRs. It is known that some trees are very sensitive to applied PGRs. Following stem injection, some genotypes develop yellowing or browning in some of their needles; some genotypes have completely browned branches, and, very occasionally, some trees die. To avoid damage and death of GA-hypersensitive trees, caution is generally exercised when developing dosages for stem injection strategies. Until now, no pre-injection tests for hypersensitivity existed.

Our study of lodgepole trees stem-injected with PGRs confirms that an alteration in the early development of proximal buds can be induced: buds did not develop as males but produced female cones instead. This developmental response was partly genotype-dependent. We also report a simple operational method to test genotypes for hypersensitivity to particular PGRs, the benefit of which is to reduce unnecessary losses of reproductive adult trees in elite seed orchards.

Materials and Methods

Plant materials

Genotypes of lodgepole pine were tested in three clonal seed orchards: Sorrento Seed Orchard, Kettle River Seed Orchard and Vernon Seed Orchard in Okanagan, British Columbia, Canada. We selected ramets aged between 12 and 16 years old. For PGR injection treatments, trees of similar diameter were selected. Hand-sectioning was used for general morphological observation of plant samples collected at selected time points. Buds were cut longitudinally in two. To prepare materials for plastic embedding and sectioning on a microtome, buds were fixed in 2.5% glutaraldehyde in phosphate buffer at pH 7.5 for a minimum of two days at room temperature. After two rinses with buffer, the samples were dehydrated stepwise in an ethanol series, infiltrated with glycol methacrylate (Historesin, Reichert-Jung) for a number of days and kept at 4°C for a week prior to polymerization. Embedded samples were sectioned into 5 µm-thick sections using a Leitz 1400 microtome equipped with a tungsten-carbide knife and stained using Toluidine Blue O with sodium hypochlorite pretreatment (Gutmann, 1995).

Stem injection of GA and BA

The GA mixture was dissolved in 100 % MeOH at a concentration of 100 mg mL^{-1}. 6-benzylaminopurine (BA, Caisson Laboratories, North Logan, UT, USA) was dissolved in 1 N KOH and diluted to a final concentration of 100 mg mL^{-1}. All PGR treatments were applied in late spring before cone bud differentiation had occurred. Four stem injection treatments were used initially: $GA_{4/7}$ alone, BA alone, $GA_{4/7}$ and BA, and a PGR-free control. Solutions were injected into holes drilled into the stem at a 45° angle. Holes were 6 mm in diameter and 40 mm deep (Kong et al., 2008). The holes were 60–75 cm above the ground. Further treatments focused on just two of the treatments, $GA_{4/7}$ alone and $GA_{4/7}$ plus BA. Solutions of $GA_{4/7}$ and BA were injected into separate holes one after another. Cone yield data was collected the year following PGR injection from three to five ramets of each genotype. Data from the analysis and treatments were subjected to a one-way analysis of variance (ANOVA). The variance was analyzed by Tukey's significant difference with the level of significance at $P < 0.05$.

A simple foliar test to screen for genotype sensitivity to GA and/or BA

Two types of solutions were prepared. Solution I stock (2 mg $GA_{4/7}$/L) was prepared as follows: 1 g $GA_{4/7}$ was dissolved in 20 mL MeOH and 5 mL 1 N KOH, to which an initial 400 mL of water was added. The solution was adjusted to pH 7. Water was added to bring the final volume up to 500 mL. Solution II (2g /L $GA_{4/7}$ and 2 g/L BA) was prepared as follows: 1 g BA was dissolved in 15 mL 1N KOH, and separately, 1 g $GA_{4/7}$ was dissolved in 20 mL MeOH. The two solutions were mixed together; the pH was adjusted to pH 11. Water was added to bring the final volume to 500 mL. Stock solutions were stored at 4°C and used within a week of preparation. To test sensitivity, 1 mL was sprayed in late May on shoot tips. Two weeks after application, the colour of the sprayed tips of expanded needles was assessed. The test was run a minimum of two years in a row.

Results

Bud development

The proximal-distal axis of a dormant lodgepole pine long-shoot bud typically has an apical bud, followed by lateral buds and female-cone buds, short-shoot buds and, finally, male-cone buds (Fig. 1). Histological study of the various buds showed that they could be readily differentiated from one another (Fig. 2). Male-cone buds (Fig. 2, H and I) were recognizable by mid- to late June. Female-cone buds, which were hemispherical in shape (Fig. 2, E and F), could first be distinguished by mid-July in some genotypes. This provided an important piece of information, namely that male cone-bud development preceded female cone-bud development, which was used to inform our timing of stem injection of PGRs: it had to be done by mid-June before buds began to differentiate into male or female cone-bud.

Stem injection

As a starting point, i.e. to provide a proof-of-concept, we carried out a trial on genotype 2082, which was known to be able to occasionally produce female cone-buds in the proximal portion of a long shoot. Compared to control trees that had not been stem-injected with PGRs, trees treated with $GA_{4/7}$ had four times the number of female-cone clusters per tree (Fig. 3). Injection of BA alone had no effect. However, treatment with BA in combination with $GA_{4/7}$ boosted female cone-bud cluster production 10-

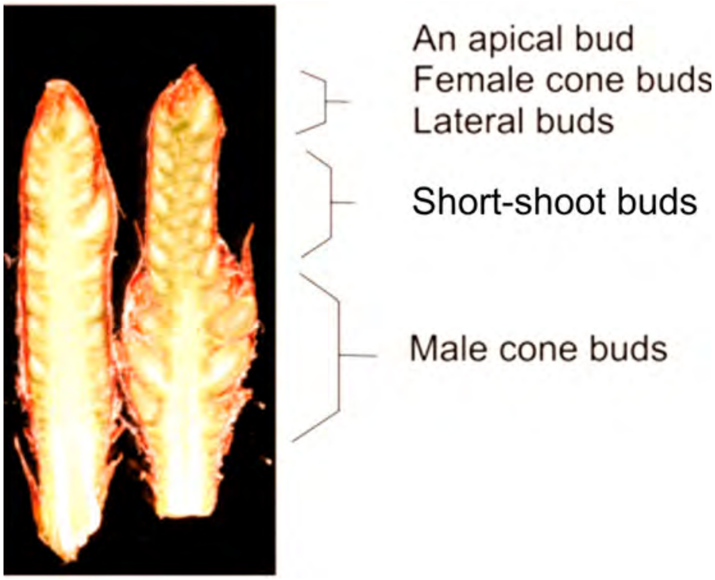

Figure 1. A long-shoot bud of lodgepole pine in the fall that has been cut in half to show the locations of various buds.

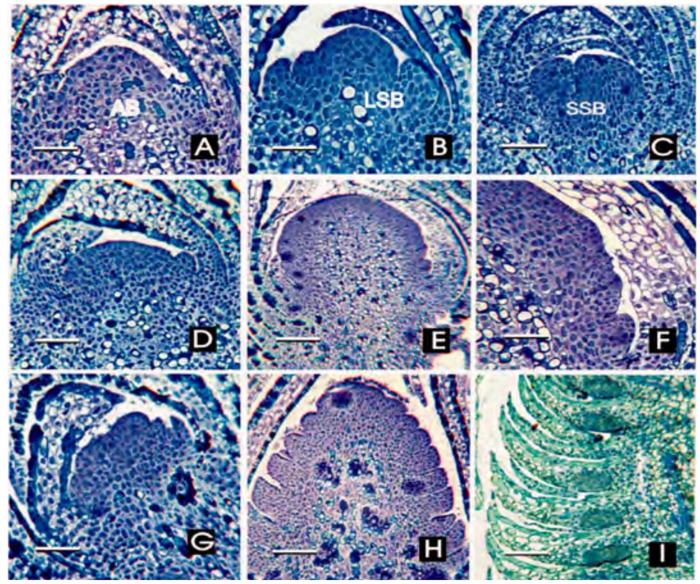

Figure 2. Buds of longitudinal section in lodgepole pine. A-C vegetative buds; D-F female cone buds at different developmental stages; G-I developing male cone buds. AB: apical bud, LSB: long-shoot bud, SSB: short-shoot bud. All Bar = 50 µm.

fold (Fig. 3). The conclusion is that plant growth regulator application is an effective method of boosting cone-bud clusters in genotype 2082 and that these cone-bud clusters are occurring uniformly in the region in which male cone-buds would normally occur. Furthermore, the combination of PGRs can make a big difference in female cone-bud production.

We then used the treatment that provided the highest yield of female cone-buds in genotype 2082, i.e. stem injection with $GA_{4/7}$ plus BA, and applied that treatment to numerous genotypes in various seed orchards. This study demonstrated that female cone cluster yield response to $GA_{4/7}$ plus BA was genotype-dependent (Fig. 4). Except for a few genotypes that showed no response, e.g. 224, 4066, increases in female cone yield by PGR injection ranged between 2.5– and 5.6–fold compared with controls.

Stem injection with the combination of $GA_{4/7}$ and BA increased female cone yield per tree in four ways: 1) more long shoots per tree that produced female cones; 2) the number of female cones per whorl increased, resulting in as many as four cones per whorl; 3) the number of whorls of cones per long shoot increased (e.g. Fig 5); 4) clusters of numerous female cones were produced *de novo* in the proximal portion of long shoot, which as stated above, was the site usually occupied by male cones (Fig. 5). Heavy cone production referred to in 4) above resulting in large clusters (Fig. 5) occurred only in a small percentage of genotypes. As many as 18 clusters per branch were recorded from genotype 1831. An average of 13.7 cones per cluster, with a maximum of 48 cones per cluster, was recorded in this genotype. Genotype 2082, not surprisingly, also had a high number of clusters. The cones in all clusters matured normally two years later following induction (Fig. 6). Seeds germinated readily.

Sensitivity tests

Hypersensitive reactions to PGRs were consistently observed in particular genotypes. In PGR-sensitive genotypes, treatment of $GA_{4/7}$ plus BA caused a stronger reaction than using $GA_{4/7}$ alone in the test of shoot tip spray (Fig. 7). In order to avoid or reduce the damage caused by PGRs, we needed to determine which trees were PGR-sensitive for possible damage prior to injection. A method was developed to test genotype sensitivity by spraying PGRs on the shoot tips of small branches. Responses of 10 genotypes were highly genotype-dependent (Table 1). We went on to test this at scale. A total of 86 genotypes were tested, of which 12 showed negative responses (13.95% of the total tested). Six genotypes showed yellowish needles, and six genotypes

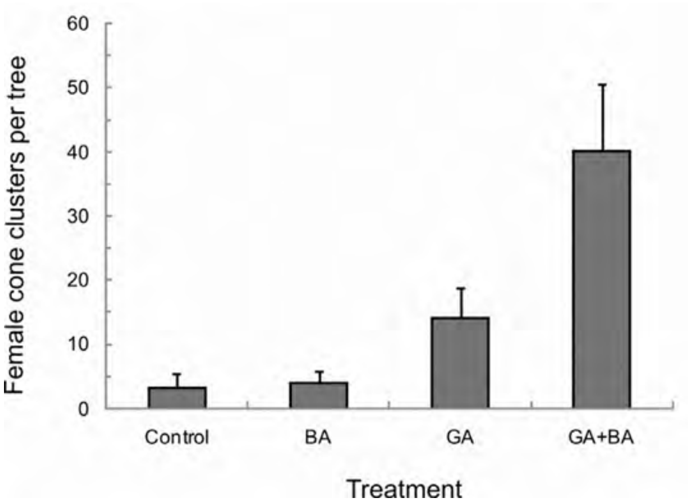

Figure 3. Cone induction in lodgepole pine. Female cone clusters were induced by stem injection of PGRs including GA, BA, or GA plus BA. PGRs were applied to ramets of genotype 2082 at Sorrento seed orchard, British Columbia.

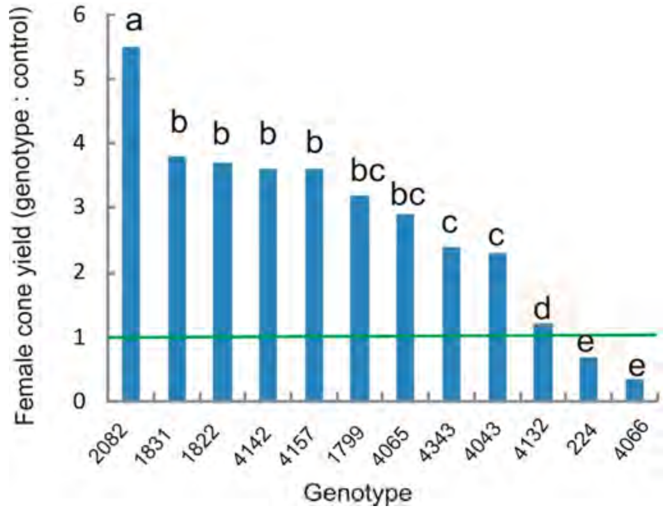

Figure 4. Female cone yield per ramets of various genotypes after stem injection with $GA_{4/7}$ and BA (N = 3 to 5 ramets). Different letters in the graph represent statistical significance between genotypes. The green line represents the uninduced controls.

Figure 5. Female cone clusters of genotype 1831. A) a cluster of male cones on an uninjected control tree; B) a cluster of female cones on a tree treated by stem injection with $GA_{4/7}$ and BA; C) clusters of female cones. Photos were taken the year following stem injection.

Figure 6. A) Female cone clusters in genotype 2082. B) Close-up photo of mature female cones (two years following injection).

Figure 7. Photos showing responses of branch tips to spray treatments. Upper photograph: insensitive shoot tips following the test. Lower photograph: One of the two tips was brown after the test. The white ribbon indicates that $GA_{4/7}$ was sprayed, whereas the yellow ribbon indicates that $GA_{4/7}$ and BA were sprayed.

Table 1. Qualitative response assessment of ramets of 10 genotypes to the bud spray test and stem injection with $GA_{4/7}$. Three to five ramets of each genotype were used in each growth season for the test.

Genotype	Response to spray test[1]	Response to injection	Cone yield	Female cone clusters	Years in test
2082	Positive	Positive	Increased	Increased	4
1831	Positive	Positive	Increased	Induced	3
1822	Positive	Positive	Increased	Induced	2
4142	Positive	Positive	Increased	No	2
4157	Positive	Positive	Increased	No	2
1799	Positive	Positive	Increased	No	2
4065	Positive	Positive	Increased	No	2
4132	Negative (I)	Brown needles	No change	No	2
224	Negative (II)	Branch damage	Reduced	No	2
4066	Negative (III)	Damaged or dead trees	Reduced	No	2

[1]Positive response to the test: no change of bud/needle color after the test or in the trees after injection of PGRs. Negative responses to the test were scored as: (I) the needles were light yellow or brown in color after the test; (II), brown color; (III) deep brown or deep or damaged tips.

showed brown needles or tips. Testing was consistent from year to year. Sensitive genotypes had, it should be noted, very poor cone production that was not improved by injection. By comparison, if a genotype passed the spray test and showed no damage, it would not be damaged by a $GA_{4/7}$ plus BA stem injection.

Discussion

A novel finding is that it is possible in some genotypes to initiate female cone development in both distal and proximal portions of a long shoot. In extreme cases, it was possible to produce abundant clusters of cones. In terms of cone development, such cones were normal and produced normal seeds. We did not ever observe bisexual cones as has been commonly recorded by BA treatment of long-shoot buds of both Japanese red pine and Japanese black pine (Wakushima et al., 1997). For lodgepole pine, the combination of $GA_{4/7}$ and BA was more effective for cone induction than $GA_{4/7}$ alone, which agrees with previous findings (Kong et al., 2016; 2018). We knew that stem-injected PGRs affect endogenous phytohormone concentrations and profiles, which in turn influences the physiology of bud development (Kong et al., 2011; 2012). We were surprised by the extreme response of some genotypes stem-injected with gibberellins and cytokinins. The resulting cone clusters were fairly spectacular.

The induction of such female cone clusters was genotype-dependent. For most genotypes, female cone bud clusters did not develop in proximal sites after stem injection. However, for those able to produce bud clusters, the phenomenon could be repeatedly induced over a number of years.

For PGR application to succeed, it had to be carried out before buds were determined as either males or females. From previous studies, we know that after stem injection of PGRs, the patterns of endogenous hormones resulted in higher concentrations of cytokinins and lower concentrations of abscisic acid (ABA) in long-shoot buds in which the cone buds initiated (Kong et al., 2011; 2012; 2016).

It is highly recommended that all the genotypes be tested by the spray method that we developed in this paper, as it would allow a record of the genotype responses to be recorded that could be used as a reference to prevent any potential losses of ramets of genotypes in the seed orchard due to exogenous plant growth regulator by stem injection.

Acknowledgments

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Winter warming impacts on seed germination of Acadian Forest Region tree species

The mean winter temperature of the Acadian Forest Region is projected to rise by 6°C by the end of this century under the high emission RCP 8.5 scenario (McKenney et al. 2013). This intensity of winter warming will reduce snow cover period and depth, and spring soil moisture (Houle et al. 2012), which could have significant impacts on ecological processes that control stand regeneration (Campbell et al. 2005). Specifically, successful germination of some tree species requires a particular range of environmental conditions during the winter to relieve seed dormancy (Walck et al. 2011). Consequently, variation in these conditions may affect the natural regeneration and establishment of these species.

In an experiment at the Atlantic Forestry Centre in Fredericton, NB, seeds of seven tree species native to the Acadian Forest Region were exposed to a winter warming treatment, which simulated end-of-century conditions under the Representative Concentration Pathway (RCP) 8.5 climate change scenario. The objective of this study was to determine whether future winter warming will affect the germination success of species with different levels of seed dormancy.

We evaluated seeds from four parent trees each of balsam fir (*Abies balsamea*), red spruce (*Picea rubens*), white pine (*Pinus strobus*), red maple (*Acer rubrum*), sugar maple (*Acer saccharum*) and yellow birch (*Betula alleghaniensis*) in a fully crossed in situ experiment with four replicates each of control and heated seed plots (Fig. 1). Heated plot surface temperatures were maintained at 6°C above control plots with infrared heaters. Seeds were placed in seed beds on December 17, 2019, removed on April 15, 2020 and subsequently germinated in a Conviron germination cabinet to determine the treatment effects.

Although average seed plot temperature conditions varied substantially between the two treatments (Fig. 2), none of the tested species' germination rates were significantly affected by warming (Fig. 3). However, we observed substantial differences in the response to warming among balsam fir seedlots (Fig. 4), suggesting considerable variation in this species' seed dormancy levels. These results suggest regeneration success of the tested tree species will not be

Figure 1. Seed plot layout and design: (a) arrangement of the 24 seed bags (50 seeds per bag × four seedlots × six species) within one seedbed and locations of the soil temperature and moisture sensors; (b) the seedbed after the seed bags were covered with peat moss; (c) the entire site where the eight plots were set up in two rows of four (the closest plot was not used) and the location of one of the ambient air temperature sensors; and (d) location of the seedbed relative to the infrared heater and infrared temperature sensor.

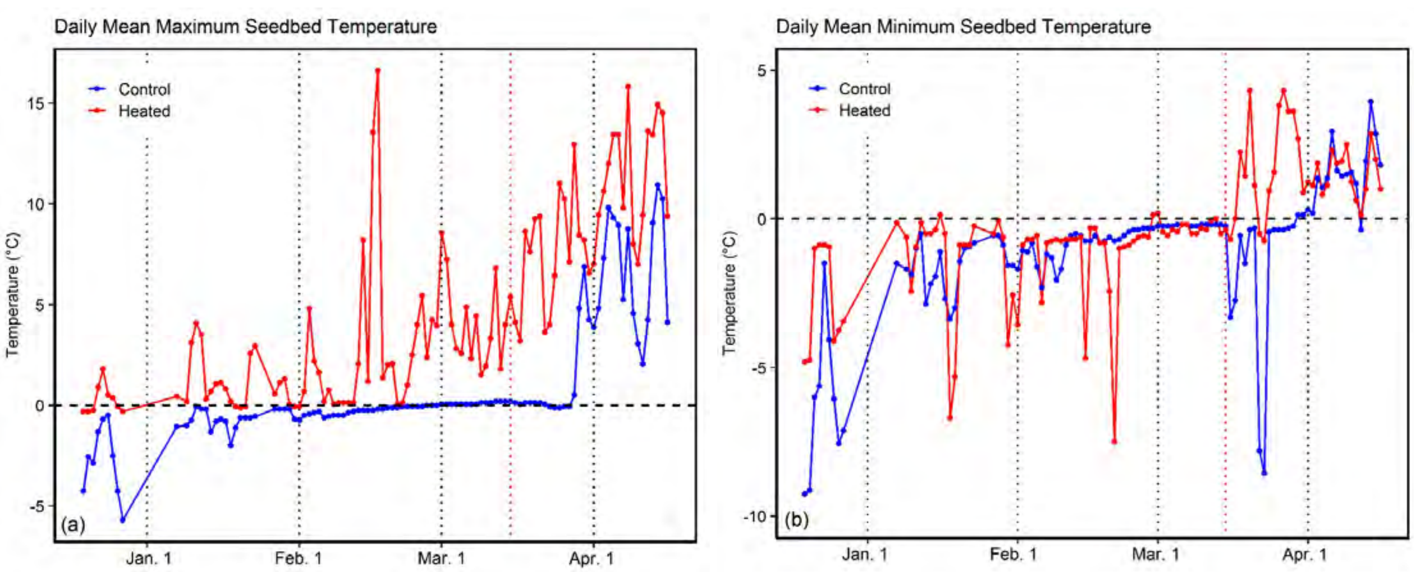

Figure 2. Daily mean treatment maximum (a) and minimum (b) seedbed temperatures of control and heated plots. Plot surface warming was limited to a maximum of 0°C until mid-March, whereby the programmed limit was removed.

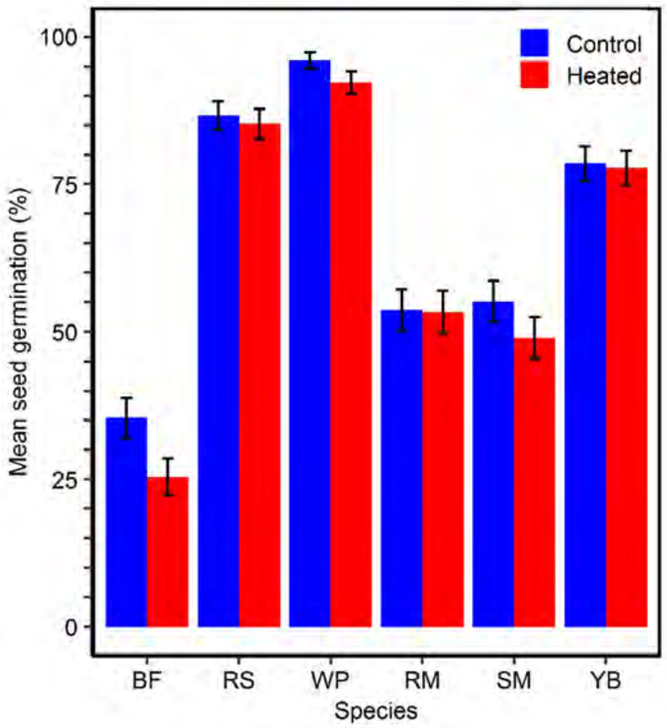

Figure 3. Mean (± 1 SE) germination results for six species (BF = balsam fir, RS = red spruce, WP = white pine, RM = red maple, SM = sugar maple, YB = yellow birch) in control and heated plots. Each bar represents four replicate plots containing four seed bags each (50 seeds per bag; one bag for each seedlot), totaling 800 seeds.

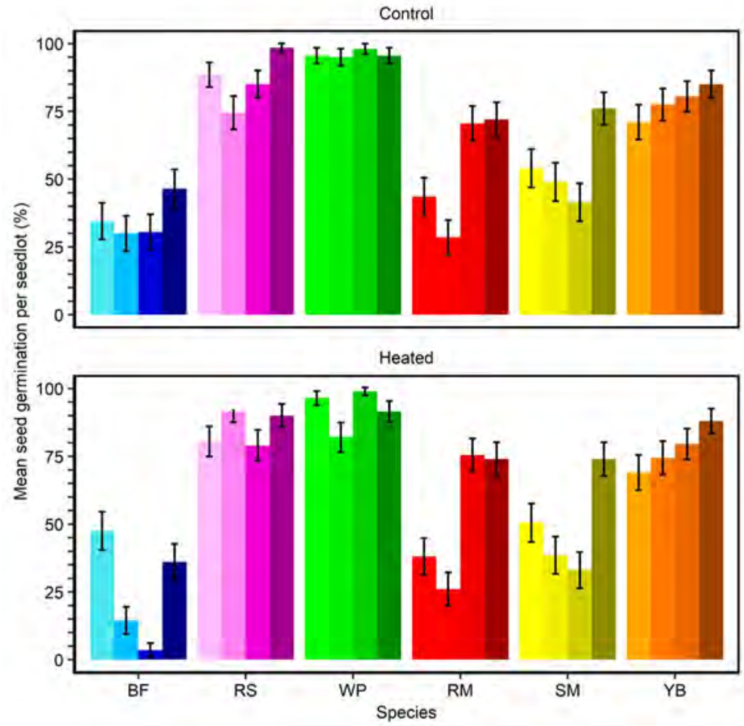

Figure 4. Mean (± 1 SE) germination results for four seedlots (different colours) of six species (BF = balsam fir, RS = red spruce, WP = white pine, RM = red maple, SM = sugar maple, YB = yellow birch) in control and heated plots. Each bar represents four replicate plots, with each plot containing 50 seeds of one seedlot, totaling 200 seeds.

impeded by their individual seed characteristics under the magnitude of winter warming projected over this century in our study area. Further research should be conducted to determine whether the response to warming varies among populations throughout the native ranges of these species.

For more information on this study, please refer to the open access article here: https://cdnsciencepub.com/doi/full/10.1139/cjfr-2021-0105.

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Unifying Great Lakes Forest Health Professionals for Resistance Breeding

As an international initiative, the Great Lakes Basin Forest Health Collaborative offers resources, training, networking, and more while encouraging collaboration to breed tree resistance against invasive forest pests and diseases.

Calling all Tree Seed Working Group members in the Great Lakes region (Fig. 1): You are cordially invited to join the Great Lakes Basin Forest Health Collaborative (GLB FHC).

The group is led by the Holden Arboretum in Kirtland, Ohio, in partnership with the U.S. Forest Service and with support from the Great Lakes Restoration Initiative. The collaborative is here to connect resistance breeding efforts across US and Canadian governmental organizations, non-profits, researchers, and members of the public who are working together to save trees threatened by invasive pests and pathogens. The long-term goal is to breed and replant resistant trees that will ensure the sustainability of North American forests for the future.

Currently, the GLB FHC is working with ash (*Fraxinus* spp.), American beech (*Fagus grandifolia*), and Canadian hemlock (*Tsuga canadensis*). In addition to monitoring the condition of tree populations and the spread of insects and diseases to new areas, partners are locating potentially resistant individuals to collect seeds and scions for research and/or planting trials. The Collaborative aims to facilitate communication and efforts between groups doing this important work, and to provide resources like training workshops to facilitate those who would like to get involved.

Identifying Resistant Trees

One of the main objectives of the Collaborative is identifying lingering trees—individuals that appear relatively healthy in otherwise heavily infested areas—across the entire region. Sightings are reported by Collaborative partners, forest health professionals, and members of the public via the TreeSnap app. Whenever possible, reported trees will be visited by a professional local partner and, if confirmed, seeds or scions will be collected for further testing.

Group effort will be key in making progress with each of the focal species. Hemlock woolly adelgid research is still

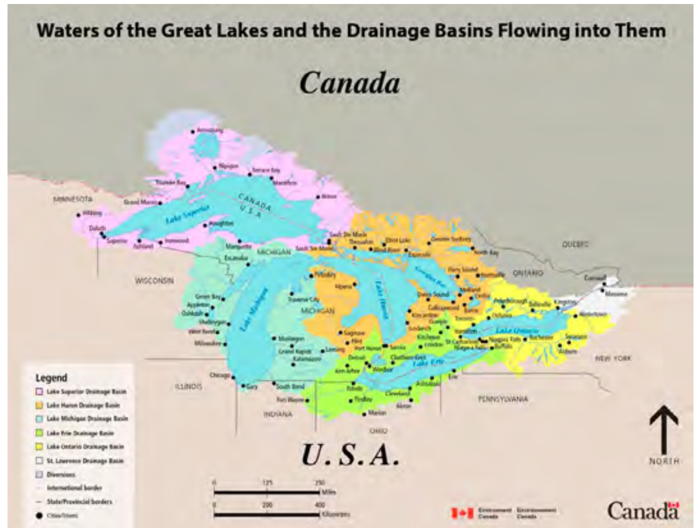

Figure 1. Map of the Great Lakes watershed drainage basins spanning US and Canadian jurisdictions. Source: Environment and Climate Change Canada.

working out the bugs, literally and figuratively, in protocols for quantitative resistance trials. Beech leaf disease resistance research is also in its infancy but progressing, and lingering beech resisting beech bark disease areas are still of interest. EAB resistance in ash has progressed furthest, and more efforts are going into identifying lingering ash across the region, i.e. see the following article from GLB FHC research partners Melissa Lehrer and Jill Hamilton on black ash.

EAB-resistance screening is well underway at the Ohio USDA Forest Service Northern Research Station, as well as at other collaborator locations in Michigan and Ohio. Researchers are constantly adding new individuals for testing and breeding trials, in an effort to start more research orchards. These research orchards, including 625 clones planted at Holden Arboretum, are in time set to be transitioned into seed orchards so seed with enhanced EAB-resistance can be produced for forest restoration (Fig. 2). Learn more about the breeding strategy in this May 2022 webinar: https://www.youtube.com/watch?v=BStP9SH_1OA.

We are eager to add partners so that this strategy can be replicated in other breeding zones, including Canada, to increase the range-wide genetic diversity of EAB-resistant ash trees available in the future. If you'd like to get involved, but are unsure about your current capabilities or skills, the GLB FHC offers training related to every step of the process—if there is not an upcoming workshop or webinar that fills your needs, please reach out with your request and we will do our best to accommodate it.

Figure 2. Holden's clonal lingering ash orchard, July 2022.

Figure 3. The Terraformation Seed Bank being delivered to the Long Science Center, December 2022.

New Seed Bank at Holden Arboretum

The GLB FHC's home institution in northeast Ohio, the Holden Arboretum, also recently launched a new seed banking program to aid efforts like those of the Collaborative. The bank will serve as a place to collect, process, store, and share seeds with those engaging in reforestation efforts across the region. The new program was initiated by a company called Terraformation, who runs a "seed to carbon forest accelerator", a funding program that helps organizations in the forest sector scale up and speed up reforestation efforts.

The seed bank broke ground—figuratively, that is; it's in a modified shipping container and was delivered by crane—in December 2022 (Fig. 3). For an inside look at the facility in operation, check out this new video: https://www.youtube.com/watch?v=KCzJ7m5Zcdk

As of Fall 2023, the seed lab is fully functional, and at the helm as the new seed bank manager is Kim Lessman. Later this year, Kim will put word out to start soliciting interest from those able to collect seeds, as well as from those who might put the seeds to use in the future, especially for large and small-scale forest restoration efforts.

Get Involved!

Anyone working with trees or forests in the Great Lakes region is welcome to join the Collaborative; we encourage participation from a wide range of partner types and industry sectors, from government organizations and academics to for-profit businesses and private landowners. We are especially interested in organizations and individuals who are interested in assisting with:

- Reporting lingering trees. Send observations directly to rkappler@holdenfg.org or submit an observation through the TreeSnap app*.
- Volunteer to survey potential lingering trees in your area. We would love to add more professionals to our network who are able to confirm reports of potentially resistant trees.
- Collecting seed. Efforts can help increase seed available for research via conservation banks, i.e. the US National Seed Lab and Canada's National Tree Seed Centre.
- Collecting scions for grafting and propagation.
- Providing greenhouse space and/or properties for planting trials.

*We reached out to TreeSnap to confirm its utility in Canada. From Noah Caldwell, Staton Lab: "TreeSnap supports collecting data anywhere on the planet. We (the creators) are located in the eastern U.S., hence our personal focus on this region, but we've made very sure to build the app so that it will function anywhere."

Please visit our website to join our mailing list, browse past webinars and upcoming events, read past newsletters, and more: https://holdenfg.org/great-lakes-basin-forest-health-collaborative/

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Preserving Range-wide Genetic Diversity of *Fraxinus nigra*

Introduction

Trees are long-lived components of forest ecosystems, providing foundational services in biodiverse environments (Brockerhoff et al., 2017). As a result, they are exposed to myriad biotic and abiotic stressors throughout their lifetime, requiring a capacity to adapt and persist in response to changing conditions (Bisbing et al., 2021; Compagnoni et al., 2021). Thus, understanding how biotic and abiotic stressors influence forest productivity has implications across diverse systems (Brockerhoff et al., 2017).

A prime example is the emerald ash borer (*Agrilus planipennis*, EAB), a beetle native to East Asia (Schrader et al., 2021). Since its unintentional introduction into Southeastern Michigan, USA in the late 1990s, the EAB has decimated populations of *Fraxinus* (ash) trees across eastern North America (Siegert et al., 2007; Knight et al., 2013). The larval stage of the EAB life cycle devastates ash populations through the consumption of vascular tissue, impacting system-wide carbohydrate and water transport, effectively girdling the infested tree (Knight et al., 2013; Herms and McCullough, 2014). Following its spread over the past two decades, the EAB has been detected in over thirty states and five Canadian provinces, killing tens of millions of ash trees across North America (Knight et al., 2013; Natural Resources Canada, 2021; USDA Forest Service, 2021). With its continued expansion, EAB-induced tree death will significantly impact ecosystem health and cultural knowledge associated with foundational ash forests (Herms and McCullough, 2014).

These effects are of particular concern for *Fraxinus nigra* (black ash) due to its role across unique habitats, including the swamps, bogs, and other moisture-rich wetland landscapes it dominates, and ecosystem services it provides, such as hydrology, nutrient cycling, and soil stabilization (Gucker, 2005; Knight et al., 2013; Youngquist et al., 2017; Palik et al., 2021). EAB infestations are endangering the foundational ecosystem functions of these hydric systems, as black ash is one of the few deciduous trees present in these wetland environments (Gucker, 2005). In addition to the vital ecosystem services it provides, black ash has long been culturally significant to many First Nations communities across North America. First Nations communities have an extensive history of harvesting black ash for basket making, a tradition that the EAB is jeopardizing. The unique strength and flexibility of black ash makes it ideal for basketry (Benedict and David, 2004; Costanza et al., 2017). Further, black ash is at the spiritual center of the Wabanaki tribes' teachings and creation stories (Costanza et al., 2017). Given the environmental and cultural importance of black ash, preserving existing populations threatened by the EAB is critical.

A significant step in the preservation process will be establishing new and supplementing existing ex situ collections, which preserves a species' genetic diversity outside of its native environment (Falk and Holsinger, 1991; Di Santo and Hamilton, 2020; Kovács et al., 2021). These collections can comprise living plants in arboreta or botanical gardens and seed collections in seed banks (Falk and Holsinger, 1991; Kovács et al., 2021). Our ex situ collection of black ash seed (Fig. 1) represents seed populations sampled by government and non-government contributors across Canada and the United States. These resources are critical to preserving viable germplasm before EAB expands to new areas and represents a diverse collection of germplasm that may be leveraged in the future as a pre-breeding or restoration resource (Kovács et al., 2021).

Establishing our Black Ash ex situ Seed Collection

In late January/early February of 2023, I (Melissa Lehrer) had the opportunity to visit collaborators at the National Tree Seed Centre (NTSC) in Fredericton, NB, Canada. During my week-long visit, I worked with the NTSC staff to subset and organize nearly 600 seed lots of black ash from their existing ex situ collection (Fig. 1B). These collections represent many single trees and populations sampled from Ontario, Quebec, New Brunswick, Nova Scotia, and Newfoundland, spanning much of the Canadian distribution of black ash (Fig. 1A, in blue). To complement this collection, we also worked alongside the US Forest Service, the USDA-ARS-GRIN (Germplasm Resources Information Network), and generous volunteers that have contributed over 200 black ash seed lots to our ex situ seed collection from the United States, ranging from Minnesota to Vermont (Fig. 1A, in orange and green). This range-wide collection will be used to assess within and among population genetic differences.

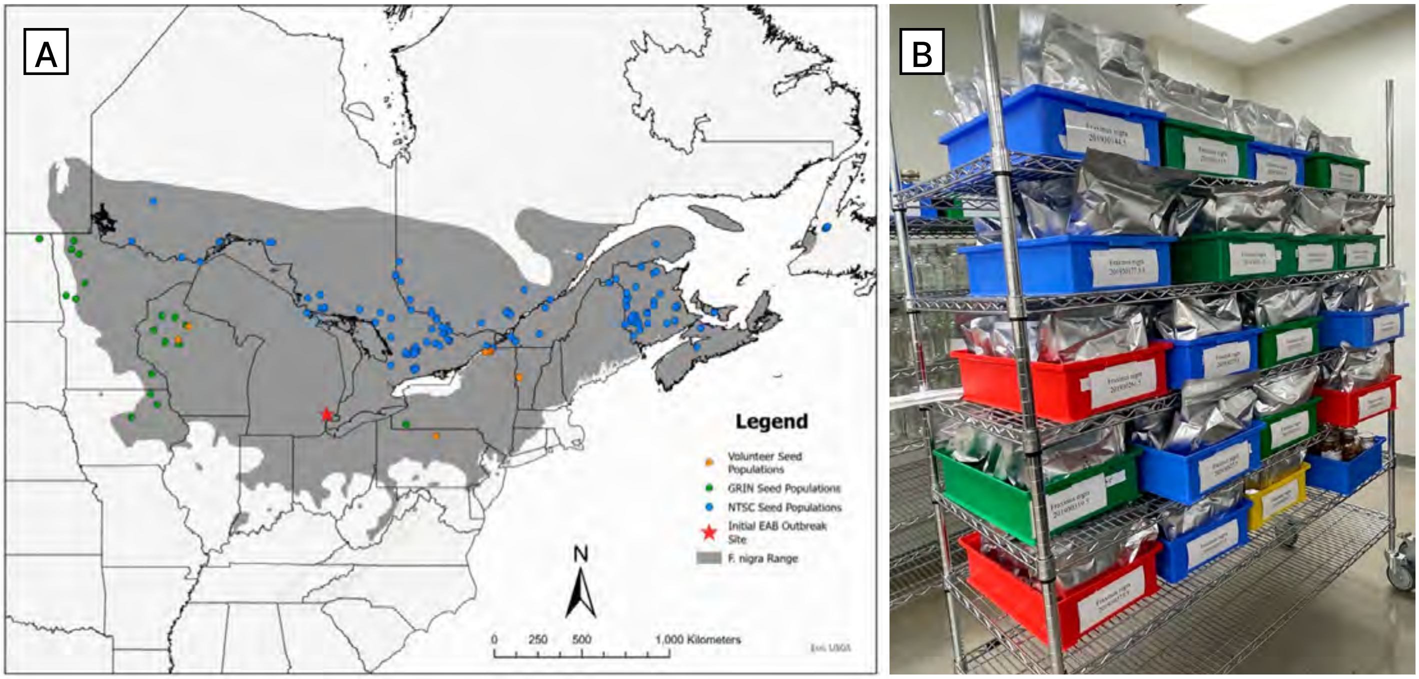

Figure 1. Map of North American black ash seed lot locations and a subset of NTSC's black ash ex situ seed collection. A) Gray overlay represents the black ash range, while colored dots represent the locations of seed populations in our collection. The red star signifies the location of the initial EAB outbreak site in the United States. B) Metallic pouches contain individual Canadian black ash seed populations (mapped in blue), ranging from hundreds to thousands of seeds per pouch.

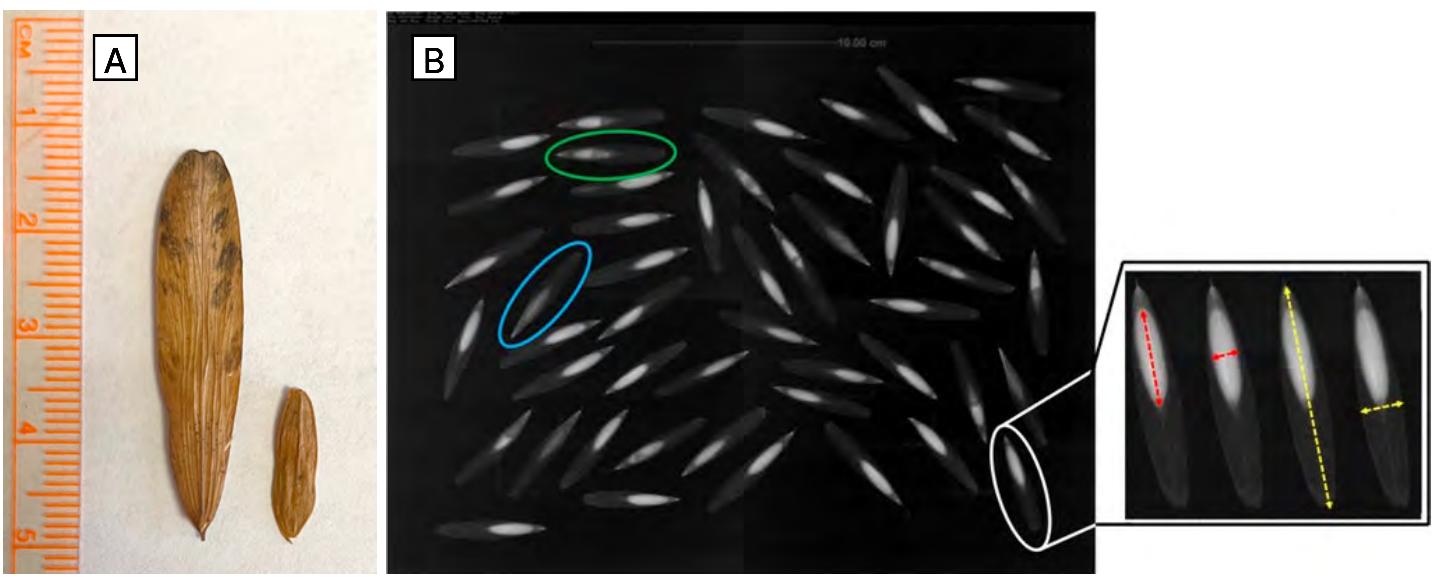

Figure 2. Sample black ash seed and seed x-ray. A) Sample black ash samara with excised seed. B) A representative seed x-ray, with examples of unfilled and insect damaged seeds circled in blue and green, respectively. Red arrows represent seed length and width measurements, while yellow arrows represent samara length and width measurements of the selected seed. These data will be used to compute seed and samara area.

Experimental Goals

Our ex situ seed collection allows us to execute experiments with short- and long-term goals. In the short term, we can evaluate within and among population variability in seed and samara morphology (Fig. 2A), using these data as a proxy for genetic variation across the black ash range. These data can also play a role in teasing apart the influence of climate, genetic background, and distance from EAB outbreak origin on these morphological traits, with the potential to uncover how reproductive efforts (i.e. seedling dispersal and seedling establishment) shift across populations and environments. For example, Fei et al. (2017) indicated that certain functional traits, such as larger seed size and weight, improved dispersal ability, aiding spatial shifts in species abundance in response to changing climates in some forest trees. In addition to monitoring seed weight, morphological variability in our ex situ seed collection will be assessed by measuring diverse samara and seed traits derived from x-ray images (Fig. 2B).

In addition to these short-term goals, our ex situ collection will be used to establish provenance trials in southern, central, and northern North America. As described in VanWallendael et al. (2022), provenance trials establish replicated plantings of diverse populations taken from across a species' range in different environmental conditions (Berend et al., 2019; Schwinning et al., 2022). This approach is advantageous, as populations sourced from different environments are grown together in the same environment, ensuring that observed growth differences are a likely result of the evolution of population-specific genetic differences (VanWallendael et al., 2022). These trials can shed light on the genetic and environmental factors contributing to adaptation to current environments or quantify the degree to which populations may be pre-adapted to novel environments (Hamilton et al., 2015; Klisz et al., 2019). Therefore, establishing our black ash provenance trials will allow for the evaluation of phenological and physiological trait variations important to adaptation and can serve as a basis to quantify genetic differences across the species' range. In the long term, the common gardens will facilitate the ongoing preservation of genetic diversity in this foundational species, acting as an invaluable resource for further genomic and quantitative genetic studies alongside restoration efforts (Schwinning et al., 2022).

Conclusions

Preserving black ash genetic diversity is more crucial now than ever due to climate change and the expanding threat of EAB. Collaborating with domestic and international partners, we have established an ex situ collection of black ash seed to be leveraged in both phenotypic and genomic analyses to evaluate standing genetic variation across the range of black ash. Our findings will be an invaluable contribution to conservation, breeding, and restoration efforts. Overall, our work is a piece of a much larger puzzle aimed at preserving the essential ecological functions and cultural significance of black ash.

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FGCA Establishes Sixth Butternut Archive in Ontario

The Forest Gene Conservation Association (FGCA) hosted a groundbreaking ceremony on Friday, August 18, 2023, at the new five-acre butternut archive orchard at Triebner Tract northwest of Exeter, Ontario. There were 20 people at the ceremony including project partners and interested woodlot owners (Fig. 1). This deer-fenced site was created to protect up to 500 endangered butternut (*Juglans cinerea*) clonal ramets after planting (Fig. 2). The FGCA began planting at the site in May 2023.

Heather Zurbrigg is the Manager of Species Conservation with the Forest Gene Conservation Association (FGCA). The Forest Gene Conservation Association is a not-for-profit organization in Ontario. FGCA's goal is to assist forest practitioners to conserve and augment the genetic diversity of forests through programs towards species conservation, seed management expertise, climate change adaptation, and education and advocacy. FGCA partners with the government, forestry sector, not-for-profit organizations, landowners, conservation authorities and other groups on projects across southern Ontario.

"Our largest project area, under the Species conservation program, is our butternut recovery program," she said. "This is a huge step both for the FGCA and for butternut recovery," she said. "North American research indicates searching for

Figure 1. Groundbreaking ceremony at the Forest Gene Conservation Association (FGCA)'s sixth Southern Ontario Butternut Seed Orchard, located in Exeter, Ontario. Ceremony included representatives from Ausable Bayfield Conservation Authority (ABCA) and FGCA, the provincial Ministry of Environment, Conservation and Parks (MECP), the federal Ministry of Environment and Climate Change Canada (ECCC), the Ontario Woodlot Association, and interested landowners, August 18, 2023. Photo by ABCA.

Figure 2. Ian Jean (left), Forestry and Land Stewardship Specialist with Austable Bayfield Conservation Authority planting a grafted butternut ramet with FGCA staff Heather Zurbrigg (middle) and Corey Gent (front, right).

genetically disease-tolerant butternuts is one of the best strategies for recovery of this species," she said. "We need to maintain as many trees as possible showing signs of tolerance to the butternut canker and that have seed production capabilities across the range of butternut to allow the exchange of genetic material and hopefully the production of the next generation of potentially tolerant trees." She thanked the Ausable Bayfield Conservation Authority (ABCA) for their work on the new archive orchard. "We are so happy to have Ausable Bayfield Conservation as our newest partner in this recovery effort and we look forward to a long and fruitful partnership together," she said.

The creation of the archive orchard is possible thanks to help of species-at-risk funding from the Ontario Ministry of the Environment, Conservation and Parks (MECP). "MECP has been integral for this archive," said Zurbrigg. "They have funded more than half of this orchard with the Species at Risk Stewardship Program," she said. "We are so thankful for all of the funding, facilitation of funding and in-kind partnerships we have received over the years from many organizations and we couldn't have the robust butternut recovery program we do without all of you."

Ian Jean is Forestry and Land Stewardship Specialist with ABCA. He thanked the Triebner family for making it possible, in 2009, to acquire the Triebner Tract. The five-acre butternut archive sits in the northwest corner of this 100-acre tract of land. "I also want to recognize our local municipalities for their leadership and support in enabling the conservation authority to acquire and conserve these important land parcels and to enter into these important collaborative partnerships to conserve and restore the watershed and contribute to broader conservation initiatives such as butternut recovery," he said. The conservation authority, with support of federal and provincial funding partners, has been restoring habitat at the site including tree planting and wetland creation to complement the adjacent provincially significant wetland in Hay Swamp.

"The butternut was an important tree for wildlife and for people," Jean said. Historically, the nuts were a food source for First Nations peoples and settlers. "Butternut was quite common locally and grows very well on our local soils," he said. "We believe this butternut archive orchard site should grow very nice butternut and we hope it will contribute to the recovery of this species." He ended his remarks by saying "I love trees and everything about them and to be able to play a small part in species recovery is very special for me."

Huron-Bruce MPP Lisa Thompson was unable to attend, but conveyed her appreciation and encouraged continued efforts to protect Ontario's natural resources. She emphasized the role of initiatives like this in preserving biodiversity and creating a more sustainable future for all Ontarians.

Butternut is a species at risk throughout its natural range in Canada and the United States. Butternut is impacted by butternut canker (*Ophiognomonia clavigignenti-juglandacearum*) which is a fungus that affects the cambial layer of butternut usually causing tree mortality. Once a common tree throughout eastern North America, butternut is now uncommon and is listed as endangered under the Ontario's provincial Endangered Species Act (ESA). Healthy butternut are very rare in Ontario and now considered too few and too far apart for natural recovery. Butternut trees that are showing tolerance to the canker are the foundation of the FGCA archiving and recovery efforts. Archive orchards are planted with clonal trees (ramets) grow from scions collected from these healthy butternuts, grafted to black walnut (*Juglans nigra*) rootstock. Establishing archive orchards will enable better cross-pollination and future seed production between tolerant trees to aid in the recovery of butternut in Ontario.

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The View from Sweden

Sweden is a forest-rich country in the northern part of Europe. With almost 450,000 km^2 of land, forest cover is just under 70% of the total land area (fao.org). The country extends from latitude 55°N to 69°N, with climatic zones ranging from maritime in the south, continental in the middle, and subarctic in the north. However, the diversity of tree species is not as wide. Approximately 80 % of the total standing volume is of only two conifers; Scots pine (*Pinus sylvestris*) and Norway spruce (*Picea abies*) are the dominating tree species on productive forest land. The remaining 20 % of the standing volume is a combination of a few other non-native conifer species and various broadleaved tree species, depending on the geographical region. On the global scale, Sweden is among the top five export countries of forest products such as sawn wood, pulp, paper and paperboard (fao.org). Thus, the Swedish forestry sector contributes significantly to our economy, and to be able to continue to do so, the forest sector will need high-value seed material for reforestation.

High-value seedlots in Sweden originate from tree breeding programs initiated in the 1930s with the selection of plus trees (Eriksson et al., 2006). Currently, tree breeding programs are administered and operated by the Forestry Research Institute of Sweden (Skogforsk). Forest companies can order scions from Skogforsk of chosen parental material to establish seed orchards. Since the 1950s, seed orchards have been established in different periods; the third and latest of these "seed orchard establishment rounds" started in 2003 and finished in 2018 (Remröd et al., 2003). The third round of seed orchards is estimated to deliver seeds with approximately 25% better gain compared to seeds collected from local wild stands (Rosvall et al., 2003).

One of the biggest challenges for Swedish forest tree breeders is the uncertain future that we are facing regarding climate change on the biological and social values of the forest. Another challenge with conifer trees is the long traditional breeding cycle, around 20 years, which limits the beneficial gain over the long haul (Eriksson et al., 2006; Prescher, 2007; Rosvall and Mullin, 2013). There is also an increasing demand for forest products worldwide, and one of the reasons why seed orchards and reproductive materials are so important (Remröd et al., 2003; Westin and Haapanen, 2013; Hallingbäck et al., 2023). Therefore, the fourth round was initiated, with new orchards established in late 2022 (Högberg and Uggla, 2021).

Sveaskog Förvaltnings AB is the Swedish state-owned forest company and largest forest owner with 3.9 million hectares, representing 14% of the total Swedish forest land area. Out of that land, 3 million hectares are classified as productive forest land. Svenska Skogsplantor is a business area within Sveaskog, with the goal of being the leading provider of forest reproductive material with high breeding values. Svenska Skogsplantor has five nurseries producing around 140 million seedlings annually and a seed unit. The seed unit operates one cone processing facility and manages over 100 seed orchards (approximately 950 hectares) ranging from latitude 55°N and almost up to latitude 66°N. The distribution of seed orchards of different tree species within the company is shown in Figure 1.

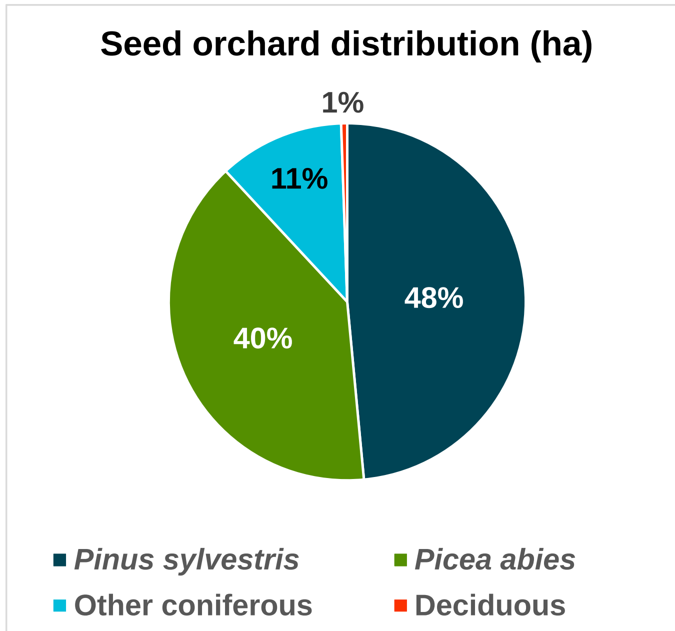

Figure 1. Distribution of seed orchards in hectares managed by Sveaskog Förvaltnings AB and Svenska Skogsplantor.

The cone processing facility is in the south of Sweden outside the town of Ljungby. During the autumn when the cones are collected, they are transported to our facility in bags stacked on pallets, you can see it in the top right corner in Figure 2. The yearly production capacity of the cone processing facility is around 7,000 hectoliters (hL) of Scots pine and Norway spruce cones. Since the cone yield varies greatly from year to year the average seed yield is 2,500–3,000 kg per year. Cones are stored at –2°C until they are ready to be processed. The first step is pre-screening non-cone debris, i.e., needles and small branches (Fig. 2).

The cones are collected in black metal boxes with a net in the bottom to allow airflow and limit mold infections. Then, the cones are placed in a room with high humidity, a temperature around 10°C and elevated ventilation for about 2–3 weeks for maturation of the seeds.

The next step is the kiln. Cones are moved from the maturing box to a kiln box, which has a solid bottom to prevent losing seeds when the cones are opening (Fig. 3).

Svenska Skogsplantor has four kiln ovens, and each oven can process 14.4 hL of cones at a time (Fig. 4). The heating program is automatic and runs for 16 hours and adjusts according to humidity and heat inside each kiln to ensure good seed quality. In several steps, humidity is reduced, and temperature is increased, to a maximum of 52°C. Thereafter the kiln turns off and cones are left in the residual warmth until the production staff starts their work the next morning. The cone racks are then fork-lifted into a rotating drum (Fig. 5) where the seeds will fall onto a conveyor belt to be collected (Fig. 6). Empty cones are transported on another conveyor out to a container and shipped to the local biomass plant, which is recycled back to us as the heat for our kilns.

The following steps are then performed to produce a high-quality seedlot. Dewinging is done by adding water and air so the wing will detach from the seed and can be blown away (Fig. 7). Next, debris and bigger particles are removed using a seed cleaner equipped with sieves (Petkus 100). Depending on which species are processed, a water treatment is carried out. For *Picea*, we remove resin from the seed lot by using temperate water. For *Pinus*, we perform the Prevac treatment to separate damaged seeds from the seedlot. The seeds are dried overnight, and a last step of fine cleaning is performed in a seed cleaner (Petkus K541, Fig. 8) equipped with air streams that will remove light-weight debris from the lot.

Finally, we perform an initial germination test of 4 × 100 seeds for each seedlot using the Jacobsen table (Fig. 9). With these results we can apply for a seedlot master certificate from the Swedish Forest Agency, the national authority in charge of forest reproductive material issues and utilization.

In 2018, Sweden had the warmest and driest spring and summer in modern history. It resulted in a record year of

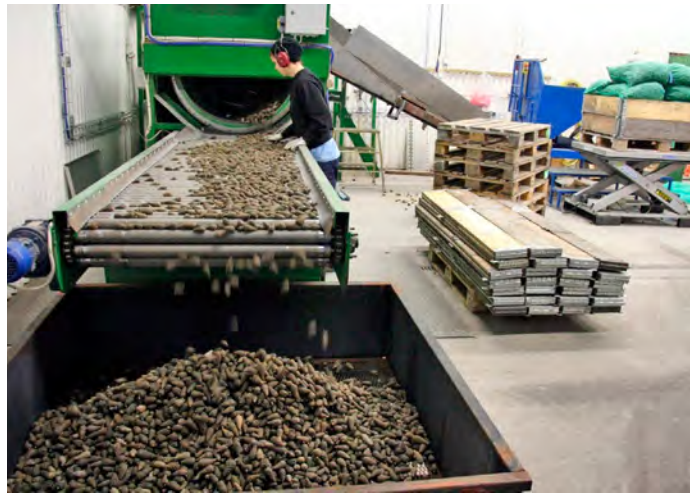

Figure 2. First step is mechanical pre-screening and manual sorting of cones from debris. Photo: Finnvid Prescher.

Figure 3. The cone filler is used for getting the right volume of cones into one kiln box. The filler was custom made for our facility when it was established during the 1980s.

Figure 4. Our four kiln ovens. Each kiln can be monitored individually to track the temperature during the drying program.

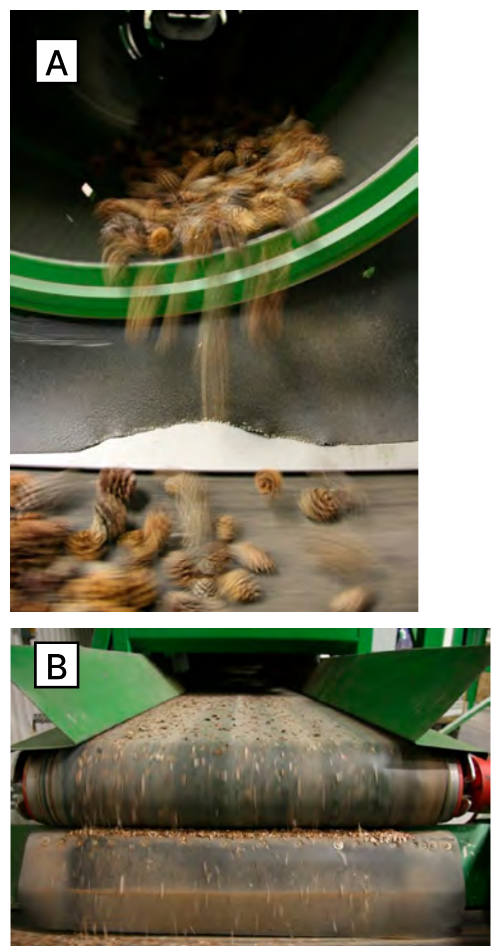

Figure 5. Time to get the seed out of the cones using a rotating drum. Cones are first fork-lifted up and dumped into the hopper.

Figure 6. Cones goes through a long fine mesh tumbler so that the seed can fall through underneath the tumbler (a) to a conveyor belt to collect seed (b). Empty cones are collected at the end of the tumbler on to another conveyor belt that will take them outside to a container and transported to the heating plant.

All of the equipment on this page was custom made for the establishment of the facility by the same Swedish company that made the cone filler.

Figure 7. Wet dewinging is performed in a BCC dewinger unit.

Figure 8. To achieve as high-quality seed as possible the final step performed is using the seed cleaner (Petkus K541) three times for each seed batch.

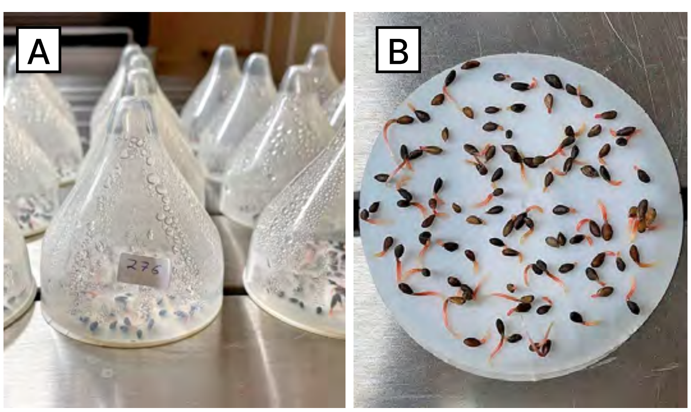

Figure 9. To validate seed quality, a germination test is performed using Jacobsen germination table and bells (a), with 4 repetitions × 100 seeds each (b). Here, *Pinus sylvestris* seeds have started to germinate after 4 days.

Norway spruce cones the following year. And so far, the first six months of 2023 are equal to the weather in 2018, so perhaps we will have a similar situation with a massive Norway spruce cone crop in 2024. In recent years, we have had warmer and wetter collection periods in autumn-early winter, which have led to soil damage and increasing costs of restoring the ground in our orchards. For us in the Swedish seed orchard business, climate change is one of the biggest challenges that we are facing in our daily work. Finding new methods and learning from others is essential.

I am very glad that groups like the Tree Seed Working Group and the Canadian Forest Genetics Association are active and are working to keep getting like-minded people together. Thank you for your work.

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- Sveaskog Förvaltnings AB https://www.sveaskog.se/en/
- Swedish Forest Agency https://www.skogsstyrelsen.se/en/

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ISF Tree and Shrub Group Meets in Sweden

Modified slightly from original LinkedIn post: The ISF Tree and Shrub (TAS) Working Group met for its annual meeting in Falun, Sweden from August 29–31, 2023. It was a great opportunity to gather more than 30 experts and key actors of the forest tree industry from around 20 different countries to discuss matters of relevance for a sustainable forest sector (Fig. 1)

Forest management is a long-term commitment requiring good planning, wise and sustainable growing techniques, innovative breeding and varieties-population selection to ensure the growth of the forest area for the next decades. To perform in a changing environment, the tree industry needs a predictable regulatory environment and schemes to improve market access and facilitate trade in relevant parts of the world, allowing nurseries and producers to get access to high-quality planting material (including seeds) free of any pest and disease but also capable of tackling challenges due to changing growing conditions.

Forests are also great contributors to biodiversity and carbon sequestration and important source of employment for many countries (UNSDGs 8, 13, 15). ISF provides a platform to address all these important topics to support the industry. If you are interested to learn more about the ISF TAS Group please visit: https://bit.ly/44wS4KL

Figure 1. Drone image of the ISF Tree and Shrub group touring one of Sveaskog Förvaltnings AB's Scots pine (*Pinus sylvestris*) seed orchards, located at 60°57'N, 30 minutes drive outside the city of Falun, Sweden. Photo credit: Mårten Tovedal.

Thanks to our hosts: Sveaskog Förvaltnings AB, Svenska Skogsplantor Johanna Gårdebrink, TAS Chair person- Øyvind Meland Edvardsen and newly elected Vice-chair: Remko Boevé, and all our international partners (ISTA - International Seed Testing Association, OECD - OCDE, EUFORGEN (The European Forest Genetic Resources Programme), the European Forest Nursery Association, and the ISF Technical Team: Benjamin (Ben) Rivoire, Rose Souza Richards, and Khaoula Belhaj Fragniere). Looking forward to meet next year in New Mexico, United States.

Editor's Note: The International Seed Federation's Tree and Shrub group is looking for more North American members and participation. Please contact Ben Rivoire: b.rivoire@worldseed.org.

Second Tree Seed Summit in the Pacific Northwest

In June 2023, Mast Reforestation partnered with the Society for Ecological Conservation (SER) Northwest Chapter to host the 2nd Tree Seed Summit in Eatonville, WA. The Tree Seed Summit (TSS) is an annual gathering centered around the science and procurement of native tree seeds where academic, government, tribal, and industry stakeholders can discuss the challenges in native tree seed procurement. Presenters were from Mast Reforestation, the University of Montana, The Nature Conservancy, Institute for Applied Ecology, US Forest Service, USDA Forest Service, BC Forest Service Tree Seed Centre, WA Department of Natural Resources, Alpha Services LLC, Sierra Cone LLC, SEGI Consulting LLC, Glacier Peak Institute.

The inaugural 2022 TSS was held to identify the biggest barriers and challenges with seed procurement and strengthen relationships to benefit the broader industry. Our key findings from the first TSS were published in Tree Planters' Notes (Spring 2023). This year's summit continued last year's discussion with presentations on assisted migration, seed and cone pests, inventory management, collection strategies, and engaging with local communities. The summit's format opened with presentations from domain experts followed by smaller group breakout sessions. The smaller groups provided the opportunity for in-depth discussion on topics such as the challenges in forest regeneration and seed, and public access for cone collections.

TSWG Chair Dave Kolotelo presenting at the Tree Seed Summit, June 22, 2023.

TSS attendees practice assessing cone cut tests.

To see presentation slides and more event photos, visit the Materials page on the Tree Seed Summit website here: www.treeseedsummit.com. Updates from the sessions, as well as information on future Tree Seed Summits, will be posted quarterly.

Although the summit's geographic focus was on the western US, we were joined by stakeholders from Canada and other temperate forested regions of the world. In the future, we aspire to serve a broader area with future Tree Seed Summits and corresponding events. Through collaborative learning, we aim to scale up efforts for seed collection, raise awareness about the various stages of the seed supply chain, and promote sustainable practices for regenerating biodiverse ecosystems. Together, we strive to create a resilient future for our region and beyond.

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Highlights from the 2023 Joint Northeast Nursery Conference

This year's Joint Northeast and Southern Nursery Conference, held in State College, PA, July 17–20, 2023, was sponsored by the State of Pennsylvania and the Forest Service's Center for Reforestation, Nursery, and Genetic Resources (RNGR) through an agreement with the Western Forest Nursery Conservation Association (WFCA). This conference is held in the Northeast on odd years, alternating with the Southern Forest Nursery conference on even years. More than 50 participants were from public agencies and commercial production nurseries, seed companies, and other organizations. Attendees came from 19 states, two Canadian provinces, and South Africa. Registration was cut off one week before the conference because of high attendance, which is a first for this conference!

Topics at this year's conference included agroforestry, urban forestry, climate-smart seed sourcing, biochar, American chestnut, market research findings, and mineland reclamation. In addition, there was a question and answer session on seed collection and storage featuring panelists from three seed companies: Calvin Ernst (Ernst Conservation Seeds, PA), Chris Kiratzis (Better Forest Tree Seeds, PA), and Eric Lovelace (Lovelace Seeds, MO). The field day consisted of visits to the Pennsylvania Bureau of Forestry's Penn Nursery, the Pennsylvania Game Commission's Howard Nursery, and the Arboretum at Penn State.

WFCA hosted a keynote speaker from South Africa, Siyabulela "Siya" Sokomani, who founded and owns Nguni Nursery in Cape Town; his business focuses on producing native plants and trees for planting in South Africa. Nguni Nursery also provides job opportunities in a community where unemployment levels exceed 40% for some demographic groups.

Staff from the RNGR team developed a pre-conference tour for Siya, with help from staff at the Northern Research Station field station in Baltimore, to learn how communities accomplish reforestation in the urban context. Siya and RNGR staff also visited city employees in Philadelphia to learn more about TreesPhilly and the city-run Greenland nursery. The tour also included several other for-profit and non-profit nurseries that serve this region. The need to provide expertise and address plant material shortages for urban forests is increasing across the US to help cool cities, improve air quality, and increase carbon fixation.

The RNGR team has historically focused on providing technical assistance to nurseries that serve rural communities where the vast majority of trees are planted annually. Demand to increase reforestation across urban landscapes has spiked, partly due to the Biden Administration's Inflation Reduction Act (IRA) including $1.5 billion for urban forestry. Urban parks and natural areas require different stock types but still often rely on native tree species from diverse seed sources. These tree plantings are more successful with stock larger than the conventional 1- or 2-year-old seedlings used in conservation plantings, but may not require expensive balled and burlapped trees commonly used on roadsides. Cultivars are still popular and appropriate in some urban spaces but native trees, with diverse genetics, are favoured in many urban areas.

Urban and rural interfaces are also relatively under-utilized for seed production and education. Many urban foresters maintain inventories and may know the origin of large legacy trees in urban parks and cemeteries. Seed from large trees can often be easily accessed from the ground. In addition to the seed collection opportunities, urban trees generate interest in under-served sectors of the population and can be used for workforce training and education. Bridging the urban and rural communities through seed collection and tree propagation can serve all communities. The RNGR team is looking forward to connecting with urban nurseries in the future once the Urban Nursery specialist position is filled, hopefully later this fall.

Stay tuned for more information on the 2024 Joint Northeast and Southern Nursery Conference, which will be held in Little Rock, Arkansas in July, sponsored by the State of Arkansas and Western Forest Conservation Association. The 2025 conference will be hosted by the State of Wisconsin.

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Spruce Seed Problems Workshop

The purpose of this workshop was to exchange knowledge and current best practices for maximizing spruce seed germination. As the value and genetic worth of seed rises, so does the need to optimize production processes and reduce variability from the lab test to the greenhouse. There are many factors that may contribute to the variable germination of spruce.

This workshop was intended for seed technicians, orchardists and nurseries that produce, process, and grow white spruce (*Picea glauca*), Engelmann or hybrid spruce (*P. glauca* × *P. engelmannii*) seed and/or seedlings. These are important species for reforestation and afforestation programs in Canada and the northern USA. There may also be other regionally important *Picea* species that share similar seed-handling problems this workshop may inform.

This workshop was initiated by Mark Montville, Crop Production Manager at JD Irving, and supported by the National Tree Seed Centre's 2 Billion Tree Program knowledge mobilization efforts. The virtual workshop received 112 registrants from across Canada and the northern United States, with 85 attending the majority of the 6-hour agenda (Table 1). Additional resources were received and compiled from Drs. Yang Lui and Alison Kermode, Dr. Barb Thomas, the province of Alberta, and relevant Canadian and US Forest Service publications.

A hands-on field component was desired to continue information exchange, but spruce cone crops did not materialize across much of eastern Canada in 2023. Some attendees participated in the Seed Conservation Course with Alberta Provincial Seed Specialist Lindsay Robb hosted by the National Tree Seed Centre February 13–14th and more will reconvene October 24–26th Atlantic Forest Nursery meeting in Fredericton, NB. Stay tuned for further information.

Summary from JD Irving

The January 18th Spruce Seed Workshop involved many great presentations from speakers across Canada and from different technical backgrounds. Seed germination is critical to make the most of limited top gene pools, plant the highest genetic gain, reduce waste and cost in nurseries,

Table 1. Summary of the Virtual Spruce Seed Problems Workshop, held on January 18, 2023.

Presentation	Speaker(s)
Welcome, Opening Statements, JD Irving's Impetus for Organizing, Summer Tour	Melissa Spearing & Mark Montville (NB)
Global tree seed organizations – Overview and Initiatives BC Tree Seed Centre experience with spruce germination monitoring, extended stratification, family processing and continuous improvement	Dave Kolotelo (BC)
Reproductive Biology, Breeding & Seed Production	
Sitka Spruce & White Spruce: Pollination to Maturation – What can go wrong?	Dr. Patrick von Aderkas (BC)
Variation in fecundity of seed orchard parents, annual variability and seed requirement implications	Greg Adams (NB)
Managing Seed Quantity and Quality in Seed Orchards	Tia Wagner (BC)
Huallen Seed Orchard Company – Programs & Production Systems Overview	Ian MacLachlan (AB)
Spruce Extraction, Processing & Storage	
Millson Forestry Service Spruce Extraction & Testing	Jenny Millson (ON)
Smoky Lake Forest Nursery Spruce Extraction & Testing	Peggy Popel (AB)
GNB Kingsclear Orchards, Nursery & Atlantic Seed Centre Operations	Shona Millican (NB)
Seed treatment at the Berthier Seed Centre: Separated Extraction, Water Activity as Conservation Indicator and Thermal Priming	Fabienne Colas (QC)
Imbibition, Stratification & Vigour	
SeedTek: Spruce Upgrading Options and Results	Karen Copeland (ON)
Forests Ontario Seed Testing: Dealing with 25-yr+ Seedlots, Initial Germination over Time	Mark McDermid (ON)
Growers Roundtable	
Strathlorne Provincial Nursery Operations	Sean Gillis (NS)

Table 1 continued.

Presentation	Speaker(s)
Frank Gaudet Provincial Nursery Production	Mary Myers (PEI)
Green Legacy Wellington White Spruce Production	Jessica Trzoch (ON)
Future Directions	
What's the Top 3 problems today? What should researchers or the field tour be focused on?	
Closing Remarks - Josh Sherrill, Mark Montville, Melissa Spearing	

and achieve high consistency in crop production results. The engagement, questions, and discussion from participants indicated that it was a successful and beneficial workshop. A great deal was discussed about best practices, techniques, and research into improving seed germination. The topics ranged from the health of trees in seed orchards, cone collection, seed processing, seed storage, seed prep and stratification, nursery environment, and feedback systems for germination performance.

Two major factors became themes across presentations: temperature and moisture. Whether it was environmental conditions in a seed orchard or nursery or during a step in seed processing, these factors were mentioned repeatedly. In many cases, these factors can be manipulated to benefit germination.

Discussions involved other factors that could affect germination including mechanical damage, sodium in water, repeated stratification, seed orchard conditions, timing of treatments, free water in seed storage, and many more. There are still unanswered questions a keen student or academic investigator could tackle that, if successful, would improve our operations and future impact.

We thank all the speakers and those who brought up questions and comments. We also want to thank Melissa Spearing for her great job hosting and Melissa and Mark Montville for organizing this effective workshop.

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Opinion: Planting Trees is the New Black

Hello TSWG readers, my name is Edoardo Vincenti, I'm an Italian forest engineer living and working in the Algarve region, Portugal, Europe. Trees, seeds and wild foraging have been my passions since I can remember. This love took me to study Environmental Science, Forest Ecology and Forest Management. And made me travel and live in several countries too. So far, I've studied and worked in Italy, Portugal, Germany, Greece, the Netherlands, England, and Portugal again.

Seed testing is my expertise, seed banking my goal, forestry my academic background, growing carob trees (*Ceratonia siliqua*) my hobby. I'm an elected member of the Forest and Shrub Seed Technical Committee (Dave Kolotelo is an active member too) at ISTA (International Seed Testing Association) and I'm also a member of the SSG (Seed Specialist Group) at IUCN (International Union for Conservation of Nature).

Now, for the reason of my article. Globally, trees are on top of governments' political agenda.

- People think that planting trees will cool our warming planet.
- People think that planting trees will offset our rising carbon emissions.
- People also think that planting trees will increase biodiversity.

Planting trees is the new black then. As a forest enthusiast, I should be happy about it. But honestly, I'm not convinced it is the right answer...yet. Why? A few examples from around the world will help express my doubts.

"The 2013 Rim fire in California, for example, burned through 25-year-old Ponderosa pine stands in a reforestation project designed by Forest Service officials. These young, same-age, same-species trees are highly flammable, and contributed to the conditions that caused the blaze to explode over two days, eventually blackening 104,000 hectares" (https://chinadialogue.net/en/nature/lessons-from-the-rush-to-reforest/).

"Take China's attempt at seeding a "Great Green Wall" to mitigate against the erosion of the Gobi Desert. Up to 85 per cent of the new trees died in the process. In Sri Lanka, efforts to restore the mangrove forest failed because the wrong species was planted. Not a single tree survived on 9 out of 23 project sites" (https://www.ft.com/content/40498048-da55-40df-883d-20e61dbe6895).

I'm much more hopeful for Canada's recent "2 Billion Trees - Planting today for a better tomorrow" Program. https://www.canada.ca/en/campaign/2-billion-trees.html

It is a gigantic task to achieve. I'm sure all the mistakes made in the past by others will be corrected, such as putting the right tree species in the right place, using high-quality reproductive material, letting indigenous communities form an integral part of the project, and so on.

I'm not so impressed by numbers, though. According to a study made by Crowther et al. (2015), Canada is home to about 318 billion trees (https://www.washingtonpost.com/news/energy-environment/wp/2015/09/16/the-countries-of-the-world-ranked-by-their-tree-wealth/).

By reaching the ambitious goal of planting 2 more billion, Canada would get to a total of 320 billion trees. It will be an increase of 0.63%. Do you think such a low increase in trees number will really create a better tomorrow? That's debatable, but certainly challenging for all those working with tree seeds.

Being an avid reader of the TSWG News Bulletin, I realize how Canada is a reference for tree seed lovers worldwide. I'm more and more amazed by your collective tree seed knowledge, cutting-edge research and technology. In any new issue of the Bulletin, I learn something new.

Thank you to Melissa, Dave and all the others contributing to the publication. You constantly inspire me and many others.

Keep up the excellent work.

Edoardo Vincenti
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P.S.: Hey, guys, when can we finally start wearing black?

Seed Requests & Availability

This new section of the Bulletin can be used to facilitate tree seed auction notices, needs and availability. If the request is broad and/or urgent, TSWG members can post directly to tswgcanada@googlegroups.com.

2023-2024 Winter Finch Forecast

While not timely for early-fall dispersing species, this annual posting notes areas of heavy cone crops each year: https://finchnetwork.org/winter-finch-forecast-2023-2024

Tree Time Services Seed Available

Three jack pine and 27 eastern white cedar seedlots are available from Tree Time Services Inc., from Ontario seed zones below:

Species - Seed Zone[1]	Sum of Weight (kgs)	# Lots
Jack Pine (*Pinus banksiana*)		
Ontario 8	33.72	1
Ontario 9	57.60	1
Ontario 14	9.24	1
Eastern White Cedar (*Thuja occidentalis*)		
Ontario 29	11.66	1
Ontario 34	1.38	1
Ontario 35	30.39	7
Ontario 36	37.59	8
Ontario 37	20.09	6
Ontario 38	7.41	4

[1]See the Ontario Tree Seed Transfer Policy spatial tool for climate-based deployment options: https://public.tableau.com/app/profile/larlo/viz/SeedSourceOntario/Intro

We can also grow as peat plugs a wide variety of native trees and woody shrub species for your project.

Carlos Aviva
Seed and Plant Material Manager, Reclamation
Tree Time Services Inc, Edmonton, Alberta
Email: carlos@treetime.ca
Website: www.treetimeservices.ca
Phone: 780–472–8878

TransX Research Seed Needed

The [TransX climate gradient experiment] is a network of tree plantations in Canada and the United States composed of carefully selected natural and improved genotypes of key northeastern tree species. The main focus of TransX is on the response of trees to future warming, focusing on leaf and growth phenology, health and survival across species and populations. We are currently in the process of collecting seeds for each species, and we're looking for a white birch (*Betula papyrifera*) seed collection from the general area of Northwestern Ontario, and collections of red oak (*Quercus rubra*) and yellow birch (*Betula alleghaniensis*) from the general area of central New England.

For each collection, seed should be collected from a minimum of 10–15 parent trees in a mature, natural stand dominated by the species. Based on typical yields, we are looking for approximately 0.5 ounces clean, dried white and yellow birch seed, and 3,000–4,000 floated red oak acorns.

If you have collections that fit these criteria, please contact me.

Jacob Ravn, PhD Candidate
University of New Brunswick – Faculty of Forestry and Environmental Management
Cell: 506–261–7286
Email: jravn@unb.ca

Alberta: Seed Availability

From: https://www.alberta.ca/tree-improvement-and-adaptation#jumplinks-8

Improved surplus seed

As outlined in the Mandatory Use of Improved Seed for Reforestation directive, the following attachment lists the declared improved surplus seedlots available for sale. Contact seed owners directly to purchase seed.

- Declared Improved Surplus Seed

Stream 1 seed

For the Government of Alberta's stream 1 seed availability and sales please contact the Provincial Seed Officer.

Training & Meetings

ISSS-ISTA Recorded Webinar: Seed Dormancy (June 7, 2023, link includes all past webinar presentations and Q&A PDFs): https://www.seedtest.org/en/events/isss-ista-webinars.html

EUFORGEN Recorded Webinar: Estimating Effective Population Size (Ne) for FGR conservation (June 13, 2023): https://www.youtube.com/watch?v=2V4IoKLt9iI

ISTA-FAO Recorded Webinar: New Technologies in Seed Testing, October 4, 2023, 11 am–12:30 pm CEST. Will be posted here: https://www.youtube.com/@internationalseedtestingas8438/featured

FAO eLearning Module (2023): Planning seed and seedling supply for forest and landscape restoration: https://www.fao.org/sustainable-forest-management/toolbox/tools/tool-detail/en/c/1652749/

Pines & People: Human Impacts on 5-Needle Pine
October 11–14, 2023, in-person
Revelstoke, British Columbia
https://whitebarkpine.ca/pines-people-human-impacts-on-5-needle-pine/

UK Tree Council Seed Gathering Season Webinar:
October 18, 2023: Exploring Millennium Seed Bank's vital role in conserving the UK's trees, featuring Ted Chapman, UK Conservation Partnerships Coordinator, Millennium Seed Bank
Register: https://www.eventbrite.co.uk/e/exploring-millennium-seed-banks-vital-role-in-conserving-the-uks-trees-tickets-726788643397?aff=oddtdtcreator

5th International Congress on Planted Forests
November 7–10, 2023, in-person
Registration deadline: October 16, 2023
Nairobi, Kenya
https://www.plantedforests.org/icpf-2023/

Virtual National Native Seed Conference
February 7–8, 2024, virtual
Abstract submission deadline: November 10, 2023
https://appliedeco.org/nnsc24/

IUFRO Seed Orchard Conference
May 20–24, 2024, in-person
Brașov, Romania
https://www.iufro.org/science/divisions/division-2/20000/20900/20901/activities/
Contact Georgeta Mihai, email: georgeta.mihai@icas.ro

IUFRO 26th World Congress 2024: Forests & Society Towards 2050
June 23–29, 2024
Stockhold, Sweden
Registration open; early bird fees until January 15, 2024
https://iufro2024.com/

International Oak Symposium
October 7–10, 2024
Knoxville, Tennessee, USA
Call for abstracts opening October 2023
https://naturalresources.tennessee.edu/oak-symposium/

Recent Publications

CCLM Portal

The Canadian Conservation and Land Management (CCLM) Portal was created for sharing information, technical products, and real-world lessons about conservation, land restoration and reclamation, silviculture, sustainable forest management and timber solutions. Over the past few months, the 2 Billion Trees Knowledge Mobilization Team has been updating the CCLM portal with hundreds of reports, publications, videos, lectures, and various other products from Canadian Forest Service researchers.

Head over to the CCLM portal and type "2 Billion Trees (2BT)" or "Natural Resources Canada (NRcan)" in the search bar and peruse through all the knowledge products: https://www.cclmportal.ca/portal/land-management

Editor's Note: The CCLM Portal welcomes any Canadian organization involved in knowledge extension to cross-post relevant resources and events, or to get involved as a partner. For more information email: connect@cclmportal.ca.

Relaunch of the Seed Information Database (SID)

On the 23rd February 2023, the Society for Ecology Restoration's (SER) International Network for Seed-based Restoration (INSR) relaunched Kew's Seed Information Database. Visit: https://ser-sid.org/.

Book Chapters

Strong, W.B., Mangini, A.C., and Candau, J.-N. 2023. Insects of Reproductive Structures. In Forest Entomology and Pathology. Edited by J. D. Allison, T.D. Paine, B. Slippers, and M.J. Wingfield. Springer International Publishing. pp. 523–579. doi:10.1007/978-3-031-11553-0_16.

About this book: This open access book will provide an introduction to forest entomology, the principles and techniques of forest insect pest management, the different forest insect guilds/feeding groups, and relevant forest insect pest management case studies. In addition to covering 30% of the earth, forest ecosystems provide numerous timber and non-timber products that affect our daily lives and recreational opportunities, habitat for diverse animal communities, watershed protection, play critical roles in the water cycle, and mitigate soil erosion and global warming. In addition to being the most abundant organisms in forest ecosystems, insects perform numerous functions in forests, many of which are beneficial and critical to forest health. Conversely, some insects damage and/or kill trees and reduce the capacity of forests to provide desired ecosystem services. The target audience of this book is upper-level undergraduate and graduate students and professionals interested in forest health and entomology.

Khanum, R. 2023. Germination and seedling establishment of useful tropical trees for ecological restoration: implications for conservation: The ecology of tropical tree seedling. In Plant Stress Mitigators. Elsevier. pp. 87–97. doi:10.1016/B978-0-323-89871-3.00014-8.

About this book: *Plant Stress Mitigators: Types, Techniques and Functions* presents a detailed contextual discussion of various stressors on plant health and yield, with accompanying insights into options for limiting impacts using chemical elicitors, bio-stimulants, breeding techniques and agronomical techniques such as seed priming, cold plasma treatment, and nanotechnology, amongst others. The book explores the various action mechanisms for enhancing plant growth and stress tolerance capacity, including nutrient solubilizing and mobilizing, biocontrol activity against plant pathogens, phytohormone production, soil conditioners, and many more unrevealed mechanisms. This book combines research, methods, opinion, perspectives and reviews, dissecting the stress alleviation action of different plant stress mitigators on crops grown under optimal and sub-optimal growing conditions (abiotic and biotic stresses).

Pradhan, A., and Chettri, A. 2023. Improving the Conservation Status of a Threatened Tree (*Acer sikkimensis* Miq. syn. *Acer hookeri* Miq.) Through Standardization of Seed Germination Protocol and Using Ecological Niche Modeling. In Ecosystem and Species Habitat Modeling for Conservation and Restoration. Springer Nature Singapore, Singapore. pp. 169–180. doi:10.1007/978-981-99-0131-9_9.

Proceedings, Reports and Newsletters

Bragg, D. C., ed. 2023. Celebrating 100 years of forest science: an abridged history of the Southern Research Station. Gen. Tech. Rep. SRS-272. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 298 p. doi:10.2737/SRS-GTR-272.

International Seed Testing Association News Bulletin (October 2023). Seed Test. Int. (166). 80 p. Available from https://issues.ink/ista/166-september-2023

Natural Resources Canada, Canadian Forest Service, Science Policy Integration Branch. 2023. Grow a Green Future: A Guide for Successful Tree Planting. Ottawa, ON. 21 p. Available from https://cfs.nrcan.gc.ca/publications?id=41052

Pike, C.C. 2023. Genetic Considerations for Assisted Migration Efforts: Northern Hardwoods. In Proceedings of the first biennial Northern Hardwood Conference 2021. Edited by C.C. Kern and Y.L. Dickinson. U.S. Department of Agriculture, Forest Service, Northern Research Station. p. 271. doi:10.2737/NRS-GTR-P-211.

Spearing, M., McPhee, D., and Loo, J. 2023. Sizing Canada's National Seed Supply Chain: Preliminary Assessment focused on Trees and Shrubs. Natural Resources Canada, Canadian Forest Service, Atlantic Forestry Centre. Interim Report. 35p. Available from https://cfs.nrcan.gc.ca/publications?id=40879

Sutton, R.F. 2023. White Spruce: Taxonomy, Phylogeny, Biosystematics and Plant Geography. A Historical Review. Edited by B. Haddon, K.. Jamieson, D. Jamieson, F.. Ortiz, and S.V. Phippen. Sault Ste. Marie, Ontario. 144 p. Available from https://cfs.nrcan.gc.ca/publications?id=40919.

Call for Abstracts

Invitation to publish in a special issue of Seed Science Research under the theme of the 14th ISSS conference: "Challenges of Seed Science in a Changing World". SSR accepts Research Articles, (short) Reviews, Short Communications, as well as Technical Updates. Guest-Editors are Christophe Bailly and Julia Buitink. Deadline for submission is December 1, 2023.

Note from Seed Science Research

From 25 October 2023, Seed Science Research will be moving to a Gold Open Access publishing model. All accepted articles from this date will be published with a Creative Commons licence and will be subject to an Article Processing Charge (see the journal's Open Access Options page for available licence options). Learn more here: https://www.cambridge.org/core/journals/seed-science-research

Peer-reviewed Publications

Akram Mohammed, A. 2023. A Review of Breaking Seed Dormancy in Hawthorns (Crataegus spp.). Int. J. Adv. Res. 11(02): 495–500. doi:10.21474/IJAR01/16274.

Aniszewska, M., Gendek, A., Tulska, E., Zięba-Kawecka, A., Malaťák, J., Tamelová, B., Malaťáková, J., and Krilek, J. 2023. Effects of electromagnetic waves on the moisture content of cones and the quality of extracted seeds in the Norway spruce and European larch. New For.: 1–18. doi:10.1007/s11056-023-09979-5.

Azevedo-da-Silva, D.A., Alves-de-Oliveira, D.F., Bezerra-de-Oliveira, H.C., Feitosa, T.M., Da Silva, I.B., Giordani, R.B., and Voigt, E.L. 2023. Reserve mobilization and secondary metabolites during seed germination and seedling establishment of the tree *Erythrina velutina* (Fabaceae). Rev. Biol. Trop. 71(1): e49004. doi:10.15517/rev.biol.trop..v71i1.49004.

Bartlick, C.I., Burton, J.I., Webster, C.R., Froese, R.E., and Dickinson, Y.L. 2023. An experimental approach to identify drivers of tree regeneration diversity, composition, and heterogeneity in northern hardwood forests. For. Ecol. Manage. 546: 121320. doi:10.1016/j.foreco.2023.121320.

Baskin, C.C., and Baskin, J.M. 2023. The rudimentary embryo: an early angiosperm invention that contributed to their dominance over gymnosperms. Seed Sci. Res.: 1–12. doi:10.1017/S0960258523000168.

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Bouffier, L., Debille, S., Alazard, P., Raffin, A., Pastuszka, P., and Trontin, J.-F. 2023. Pollen contamination and mating structure in maritime pine (Pinus pinaster Ait.) clonal seed orchards revealed by SNP markers. Peer Community J. 3: e68. Peer Community In. doi:10.24072/pcjournal.302.

Carrero, C., Beckman Bruns, E., Frances, A., Jerome, D., Knapp, W., Meyer, A., Mims, R., Pivorunas, D., Speed, D., Treher Eberly, A., and Westwood, M. 2023. Data sharing for conservation: A standardized checklist of US native tree species and threat assessments to prioritize and coordinate action. Plants, People, Planet 5(4): 600–616. doi:10.1002/ppp3.10305.

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