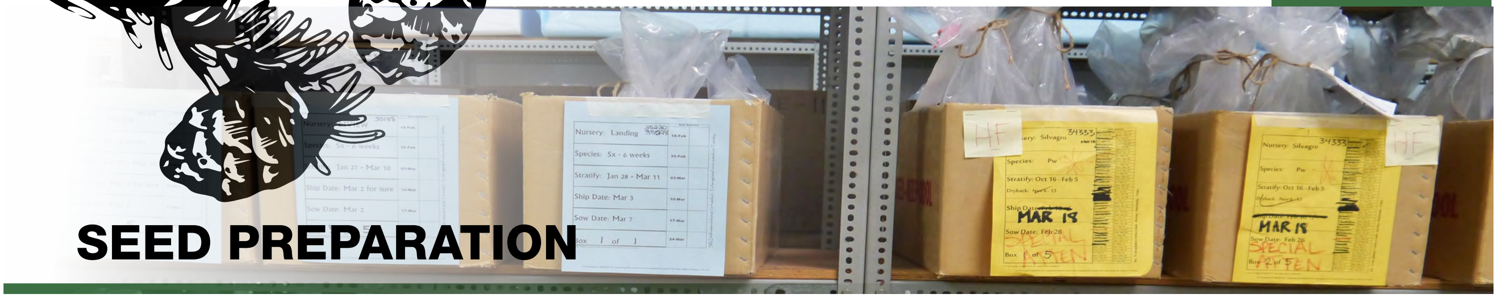
Tree Seed Working Group
News Bulletin

Canadian Forest Genetics Association
l'Association canadienne de génétique forestière

69
May
2020



SEED PREPARATION

Featured in this Issue:

Armchair Report No. 69

Hello, I hope everyone is staying safe and sane and that you have not had any losses in your life. Life has certainly changed and there is great uncertainty about what the future will look like. At our facility we continue to work and able to stay a safe distance apart while still completing our processing, testing and seed preparation activities. That is relatively easy compared to the challenges being faced by our tree planting program as a 308 Million seedling program awaits, which is heavily weighted to a spring plant. Adversity certainly breeds creativity and hopefully more on that in our next edition scheduled for December. We appreciate all the contributions we receive, so if you have something seed -related, big or small, please consider submitting it to the TSWG News Bulletin.

I wanted to thank all those involved in organizing the 2019 CFGA meeting in Lac Delage, Quebec. The futuristic theme of "*Applied forest genetics – where do we want to be in 2049?*" provided a variety of interesting discussions with an emphasis on our advances in biotechnology and genomics and the environmental/socio-economic issues these technologies raise. The CFGA should be very proud of its student sponsorship program, which sponsored six students from across Canada to attend the meeting, and for providing student cash awards for best poster and best presentation.

I want to thank my colleagues, Fabienne Colas and Melissa Spearing, for preparing and providing the Tree Seed Workshop with me and all our interesting discussions before, during and after the meeting. The workshop presentations can be found here: https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/tree-seed/events/tree-seed-workshop

Our theme was "*To reaffirm the importance of cone and seed service activities and identify knowledge gaps.*" In sharp contrast to the

Banner photo of seedlots in cold stratification treatment at the BC Tree Seed Centre. Photo by Dave Kolotelo.

CFGA Tree Seed Working Group

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Deadline for Issue No. 70: October 15, 2020

We welcome any comments, suggestions and article submissions and will solicit active, subscribing members on occasion for content. Submissions may be edited for length. Authors are responsible for the accuracy of the material in their respective articles. 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, and by
4. Advising on implementation practices.

CFGA Honourary Member Dale Simpson, former manager of the National Tree Seed Centre, Canadian Forest Service, stands in the National Forest Gene Conservation freezer in 2016. Photo by Melissa Spearing.

futuristic meeting theme, we focused on the reality of justifying the existence of such facilities in the present. These services are the foundation of maintaining the identity and integrity of our seed sources and helping to deliver our reforestation programs. The workshop theme was a direct result of tree seed facilities closing in Ontario and Manitoba over the past year. It is also a sign of a substantial decrease in the number of facilities offering cone and seed services. Even if genomic selection becomes a widespread means of advancing our “tree improvement” programs, you still need to process, test, store and prepare the seed for reforestation. We generally felt that these services are taken for granted, and there is insufficient investment in improving the efficiency of these activities.

It isn’t only a national issue. I have had some interesting e-mail discussions with IUFRO colleagues and they are facing the same challenges. This is especially true in succession planning (finding appropriate replacements) and having educational institutions cover tree seed information needs, especially at the practical level. There is a general shrinkage of the number of people dedicated to “tree seed science and technology’, but demand for services is as greater or greater than ever. It’s an important message for everyone who uses these services to repeat.

Dale Simpson was recognized as an Honourary Member of the CFGA at the business meeting in Quebec, and there is probably no one more deserving of such recognition for his contributions over the years. Dale served as Executive Secretary of the CTIA/CFGA organization from 1998 to 2016, keeping some consistency to our meetings that move across the country. He edited our conference proceedings from 1998 to 2015. This period saw a change from two to one volume and an organizational name change from CTIA to CFGA. Dale was also editor of the Tree Seed Working Group News Bulletin

Attendees at the 36th Canadian Forest Genetics Association Conference. Photo by Chris Keeling. Additional photos from the event are available on the website: https://www.acgf-cfga-conference.com/

from November 2002 (Issue No. 36) until December 2016 (Issue No. 64), leaving his imprint on 28 issues. He assisted in organizing most of our biannual workshops and migrated the News Bulletin to a colourful electronic format. Happy retirement to you Dale.

From New Brunswick, we also have another significant retirement as Greg Adams retired from J.D. Irving at the beginning of January. I'll make the case that Greg was probably the most important industrial 'tree improvement' forester in the country. He led the development of a fully integrated program and was always open to and looking for new methods to increase selection and production efficiency. Greg has left behind an incredible legacy of which he should be very proud. He's also provided us one last article summarizing the long history of tree improvement in Atlantic Canada. Happy retirement, Greg.

Locally at the BC Tree Seed Centre, we saw the retirement of our long-term employee Debbie Picard who was the Cone and Seed Processing Supervisor for the last 18 years. The competition for the position was won by Laura Klade (former TSC Testing Supervisor) and Victoria Lei (former Testing Technician) won the Testing Supervisor competition. We are back at full capacity again in the Testing area with the hiring of Laura Boiven as our newest Testing Technician.

In our branch (Forest Investment and Research Management, formerly Tree improvement) we saw Gary Giampa retire this spring, who has been a frequent contributor to the News Bulletin. Gary started as the site technician at the Kalamalka

Attendeeds at Gary Giampa's retirement celebration, Gary in the background (purple circle).

seed orchards in 1988 and retired as the manager of that site this past spring. Gary was a pleasure to work with and although he didn't favour public speaking he was always willing to share information of operational practices and the reality of running our largest seed orchard complex in BC. The photo below is from Gary's retirement celebration and it is how I'll remember Gary – at the forefront of seed orchard management, but preferring to stay in the background (purple circle). Happy retirement Gary.

The organizing committee for the joint Canadian Forest Genetics Association (CFGA) and Western Forest Genetics Association (WFGA) conference has decided to postpone this meeting, tentatively scheduled for July 2021 in the beautiful Okanagan Valley, to the summer of 2022 due to the COVID-19 pandemic. The BC Restart Plan issued recently reads gatherings of 50 or more persons will not be permitted until Phase 4 is reached which requires an available vaccination, "community" immunity or successful treatment. It is expected that this could take 12 to 18 months before a vaccine is developed.

The Host Committee, however, would like to organize a 1-day, online seminar for CFGA and WFGA Masters and PhD candidates to present their research virtually (poster and oral, with prizes awarded) and to help bridge the gap.

It looks like most upcoming in-person meetings are being cancelled: the BC Seed Orchard Association (BCSOA, June 17-18 in Sidney, BC) and the Forest Nursery Association of BC (FNABC, September 21–23 in Penticton, BC) have both announced their respective postponement and cancellation. For those interested in high elevation five-needled pines the second "High-Five" conference is still planned to occur from September 15–17 in Missoula, Montana (https://highfivepines.org/).

You'll also find in this edition a brief summary of a seed orchard 'scoping' meeting for whitebark and Limber pine organized by Parks Canada. I'm excited by this organizations' leadership in this area and expanded mandate which requires more consideration for the genetic composition of the trees in our protected areas. Exciting times indeed!

The theme of this edition is seed preparation with a couple of articles describing the specialized activity of seed pelleting, a review of some of the seed stratification and thermal priming considerations, and an overview of results-to-date on the benefits of extending stratification in interior spruce from three to six weeks. It's an important theme – apologies for not providing the information sooner, but better late, then never. Please stay safe everyone.

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Editor's Notes

Welcome new subscribers. I hope everyone is healthy, safe and what you do deemed essential. Thankfully, forestry planning has always been a long-term horizon, though certainly there are immediate logistical challenges.

Despite a world pandemic, I can't beat around the bush as to how challenging the last six months has been to publish Bulletin No. 69; the capacity and interest in extension is stretched for everyone. However, the delay afforded additional contributions on the Seed Preparation theme, a great review of Atlantic tree improvement by Greg Adams, an update from the National Tree Seed Centre, and a few more responses to the Membership Survey (which is still active if you have time). Dave and I have decided that the typical summer issue will lapse to let more content and likely-delayed research amass. In support of this themed issue on seed preparation, I'd like to point out several past TSWG Bulletins and articles which highlight past advances:

- Dave specifically examining extended stratification in Bulletin No. 22, along with Prevac enhancement details from Kim Creasey (Nov. 1994)
- Bruce Downie's feature article in Bulletin No. 31 "Upgrading seed quality of conifer seed lots: The how and glimpses of the why" (May 2000).
- Many articles in the following No. 34 issue (Nov. 2001)
- Fabienne Colas' article in Bulletin No. 59. "A New Method to Control Drying of Stratified Seed at the Berthier Tree Seed Centre."

A new book, though agriculturally focused, noting trees:

- Hasanuzzaman, M., and Fotopoulos, V. (Editors). 2019. Priming and Pretreatment of Seeds and Seedlings. Springer, Singapore. doi:10.1007/978-981-13-8625-1.

With isolation time, I went back to No. 32, where Dave transitioned to his role as Chair. In his first Armchair he said advised membership: "Be active - you'll be surprised at how quickly you will benefit." At this uncertain time, please reiterate this message to your staff, students and management. There's a seat at the table for all of us who persist in these challenging times, and plenty to feast on in the Bulletins already.

Figure 1. 2019 Tree Seed Working Group Workshop organizers (left to right, jurisdictional representation): Melissa Spearing (Ontario), Dave Kolotelo (British Columbia), and Fabienne Colas (Quebec).

In recounting events since August, first and foremost, it was an honour for me to be involved in delivering the Tree Seed Working Group Workshop with Dave and Fabienne (Fig. 1). I learned a great deal from the entire conference and CFGA Business Meeting. I also got to chauffeur Dave to Montreal and pepper him with more questions after the nursery tour. I was looking forward to the 2021 CFGA conference planned for Vernon, but the Executive has decided to postpone to 2022. Details on a virtual presentations for students are forthcoming.

Untimely as everything is these days, this issue includes two memorial notices; Dr. Alan Gordon, long-time geneticist in Ontario, and Rick Sheffield of Locke, New York, whom I had just begun to get to know since 2018. Don Pigott provides a heart-warming perspective on his travels with Rick. My condolences to all who knew these gentlemen.

Following up on happenings some may not have been aware of, the Ontario Ministry of Natural Resources and Forestry (MNRF) held the final equipment and public seed inventory auction in October 2019. Once the new Genetic Archive in Sault Ste. Marie is organized, I hope we will hear from them as to their future plans. The same would be appreciated if there is any ongoing research arising from the Pineland Nursery seed bank in Manitoba, now overseen by the University of Winnipeg. Prior to the Ontario auction, reclamation industry beyond our borders were asking MNRF and FGCA on advice for assisted migration risks of purchasing Ontario provenances (Table 1). With still-traceable Seedlot numbers and climate-based grids available for predictive provenancing, we hope to hear of

Table 1. Summary of species, estimated volume of seedlots, germination range and Ontario Tree Seed Zones (2010) that were available by auction by the Ontario Ministry of Natural Resources and Forestry (MNRF) in October 2019.

Code[1]	Est. Total Weight (kg)	# of Seedlots	Max–Min Germination (%)	Represented Ontario Seed Zones (2010)
Cw	450.3	69	94–55	28-38
He	7.7	7	61–24	30, 35, 36
Le	2.0	5	55–25	33, 34, 37
Pj	204.9	25	95–70	5, 7-9, 11-14, 22, 24, 28-30, 33, 35
Ps	44.9	12	91–56	31, 34, 36, 37
Pw	1,172.6	57	98–35	21, 23, 25-31, 33-37
Sb	3.5	10	100–95	16, 22
Sc	82.6	6	98–66	26, 32-35
Sn	555.5	39	99–73	26, 28, 31-38
Sr	4.3	2	98–93	26, 35
Sw	915.8	51	96–26	5, 12, 18, 23-26, 29, 30, 32-38
Total	3,444.2	283		

[1]MNRF species codes: Cw - *Thuja occidentalis*, He - *Tsuga canadensis*, Le - *Larix decidua*, Pj - *Pinus banksiana*, Ps - *Pinus sylvestris*, Pw - *Pinus strobus*, Sb - *Picea mariana*, Sc - *Picea pungens*, Sn - *Picea abies*, Sr - *Picea rubens*, and Sw - *Picea glauca*.

operational performance, even if sites are more reclamation than reforestation. A Trent University student survey request in this issue alludes to new demand planning in mining in Central Canada. As well, a new adaptive silviculture project initiated in 2019 at the Petawawa Research Forest is looking across multiple jurisdictions for a future-adapted genetic portfolio. Seed use policies set the broad rules, but operationally, real options must be there, along with realistic costing on the true value of seed today. I say value, not cost, in terms of the role of the right seed of the right species in the right place. As mentioned at the CFGA Business Meeting, the intention to coordinate a North American Forest Genetics Society is perhaps more relevant than ever. Unfortunately, the June 2020 kickoff conference in California has also been postponed to 2021.

As a small shout-out to collaborative opportunities, I'd like to thank Donnie McPhee of the National Tree Seed Centre (NTSC) and Simon Wilby of Colonial Manufacturing Ltd in Fredericton for reaching out in Ontario and Quebec in 2019 to coordinate the production of affordable small tumblers. NTSC needed a second unit similar to the original NTSC unit pictured in Simpson and Diagle (2009), and Simon obliged additional orders. While this unit is only suited to small collections (6–10 litres per load), it tumbles gently to maintain high seed quality and is effective for most conifers and certain angiosperm fruit. Most importantly, it's simple enough to operate and build skill in nursery staff and students new to seed extraction.

I was also fortunate to return to Fredericton this winter on a part-time contract to assist NTSC with several forward-looking projects and help in day-to-day operations. It was a flurry of activity with new and acquired collections before the pandemic. The lab was well-staffed and well-visited, and offered me a chance to dig into the meat of seed testing, jurisdictional challenges, and long-term data visualization with my new favourite piece of software, Tableau. My PDF, photo and video library tagged 'seed' has again doubled in size and specificity. Once the thrilling experiments Kathleen Forbes and I devised have run their course, I hope we can publish the investigations into improving cucumber tree (*Magnolia acuminata*) seed storage and germination. I am energized to see the support within CFS for revitalizing NTSC's national mandate and valuing its collection. Lastly, I'm glad I could finally coerce a couple articles out of Donnie.

In closing, I hope these notes will spark a few more with you reading this. Please send ideas, comments, photos, and your research; let's carry on as best we can.

Literature Cited

Diagle, B., and Simpson, J.D. 2009. Collecting and processing Salicaceae. Native Plants Journal 10(1): 49–51.

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Memorial Notice for Dr. Alan Gordon

Passed away peacefully on Wednesday, November 27, 2019 at Extendicare Maple View at the age of 90 as a result of end stage Alzheimer's. Alan graduated from Forest Hill Collegiate, Toronto, the University of New Brunswick in 1954 (B.Sc. in Forestry) and completed his Ph.D. in Forest Ecology at the University of London, England in 1958. He had a lifelong career with the Ministry of Natural Resources (Ontario Department of Lands and Forests) as a research scientist focusing on forest genetics, soil chemistry and ecosystem productivity. Alan was one of the first people to document the effects of acid rain on both terrestrial and aquatic ecosystems and was the first to 'discover' and document red spruce in Ontario in 1950. Alan developed working plantations of spruce species in many areas of Ontario and around the world, which are still generating scientific information today.

From a very young age, Alan's pursuit and interest in ornithology was infectious; he was a naturalist and an avid canoeist throughout his life and was a passionate advocate for environmental conservation. He was a proficient wood sculptor and photographer.

Dr. Alan George Gordon, 1929–2019.

Dr. Gordon was a planter of trees and was locally known as the 'tree doctor'. He inspired and mentored Junior Rangers and shared his knowledge of the forest and his powers of observation with many student field crews inspiring them to appreciate the natural world. His passion for forests and forestry lives on in all of the forests he created. The Alan Gordon Acadian Park, in Ottawa, and Gordon's Grove, in Algonquin Park, are named after him.

Drawn to the spirit and beauty of Canada's Indigenous art he helped establish a significant gallery (Tundra) in the 1970's and developed many significant friendships with artists across Canada such as John Laford, Goyce Kakagamic and James Simon. He served on the Board of the Art Gallery of Algoma and Art Procurement Juries for Ontario Government buildings. He always advocated strongly for Indigenous culture and rights.

He loved all genres of music. In the 1960s, he was a primary organizer of the Algoma Folk Festival, bringing the likes of Gordon Lightfoot, Ian and Sylvia, and Alanis Obomsawin to Sault Ste. Marie. He was notorious for telling the widest and longest stories ever. Alan was a long-term active member of St Giles and Westminster Presbyterian Churches.

In lieu of flowers, donations to Nature Conservancy of Canada would be greatly appreciated. To those he loved, you will be visited by a red-shouldered hawk in the next little while.

Retrieved from https://www.osullivanfuneralhome.com/memorials/alan-gordon/4044862/

Memorial Notice for Rick Sheffield, Sheffield's Seed Co.

It is with great sadness we are informing you that Rick Sheffield passed away suddenly from a health issue hiking in Maui, Hawaii at the age of 62 in December 2019.

Rick loved plants and cherished time with friends and family. He always was quick to share a nature moment of the local species and studied the seeds along the way. Rick enjoyed all the talks and discussions he had with his suppliers and customers throughout the years. He will be greatly missed by those who knew him, and all the thousands of customers who benefited from his knowledge and experience.

Sheffield Seeds has been a renowned institution for seed sales that Rick has nurtured from his early days at Cornell University with passion, enthusiasm and drive. His attention to detail included mentoring a staff of professionals to continue his vision of providing a world-class inventory of popular as well as hard to find seeds! Sheffield Seeds Company will continue this tradition with our knowledgeable team We look forward to providing the level of excellence Rick has always instilled. For more information on Rick's business philosophy: https://sheffields.com/about-us

Sincerely, Sheila, Allie and Ryan Sheffield

Donations to the Nature Conservancy in Rick's Name would be greatly appreciated. https://support.nature.org/site/Donation2?15000.donation=form1&df_id=15000&resultid=7TV (Rick Sheffield, Locke NY) In the form, notify for donation: Sheila Sheffield, 269 State Route 34, Locke, NY 13092, sheilaallieryan@gmail.com.

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The above notice was forwarded to the TSWG News Bulletin Editor by a seed collector who supplied the company. The Editor corresponded with Rick's wife Sheila and Tim Ingall, a 20-plus-year manager with the company, to include a timely notice. Unfortunately, the COVID-19 crisis has forced a rescheduling of the Celebration of Life to a later date. The Sheffield Seed Company intends to welcome friends, family and customers to plant trees in Rick's seed orchard. Please contact Sheila for current information.

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On December 13, 2019, I sent an email to Rick just to say hello, and got a prompt reply from Tim at the shop in Locke, NY that Rick has passed suddenly two days before while hiking on Maui. Like everyone I was shocked. Rick was one of the nicest, most knowledgeable business associates and friend that I have ever had the pleasure of knowing. Rick leaves his wife Sheila, and children Allie and Ryan. Rick started Sheffield Seeds based in Locke New York in 1978, and built the company into the leading tree, shrub, and flower seed supplier in North America.

We first met Rick and his wife Sheila at an International Seed Federation meeting in China in 2002. I had corresponded with Rick previously, but we had never met. His smile and friendly demeanor lit up the room! We traveled as a group

Rick Sheffield enjoying a recent canoe trip. Photo provided by Sheila Sheffield.

Hiking in the rain with the International Seed Federation members at Huangshan Mountain, China (Rick Sheffield, pictured far right). Photo provided by Don Pigott.

for several days, and the highlight was the evening meal We often sat together and toasted each other, and our hosts, discussed shop, and laughed about our unknown meals. I will never forget one meal when he fell out of his chair laughing as I had (after one too many toasts), filled an ashtray with pigeon soup that I had mistaken for a soup bowl! The ashtrays were referred to afterwards as Canadian soup bowls.

We have had the good fortune to be in the company of Rick and Sheila in five different counties for both work-related and social adventures. As my wife's name is also Sheila, we used to joke about us having two Australian Sheilas! Ten years ago we visited the Sheffield's in Ontario, hiked part of the Niagara Escarpment and went to a Blue Jays' game with Rick, Sheila, Allie and Ryan. Watching Ryan's enthusiasm of the game and consumption of everything from popcorn to hotdogs was more entertaining than the whole game itself. Rick and Sheila last visited us three years ago on the Island, and we spent a day hiking in the rain forest where Rick took many photos and notes on the flora and ecology.

Rick was passionate about his work and was highly respected for his knowledge and business integrity. No one knew as much about as many species as Rick did. I urge folks to visit the Sheffield Seeds website and look at the details of the seeds catalogue, the species descriptions, photos, comments, and seed preparation suggestions. It could be easily made into a book.

Though he was dedicated to his work, he was even more dedicated to his family, and always took the time to enjoy life, have a good laugh, share good times, and maybe a glass with friends and family.

He was one of a kind, and we will all truly miss him.

Sincerely, Don Pigott

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I had the opportunity to video conference with Rick several times in the Fall of 2018 during the Ontario Tree Seed Plant privatization process, to seek his advice on policy provisions on US seed supply moving forward. Sheffield's relied on the OTSP for surplus Southern Ontario seed when needed, and I learned a great dealt in a short period of Rick's success and challenges with handling the needs of an evolving industry. Despite his experience and commercial viewpoint, he was indeed a warm soul with an infectious personality and engaging positivity. Rick traveled often through Ontario and welcomed meetings I now remiss not taking. Best wishes to the team continuing his legacy.

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Seed Matters! New Technical Note Series from ATISC

The Alberta Tree Improvement & Seed Centre has released the first three editions in a new series for the public entitled 'Seed Matters'. Seed Matters is a collection of documents based on eight years of research results and experience in their seed technology labs and provides information to industries, academia and the general public in an easy to understand and concise format. Seed Matters 1 and 2 contain recommendations for aspen seed and endangered five-needle pine seed extraction and handling to improve seed quality and prolong seed lot lifespans in storage. Seed Matters 3 will be posted soon and cover recommendations for seed treatments and sowing five-needle pine seed from Alberta.

Three new editions for publication later this spring include recommendations for seeding lodgepole pine, jack pine and white spruce that may help greenhouses to increase yield while using less seed and allow more flexibility in schedules. Future editions later in 2020 will provide research results to a wider audience on species isotherms, seed survival curves and longevity estimates, and results from the currently suspended shrub seed research into improving seed storage, chemical/biological viability testing, and seedling production for oil industry reclamation. The Seed Matters series can be found by Googling 'Alberta Seed Matters' or by clicking 'Seed biology, technology and reforestation' on the Alberta Tree Improvement & Adaptation Programs webpage:

Seed Matters 1 – Recommendations for Aspen Seed Collection and Handling

Seed Matters 2 – Extracting and Handling Five-Needle Pine Seed in Alberta

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Thermal Priming

There is probably no word in seed science and technology that receives as much augmentation as the word 'priming'. One doesn't have to search very long to find the words osmotic priming, thermal priming, hydrothermal priming, solid matrix priming, membrane priming, and drum priming. You'll also probably encounter terms like fluid drilling and osmoconditioning, so it can be confusing. These are practices that have been primarily developed and fine-tuned for agricultural crops to increase the rate and uniformity of germination as well as the seeds tolerance to various stresses. Most commonly, 'priming' refers to the regulation of the moisture level in the seed, so that seed metabolism is initiated and starts moving towards germination, but the moisture level is regulated below the level which causes the radicle to emerge.

This is best represented in relation to the classic diagram on the three phases of water uptake in seeds by Bewley and Black (1994) (Fig. 1). Phase I is the imbibition phase and with our stratified seeds this represents simply soaking seeds in water, which for the majority of our species is 24 hours. Seed metabolism is initiated in this phase and a rapid increase in the respiration rate occurs. In phase II there is no increase in moisture content and this will be the phase in which dormancy is overcome if the proper conditions are provided. Priming methods aim to keep the seed in phase II moisture levels as the rapid increase in phase III is accompanied by the emergence of the radicle. You can think of priming as giving the seed a head start, reducing the time you need to heat a greenhouse for a crop to germinate, or simply a method of saving money!

The context with most agricultural crops is that they lack seed dormancy and most can be sown dry to maximize seeding efficiency whether in the field or in containers. The move to simply soaking the seed (hydropriming) is a novel treatment for many agricultural crops. If no other limitations to germination are present the moisture uptake needs to be arrested to avoid the seeds from moving directly to radicle emergence prior to sowing. In contrast, most of our tree species have physiological dormancy requiring an initial level of imbibition and a period of cold stratification to overcome dormancy. To maximize seeding efficiency, many surface dry tree seed to remove moisture that would adhere seeds together, but still maintain maximum levels of internal moisture. For agricultural crops it is common that the primed seeds are dried back after treatment, but Huang and Zou (1989) found damage, likely to the seed membrane, occurred after prolonged drying of tree seeds following drying treatments.

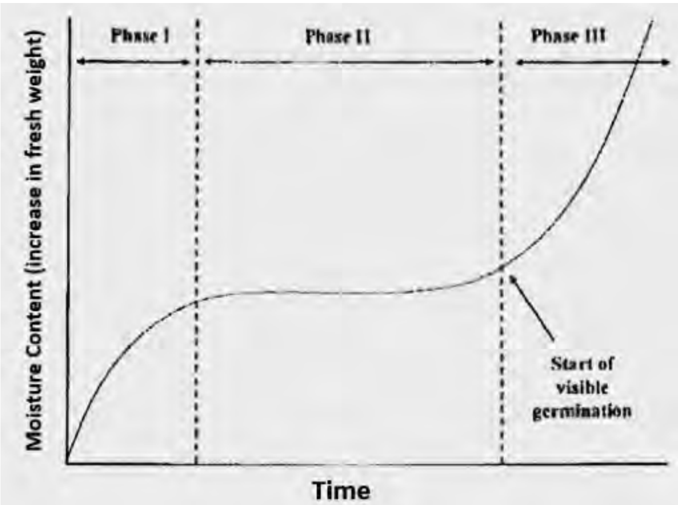

Figure 1. The three phases of moisture uptake in germinating seeds (adapted from Bewley and Black 1994).

In contrast to soaking seeds for a pre-determined duration or moisture content, there are other means to regulate moisture content to levels that will be below that required for radicle emergence. These include soaking seeds in a solute that restricts the amount of water seeds can uptake (osmotic priming), mixing seed with water and a solid in preset proportions (solid matrix priming), and exposing seeds to a controlled level of water vapor (drum priming). There is a vast amount of literature available on the topic of priming. For an introduction into priming (and seed enhancements including pelleting), I suggest Taylor et al., 1998. For a bit more history and documented benefits check out Welbaum et al. 1998, and for an in-depth look at the concepts and physics of water relations in seed germination, the review of Bradford (1995) is a must read for the focused and brave.

These techniques have been attempted on conifer seeds and, but that is not the purpose of this paper. I will list them in the references section, but my main focus is on the topic of thermal priming in the context of tree seeds that require cold stratification. It is a matter of semantics and one could argue that, at our facility, our stratification processes based on the Target Moisture Content concept are a form of species-specific priming in conifers. We simply look at it as improving stratification by trying to maximize internal moisture and provide a surface dry seed coat to allow for efficient sowing in a container system. If adequate moisture is present and dormancy is overcome then it is simply an accumulation of thermal units which controls the speed of germination.

Most of our north temperate conifers are planted as one year-old seedlings and many are germinated during winter in greenhouse systems as part of their crop cycle following species specific cold stratification durations that range from three to 16 weeks. The cost of heating these greenhouses can be substantial, especially in Canada's North where the heat differential between the greenhouse and outside environment can be 40°C or more in January. In this context, thermal priming would simply be the accumulation of some of the thermal units in the seed in a confined, and cheap space compared to heating the entire greenhouse. The benefits seem obvious and have received some attention (Liu et al. 2013), but I am always surprised by how few nurseries, especially those in the North, incorporate this practice into their operations. An overview was provided by Dawes (2008) from a forest tree seed nursery perspective.

I view thermal priming as an increase in efficiency by supplying what will be needed (thermal units) in as efficient a manner as possible. I've brought this up during various extension opportunities and there has been some desire for additional information. The following are my suggestions on incorporating this practice operationally. There really is nothing magical about the practice, anyone can do it and show the benefits in a testing environment – the challenge comes in scaling it up to an operational scale level.

1. Don't wait for someone to spoon-feed you this practice. There are no magic thermal heat unit accumulation boxes for sale. The nurseries that have incorporated this into practice have developed an environment (box, chamber, room) that meets their needs and fits into their specific operations and workflow.

2. The practice doesn't come without some risk – if you are adding thermal units you risk drying the seed out, so there must be a means to control humidity at a high level to avoid drying. Seed weight is a simple means of monitoring whether drying is occurring and to what extent. For poorer quality seedlots, fungal proliferation may

be an issue, so suggest starting this practice with good quality seedlots. The fungi may be pathogenic, but if you have a seedlot with a lower quantity of viable seeds they may simply be the fungi involved in deteriorating the non-viable seed and have no impact on the seedling crop.

3. This isn't something I recommend jumping into with both feet – start small in quantity, gain some experience and build on that in subsequent years.

4. The second risk involves going too far and having moved the germination process to the point of radicle emergence. This reduces efficiency of seeding, but could also result in damage to the root apical meristem. In Step #4 above, I recommend starting small in quantity and here I recommend being conservative in how long, or at what temperature you apply the treatment.

5. To help inform the thermal unit needs I look at our germination tests. The thermal units supplied, when we first see germination and how we could correct this for the time of radicle emergence. The whole degree day concept is too coarse for this practice, so I think in terms of degree hours. This uses the same threshold (5°C) used for Growing Degree Day (GDD) calculations, but accumulates them on an hourly basis. The most common recommended germination regime is the 30:20 one commonly used in seed testing that involves 8 hours at 30°C and 16 hours at 20°C. If we use the same GDD format then you have (25×8) + (15×16) = 440 degree hours.

   We don't record radicle emergence, but it is usually within day two to five in our germination tests. That provides a bit of guidance that between 880 and 2200 'degree-hours' are a good place to start. Table 1 provides some information on when we perform our first counts in our germination tests, but these represent when the radicle is 4× the length of the seed coat and would certainly be far too aggressive and not recommended at all – they are simply presented to provide a ranking of relative germination speed from fastest to slowest germinating species. Largest gains seem obtainable with *Picea* spp., so I'd start there.

Table 1. Equivalent degree-hours and average first day of counts when radicle is 4× the length of the seed, ranked by fastest germinating species tested.

Species	First day of counts (4×)	Equivalent Degree-hours (4×)
Pinus contorta	5.3	2332
Pinus ponderosa	5.3	2332
Abies lasiocarpa	7.3[1]	2336
Pseudotsuga menziesii	5.6	2464
Larix occidentalis	5.7	2508
Pinus monticola	6.3	2772
Picea glauca, engelmannii	6.7	2948

[1]For *Abies lasiocarpa*, germination testing is performed with a 25:15 or 320 degree-hours per accumulated per day. One may not want to thermal prime at a lower temperature.

6. The temperature you set your environment to is your next decision. If it's 15°C, then you accumulate 240 degree hours/day and if its 20°C, then you accumulate 360 degree hours/day. I'd recommend starting with an accumulation of 800 degree-hours, so that's 3.3 days (@15°C) or 2.2 days (@20°C). A useful bit of unpublished research on temperature cycling was performed by Drs Carole Leadem and George Edwards. They determined that it didn't matter how you accumulated the thermal units or whether you had diurnal fluctuations, but it was the total energy received that was most critical for germination.

I hope this is helpful and encourages nurseries to investigate and tinker with this method. I believe there are incredible gains in efficiency (cost savings) to be had for those that integrate this practice into their operations. How much does it cost to heat your greenhouse for a day? There certainly may be some additional advantages to other priming techniques, especially for direct seeding, but I think the biggest bang for your buck in conifer seedling production will come from thermal priming.

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Black Spruce Pelletizing in New Brunswick: 2017-2019

The Kingsclear Tree Nursery decided to use pelletized black spruce (*Picea mariana*) seeds in 2014 to increase seeding accuracy, reduce thinning costs and decrease the number of voids in the trays. A trial had been done in 2013 to measure the effectiveness of pelletizing black spruce, red spruce and white spruce seeds. The results for white spruce were not good so the red spruce and black spruce were pelletized and used operationally in 2014. In TSWG News Bulletin No. 60, a report was included detailing our pelletized seed trial results and cost savings.

After 2014, the nursery continued to pelletize black spruce and red spruce. We did start to have issues in some of the growing areas with the pellet coating not dissolving very easily. Another major factor causing this may be the fact that the seeding took place in July in an area with no climate controls (unheated greenhouses). In 2018, a decision was made to forgo the pelletizing and proceed with single naked seeding as usual. However, the precision seeder we use is only accurate to 97%. This results in extra doubles throughout the tray. We also tried double seeding some houses. This resulted in large thinning costs.

After contacting the provider for our pelleting, he tried a new coating, more soluble and thinner. We also sent them first for IDS and Prevac treatment, then on to pelletizing after they were dried back to storage moisture content. With this new formulation, we sowed pelletized black spruce seed

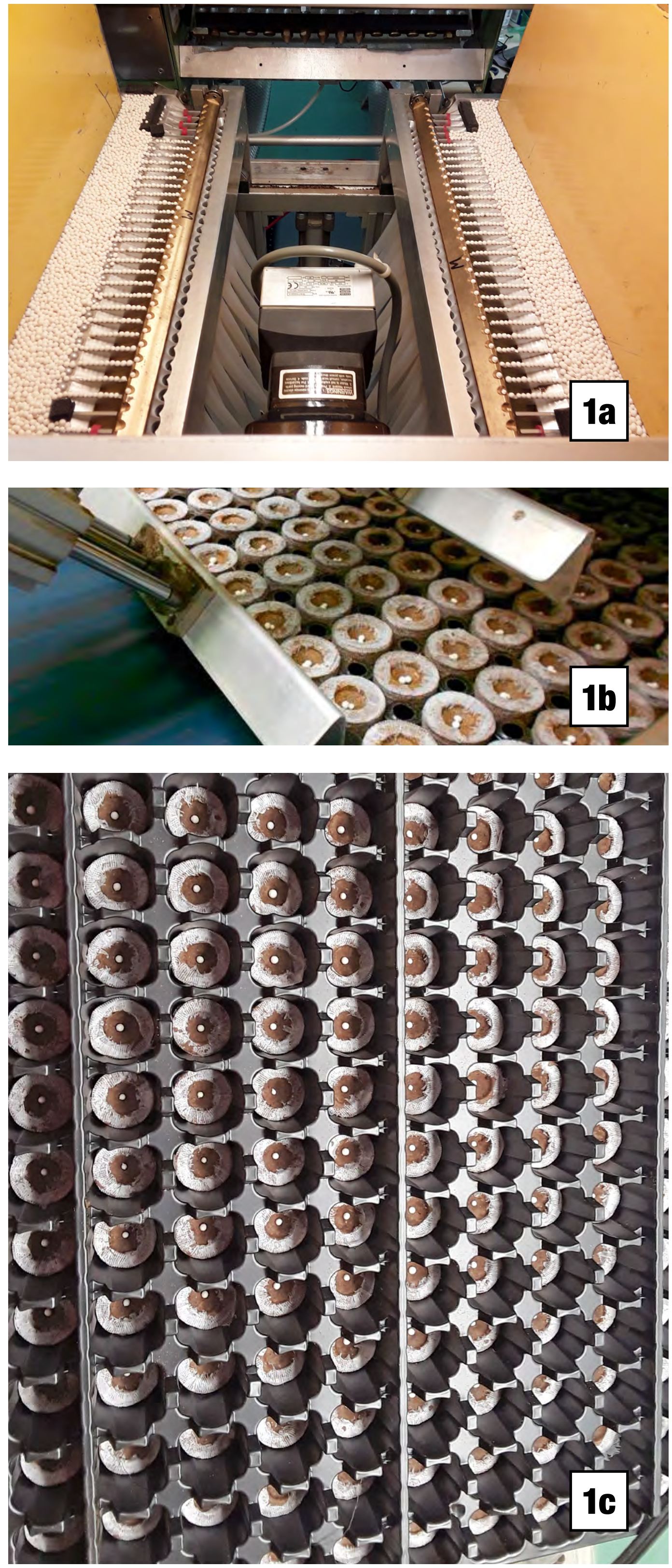

Figure 1a. The seeding machine filled with pelleted seed. (b) Close-up view of the tray beneath the seeder during the 2014 seeding and (c) a tray sown in 2020 with single pellets.

in 2019 (Figs. 1a, b, c). Formerly glue was applied, but since 2017, we use a thin layer of vermiculite to keep the seed moist, which also helps degrade the pellet coating. We had great success, with a seeding accuracy of 1 per cell vs 1.2–1.4 with non-pelletized seed. The coating dissolved much better and the germination results were excellent (Table 1). We will pelletize again in 2020, but forgo the expense of the IDS and Prevac, because the seed we will be using has a very high germination to start with. I will follow up with an article in the fall detailing additional differences in our seeding trials for the black spruce.

Table 1. Annual black spruce pelletizing results at Kingsclear Nursery 2017-2019.

Year	Total Seeds Used	Pelleted	IDS	Avg Seed Rate	Avg. Germination %
2017	10,183,080	Yes	No	1.0	93.2
2018	6,789,792	No	No	1.2	91.2
2018	3,866,232	No	No	2.8	88.8
2019	7,415,059	Yes	Yes	1.0	97.9

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Overview of BC TSC's Pellet Assessment Program: 2003–2019

Introduction

Western redcedar (CW) and Red alder (DR) seeds have been pelleted since the 1990s (Klade, 2010). A standardized Pellet Assessment Test (PAT) was established at the Tree Seed Centre (TSC) in 2003 for quality assurance purposes. Previous internal reports by TSC staff examined the pellet assessment program, but a review of all Pellet Assessment Tests (PAT) has not been conducted since 2010.

CW and DR seeds are pelleted to increase sowing efficiency. Due to their light, winged nature, unpelleted seeds tend to cling or 'jump' when there is static or air movement. This is especially problematic in nurseries during the movement of styroblocks before gritting. Pelleting encases the seed in a diatomaceous earth coating to make it heavier, rounder, less staticky, and easier to sow with seeding machines (Kolotelo, 1996).

Approximately 30 to 40 pelleted seedling requests are sampled each year prior to shipping. For each request, 200 pellets are counted out and divided into 8 replicates of 25 pellets (Fig. 1). Each pellet is put into an individual compartment of a vitamin organizer which is then filled with water. After the pellet has broken down, the contents are examined and classified as containing: 1 seed, no seed (empty), debris, 2 or more seeds, or seed from another species. The number of pellets containing no seed, 2 or more seeds, or seed from another species are subtracted from the total number of pellets to calculate the PAT percentage.

The TSC has had a contract with Carl Happel Seed Pelleting since 2000 (Klade, 2010). According to the terms currently agreed upon, no more than 3% of CW and 5% of DR pellets

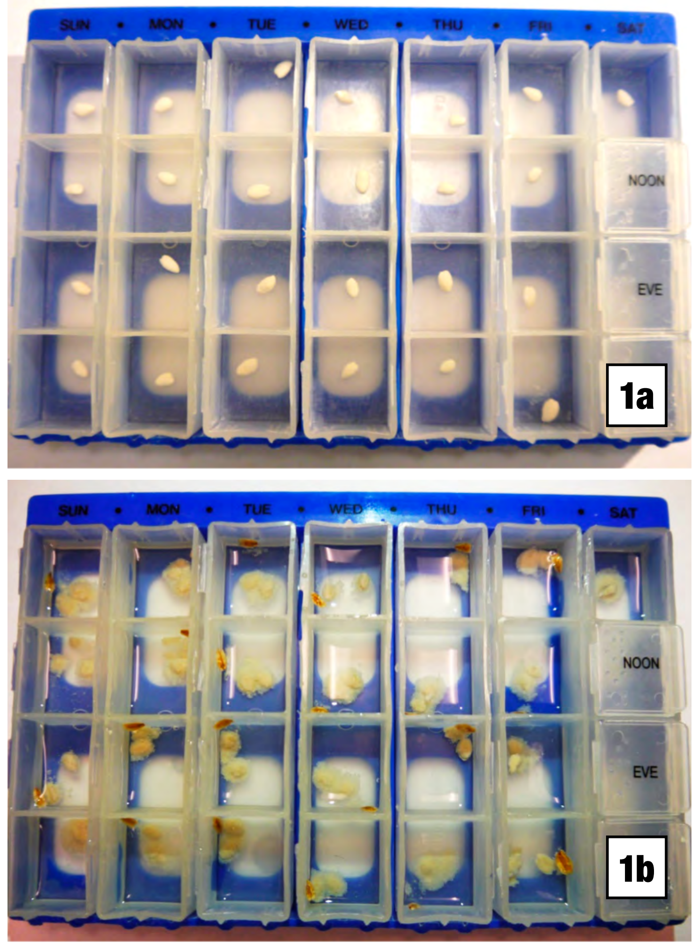


Figure 1. A single replicate of a Pellet Assessment Test (PAT) (a) before, and (b) after water is added.

are to be empty or contain 2 or more seeds. The contractor is not held accountable for pellets containing debris, which is dependent on the purity of the seedlot. The pellet assessment results used in this report include debris-filled pellets in the percentages, except for tests from 2005 where individual testing records were unavailable.

Results

There was a total of 599 Pellet Assessment Tests (PAT) from the 2003 to 2019 request years. Most of the assessments were conducted on CW requests, with 511 CW PATs and only 85 DR PATs, due to the larger number of CW seedling requests. There were three Paper birch (EP) PATs which had an average PAT result of 98.7% but have not been included in the tables due to their scarcity.

Figure 2 shows the average PAT result per request year for CW and DR seedling requests. Except for in 2003, average CW PAT results were 97% or higher. Average DR PAT results were higher than 95% except for in 2004 and 2018. Overall, less than 3% of CW and 5% of DR pellets were empty or contained 2 or more seeds, meaning the terms of the contract were upheld.

Table 1 shows the number of PAT tests, the average seeds per gram (SPG), and the average PAT result by request year for Class A (seed orchard) and Class B (wild stand) CW and DR seedling requests. There were DR seedling requests in 2003 and 2008, but no PAT tests were conducted. B-class CW had higher average SPG, or smaller seed, than A-class CW, but the average PAT result over all seedling requests of each class was the same (98.7%). The average PAT result for each DR class was lower than those of CW, but the small number of DR PAT tests make it difficult to say if this is a good comparison.

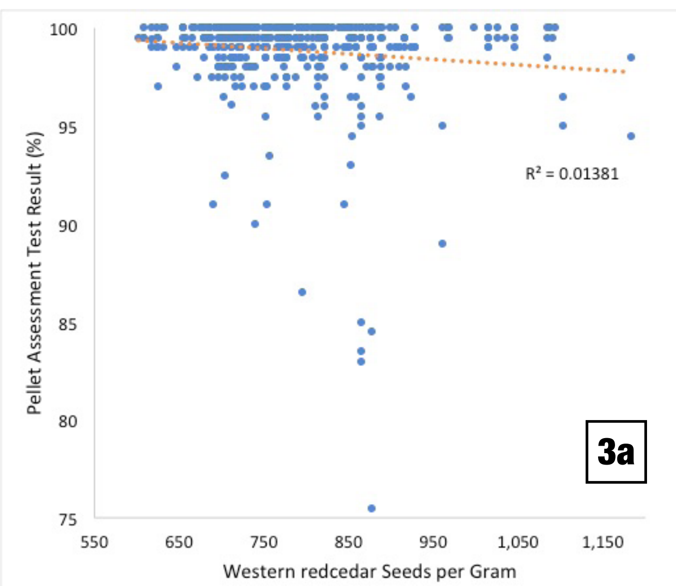
To investigate the impact of SPG on PAT results, PAT and SPG results were plotted against each other within species (Figures 3a and b). No strong correlation was identified, suggesting that PAT results are independent of SPG.

Figure 2. Average Pellet Assessment Test Results of Western redcedar (CW) and Red alder (DR).

Table 1. Average of Seedlot Seeds per Gram and Pellet Assessment Test (PAT) Results for CW and DR by Request Year.

	CW - Class A			CW - Class B			DR - Class A			DR - Class B			
Seedling Request Year	# of PAT Tests	Average of Seeds / Gram Results	Average of PAT Results (%)	# of PAT Tests	Average of Seeds per Gram Results	Average of PAT Results (%)	# of PAT Tests	Average of Seeds / Gram Results	Average of PAT Results (%)	# of PAT Tests	Average of Seeds / Gram Results	Average of PAT Results (%)	Total # of PAT Tests per request year
2003	13	746	96.3	11	820	97.0							24
2004	11	759	99.7	15	824	98.1				2	1815	89.0[1]	28
2005	17	729	97.3[1]	17	839	96.6[1]				5	1792	96.3[1]	39
2006	16	733	99.6	19	818	99.1				5	1801	97.0	40
2007	12	729	99.3	17	833	99.5				4	1671	99.0	33
2008	17	760	97.1	20	784	99.0							37
2009	12	741	99.1	16	770	99.2				1	1611	99.5	29
2010	9	719	99.2	15	806	99.3				3	1984	97.8	27
2011	13	795	99.0	15	840	99.7				6	1797	98.3	34
2012	15	748	99.2	18	808	98.9				10	1716	98.2	43
2013	8	721	99.5	18	853	99.5				9	1635	97.8	35
2014	14	730	98.6	21	832	99.4				8	1651	97.4	43
2015	9	709	99.2	25	824	99.4				7	1868	97.3	41
2016	15	759	98.5	23	831	96.6	1	1699	93.0	9	1663	97.6	48
2017	8	726	99.6	19	790	99.2	1	1363	94.0	7	1569	97.9	35
2018	10	774	98.2	17	816	98.9	1	1363	98.0	4	1680	92.0	32
2019	12	780	99.6	14	828	99.0	1	1363	97.5	1	1320	96.5	28
Average	12.4	746	98.7	17.6	819	98.7	1.0	1447	95.6	5.4	1713	97.2	35.1
TOTAL	211			300			4			81			596

[1]Average PAT values from a previous report were used since PAT records were unavailable.



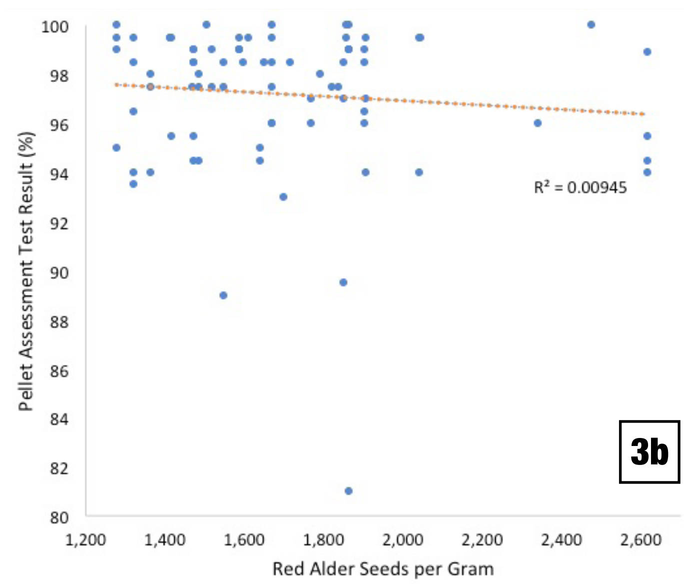


Figure 3. The Pellet Assessment Test and Seeds per Gram results of (a) Western redcedar, and (b) Red alder. Each marker represents one seedling request.

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The Effects of Water Source on Seed Germination

The BC Tree Seed Centre (TSC) has a long and complicated history of obtaining its water from wells that were located on the adjacent Surrey nursery site. This involved co-management of the systems which included infrastructure maintenance and later water treatment (topping up a bleach reservoir). This was complicated enough when the nursery and TSC were both government facilities and become more complicated when the nursery was privatized. A significant event was the water holding tank was infiltrated by tree roots causing an increase in microbial activity. This initiated the bleach treatment mentioned above and resulted in the TSC installing reverse osmosis systems into the lunchroom and seed testing area in addition to making bottled water available for staff to drink.

The most significant change to our water source occurred in July 2007 when we started receiving our water from the city of Surrey and abandoned the well systems. The move to city water had the Tree Seed Centre as the primary water user on a 1.5 km large city water main consisting of the current standard of ductile iron piping with an internal lining of cement mortar. The city water was evaluated shortly after connection by an independent lab and although generally water quality was good, the pH was found to be extremely high with a value of 10.6! Previous results from the well based system were generally between 7.4 and 7.8. The water was retested on August 1, 2007 and a pH of 10.2 was found. An investigation involving the city of Surrey and contractors was initiated.

Activities initially focused on flushing of the city's water line to try and reduce the pH. It became clear that a) pH is not a general problem in the area; b) pH at the Tree Seed Centre is high; c) pH decreases as the pipe flushing progresses; d) pH levels increase again overnight.

The eventual solution was to install a pH adjusting system which had several issues with installation and calibration. The installation and management of the system was paid for by the Ministry of Transport and Highways until March 2010 when the TSC became responsible for funding the required sulfuric acid and pH adjustment systems maintenance. The system has required significant amounts of maintenance and monthly acid top-up costs and there was a great deal of uncertainty regarding the need for continue to use it after over 12 years of activity. There are also many new users on the water line which should help alleviate the problem. There were a variety of monitoring logs developed, but I will simply provide those that are relevant to the germination testing performed using various water sources at the TSC.

Using a portable pH probe water samples were assessed at four different TSC locations which were the water sources used for the germination tests:

a) **Untreated** – yellow hose in photocopier room
b) **Treated** – Lab (main tap)
c) **Treated + reverse osmosis** – Lab
d) **Treated** – Seed [reparation soak tanks

The Untreated water was critical as it is this which we must be comfortable using for all operations if the pH adjustment station were decommissioned. During initial pH monitoring in 2019 we noticed a significantly lower pH in the Lab (treated + reverse osmosis) water and differences between the lab and seed preparation soak tank pH, although the latter two samples should represent the same water. The untreated water had a consistently higher pH than the other water sources (Fig. 1). This timeline represents the main period of water use for soaking seed to initiate the stratification process.

Water from these same four sources was also sent to an analytical chemical lab for testing on two occasions with pH results of 7.49 and 7.59 for the untreated water and 5.9 and 6.3 for the treated plus reverse osmosis water in the testing area. The other two treated water samples ranged from 6.85 to 7.25 across both dates with no consistent trend.

There are few references available on the impact of pH on tree seed germination . It was decided to test a variety of BC trees species using the same four water sources illustrated in Figure 1. A total of 12 seedlots were selected across seven species (Table 1). The western redcedar (CW) seedlot was tested dry on moistened media as per our standard testing procedures. The species is does not have embryo dormancy and operationally the seed is pelleted dry for ease of nursery sowing. All other seedlots received a 24-hour soak, with interior lodgepole pine (PLI) and grand fir (BG) subsequently receiving four weeks stratification and all other seedlots stratified getting three weeks. The various water sources were used for the initial imbibition of the seed, as well as the 37.5 ml used to moisten the Kimpak and filter paper. All germination tests ran for 21 days and a seed was considered germinated when the radicle was 4× the length of the seed coat.

There were some very small seedlot differences (Table 1, Fig. 2), but overall the average germination across all 12 seedlots ranged from 82.2% to 82.7% by water source, so there is no impact of the tested water sources on tree seed germination.

Discussion

The results of our germination tests indicated that within the pH range tested there was no impact on seed germination. Looking into our water systems brought up many more questions than simply 'to turn off our pH adjustment system' or not. We are continuing to monitor water quality as the lab tests had shown an increase in the copper content. The increase was relatively large and consistent across the four water sources, but well below the Canadian Guideline limit of 1,000 ug/L (our highest value was 170 ug/L). This may also be a seasonable difference as the higher levels were found in the summer during much less water flow at our facility. It is also possible that after such a long period of time the sulfuric acid treatment is beginning to deteriorate our copper pipes.

There has never been an official designation that the water at the TSC is unsafe for human consumption. Primary concerns with water safety revolve around the presence of harmful bacteria (i.e. *E. coli*) or conditions which could promote

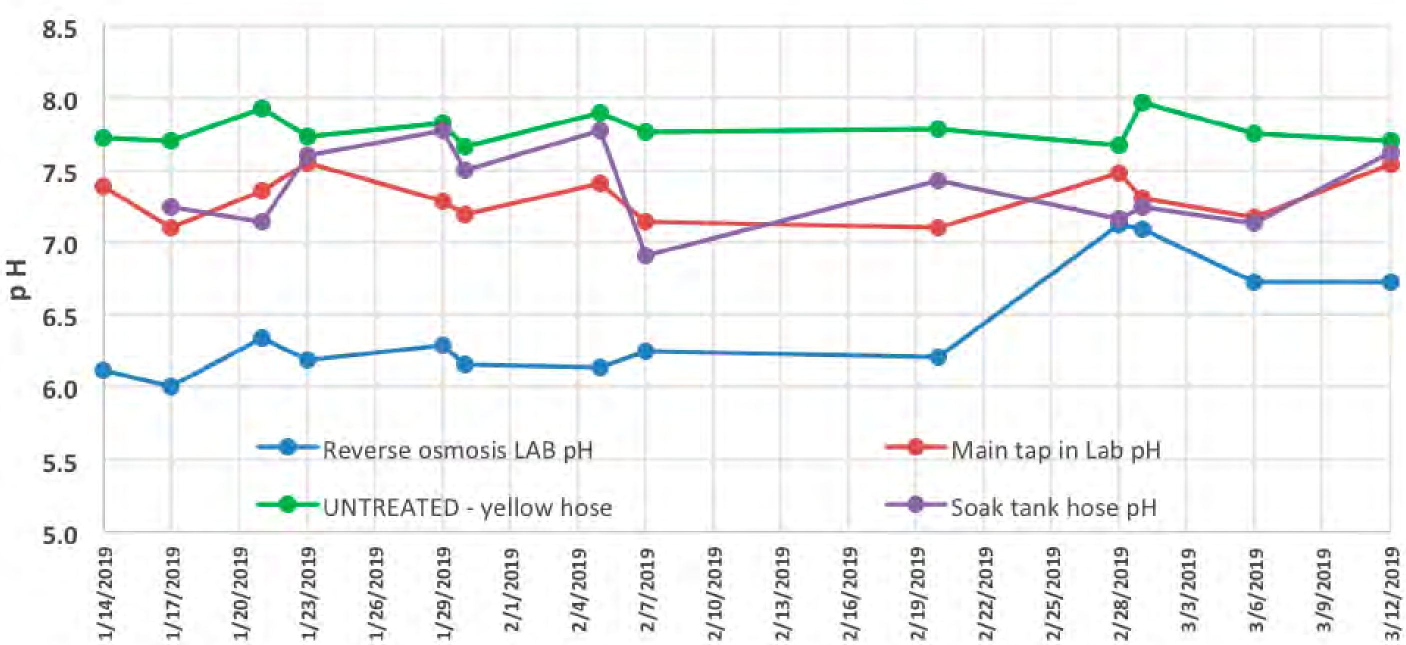

Figure 1. The pattern and values of water pH observed locally through early 2019.

Table 1. The seedlots and species used and the range and average germination capacity (%) across all four water sources.

Seedlot	Species	Code	Average Germination (%)	Germination Range (%)
2484	*Pinus contorta* var. *latifolia*	PLI	62.2	60 - 64
8077	*Pinus contorta* var. *latifolia*	PLI	84.2	82 - 86
39295	*Pinus contorta* var. *latifolia*	PLI	94.2	93 - 96
14383	*Picea glauca* × *engelmannii* complex	SX	63.2	63 - 64
39071	*Picea glauca* × *engelmannii* complex	SX	82.5	76 - 86
35656	*Picea glauca* × *engelmannii* complex	SX	87.8	87 - 89
5130	*Pseudotsuga menziesii* var. *glauca*	FDI	80.8	77 - 82
60304	*Pseudotsuga menziesii* var. *menziesii*	FDC	92.5	91 - 94
48527	*Thuja plicata*	CW	81.8	80 - 84
39263	*Larix occidentalis*	LW	92.2	90 - 94
42261	*Pinus ponderosa*	PY	89.8	88 - 92
20154	*Abies grandis*	BG	77.5	76 - 79

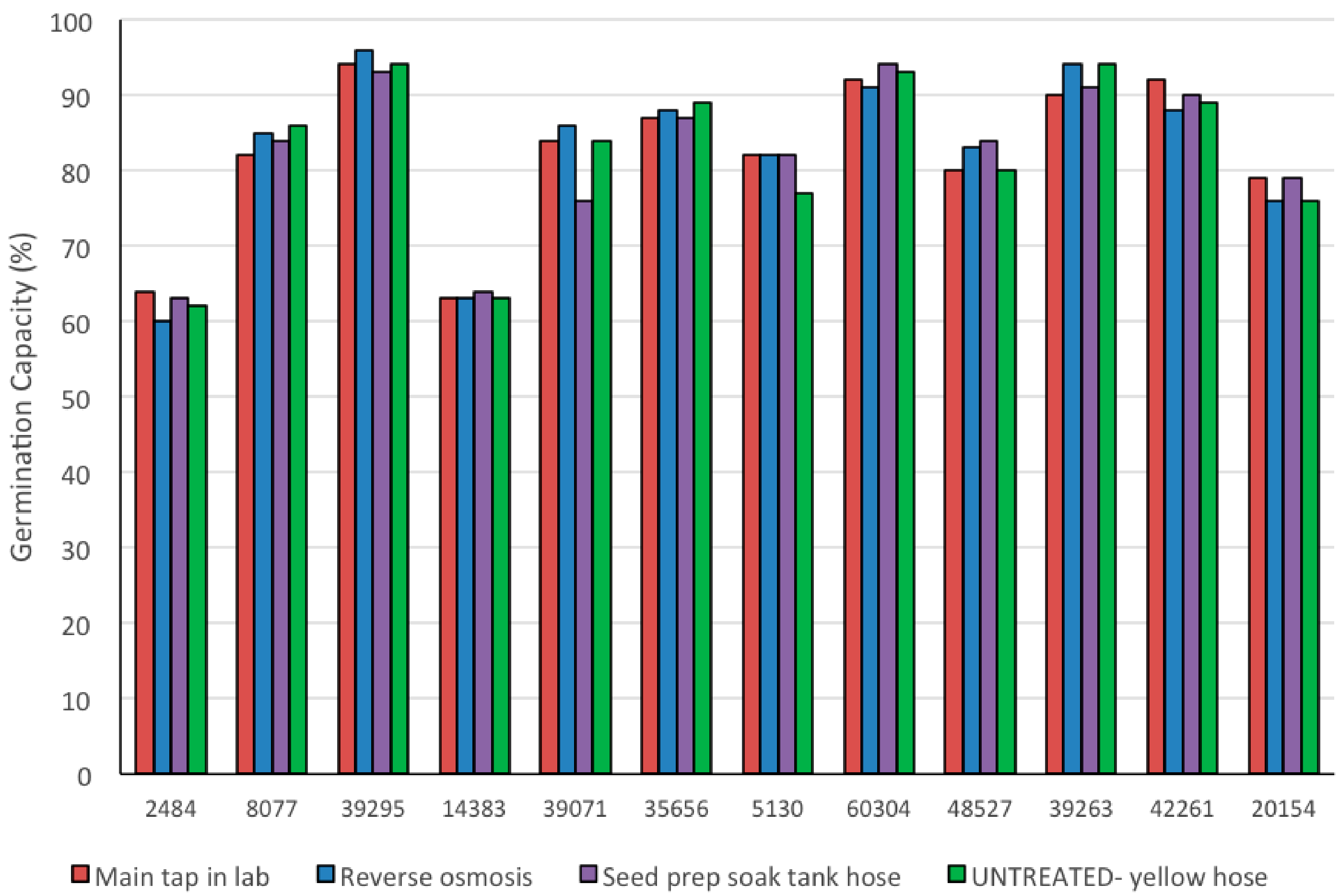

Figure 2. The germination capacity of seedlots tested with four different water sources at the Tree Seed Centre (see Table 1 above for seedlot definitions).

harmful bacteria (i.e., turbidity, low chlorine residuals). The city of Surrey conducts regular water testing across 52 test sites in accordance with the B.C. Drinking Water Protection Regulation and local results of water coming onto our site all indicate no problems with heterotrophic plate counts (tool used for monitoring general bacteriological water quality) or pH. Use of water from the lunchroom sink has been discouraged due to problems with the reverse osmosis system (inability to find replacement filters) and variability in pH. There have also been concerns with the quality of piping (non-copper) within the TSC found through repairs to non-visible components. The organic build-up found on one PVC connector may be a source of bacteria or other micro-organisms. It is uncertain whether other such components are within our walls. We will continue to supply bottled water for staff use.

There is some guidance provided by the International Seed Testing Association (ISTA) regarding water. The water should be reasonably free from organic or inorganic impurities and the pH value should be within the range of 6.0–7.5 when checked in the substrate. They do not provide other specific guidelines, but do indicate that demineralized water, deionized water, tap water and spring water are commonly used, so it's rather loose. Our current testing of water that goes through reverse osmosis is close to the lower recommended limit at some points in time (Fig. 1), so that is a definite concern as to why the water is becoming more acidic at that point. The reverse osmosis process neutralizes the water (to pH=7), but the water can become acidified by absorption of carbon dioxide which forms carbonic acid. This is often caused by use of a holding tank, but that is not our case and our lab reverse osmosis system has had its filters regularly changed (vs. the lunchroom system). We will continue to work through our 'water system', evaluate or reverse osmosis system needs, investigate water use and water recycling possibilities and would be happy to communicate with others contemplating similar operational questions.

The pH references on tree seed germination I found are included below; if you know of others, please let me know.

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Extended Interior Spruce Stratification

For the 2020 sowing season, the BC Tree Seed Centre (TSC) is implementing an extension of stratification, from three to six weeks, on all seed orchard (Class A) seedling requests for interior spruce (SX). Interior spruce is the designation used in BC to classify seedlots derived from *Picea glauca*, *Picea engelmannii* and the hybrids and back-crosses between these two species. The goal of this initiative is to increase production efficiency by increasing germination speed, vigour and germination capacity of SX seedling requests. This will also result in greater seed use efficiency (reducing the number of seeds required per seedling produced). The 5-year species germination average of seed orchard interior spruce is only 87% and nursery feedback has indicated that results have been variable. In 2019, over 97 million seedlings of orchard produced SX seedlings were grown in BC and even small gains in germination characteristics will have huge implications for seedling production.

The question of extending stratification in SX has received some research attention and all evidence supports the idea of an increase in germination speed and uniformity with increased stratification. This has implications into germination heating costs (most SX is produced in heated greenhouses), crop uniformity and decreasing the window for pests. Although more limited in available data, extended stratification can increase the vigour or ability of seed to germinate at maximum potential under suboptimal conditions (e.g. temperature). Gains in germination capacity are also expected, but the other gains are expected to be more substantial.

The most compelling argument for this change being low risk are the results of Class A SX seedlots derived from unused stratified seed returned from nurseries. This seed is not recombined back into the parent seedlot, but retested and reregistered as a new seedlot (fortunately this activity has decreased due to great efforts in fine-tuning seed needs). These returned seedlots would have received at the very least six weeks stratification (three weeks initial stratification + three weeks stratification for registration of the new seedlot) if sown immediately upon receipt and then dried back – an unlikely scenario. It is more likely that this returned seed has received several months of stratification before being dried back and retested. There are 182 'returned seed' seedlots of Class A SX. The results are very encouraging with 55% of these seedlots still exhibiting 90%+ germination (whereas the species average was only 87%!) and 94% of them above 80% germination.

We had to make the decision without many extended stratification test results to initiate this practice, but we currently have 25 of the largest and most commonly used SX seedlots with germination tests with both a three-week (test code G10) and six-week duration (code G12) of cold stratification. The results are encouraging with 23 out of the 25 seedlots performing better with extended stratification with an average gain of 2% germination. The speed of germination (peak value) also improved from 6.7 to 7.4. This is equivalent to seeing 74% vs. 67% germination at day 10 under test conditions. These are conservative estimates as for most of the seedlots, the G10 was based on an older test which is likely to have deteriorated slightly since the test date. We are continuing to expand the number of seedlots we test with extended stratification (G12) and retest with the G10 test and will provide updated results, and a more thorough review of existing literature, in a future TSWG News Bulletin.

In terms of operational implementation, all Class A SX seedling requests will receive a total of six (vs. the standard three) weeks stratification in relation to the nursery sow date. The TSC will be shipping seed after five weeks of cold stratification, which is one week before the nursery sow date. There will be an additional monitoring step invoked at the TSC for this extended stratification. In some seedlots the germination increase has been as much as 8% and there is the need for gram adjustments before seed withdrawal. Additional quality monitoring is also being conducted and we are encouraging nurseries to provide feedback on this new extended stratification program. It is a year of learning and fine-tuning the logistics involved. I strongly believe that this practice will increase the efficiency of Class A SX seedling production in BC.

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National Tree Seed Centre Update

2019 marked Year 1 of 'Putting the National' back into Canada's National Tree Seed Centre (NTSC). Looking back, it really was a busy and eventful year. We feel that headway in three main areas highlight the year in review: visibility, addressing research program needs, and collections.

Visibility of the NTSC

A strong effort to get out to meet collaborators resulted in 36 tours and presentations in seven provinces. Additionally, a presentation and collaborative discussion took place with the U.S. Department of Agriculture's Genetic Resources Preservation Facility in Fort Collins, Colorado. In-person collaborative talks took place with six provincially-run seed centres, with the emphasis on the NTSC's role as a backup to the province's conservation collection. Initial discussions on the storage of seed of all Canadian tree and shrubs on an ecodistrict level as a back up for unknown future threats were entertained. In regions where collections are not being made, how can we work together to resolve this?

Opportunities to speak to young foresters featured lectures at three schools offering forestry programs (Lakehead University, University of New Brunswick, and the Community College environmental and forest tech program in Bridgewater, Nova Scotia).

Collaborative talks with National Parks in eight provinces focused on species of concern and conservation of rare genetic resources through long-term seed and germplasm storage at NTSC. Provincial Parks in five eastern provinces were also involved in the NTSC's largest response to expanding invasive pest in the region, Emerald Ash Borer and Hemlock Woolly Adelgid.

With support from the communications team at CFS Atlantic, the NTSC conducted 10 media interviews resulting in stories that were published at least 132 times coast to coast (Fig. 1). Eight interviews focused on what the NTSC and collaborators are doing to mitigate invasive pest effects, through long-term seed longevity to maintain genetic diversity of many species and populations threatened. Active restoration will be needed at some point and in general, industry is not focused or interested in some of these ecologically important species or habitats.

The NTSC also hosted five individuals for week-long training in seed processing and storage techniques (Fig. 2), as well as providing seed collection training in the field for over 25 individuals including First Nations and provincial technicians.

Addressing Forest Research and Canadian Forest Service Programs' Need for Seed

In 2019, the NTSC supported 50 seed requests to researchers in Canada (nine provinces), the USA (two states) and Portugal. Over 6.5 million seeds from 520 source-identified and quality-tested seedlots representing 60 species were provided free of charge. All requests stipulate "we kindly request recognition of the in-kind support the National Tree Seed Centre (NTSC) is providing by filling this request in project proposals, presentations, reports and publications. A copy of (or links to) results, reports or publications from research using seed provided by the NTSC is requested and will be captured in our seed lot database and promoted as part of our Open Science Initiative."

Canadian Forest Service research programs 2015–2019 supported through seed requests include Sustainable Forest Management, Cumulative Effects, Forest Climate Change, Pest Risk Management, Urban Forestry, Wildfire Risk Management and general Education programs (Fig. 3). The NTSC is also initiating a four-year study looking into seed supply issues in Canada. TSWG Editor, Melissa Spearing joined the NTSC staff on loan from the FGCA in Ontario to help scope what this project should entail. How do we address diverse seed and knowledge extension needs nation-wide, across all forest seed-related programs (from anticipating climate change to urban forestry to land reclamation to industrial forestry and everything in between)? We will be reaching out to many of you in the near future, as this is a topic many countries are preparing for new challenges facing seed supply (Bozzano et al 2014, Jalonen et al 2018, Jansen et al 2019, Hancock et al 2020, Oldfield 2019, Whittet et al 2016) with the help of regional expertise.

New Collections

2019 collections were dictated by urgencies to conserve representative population genetics due to invasive pests. Due to the progressive nature of Emerald Ash Borer spread in Central and Atlantic Canada, 2019 resulted in the largest seed and DNA collections effort the NTSC has spearheaded for ash (*Fraxinus* spp.) since initiating the program in 2004. Coinciding with federal listing by COSEWIC as a threatened species of important cultural value, 2019 was a rare once-every-five-to-seven bumper crop year for black ash seed production throughout its range in Ontario, western Quebec, eastern Manitoba and New Brunswick. 648 black ash collections now held at NTSC cover a large proportion of its Canadian range (Fig. 4).

609 single tree ash collections were made in a five-week collection window by NTSC staff, and assistance from 34 private collectors and three partnering agencies in Ontario – the Forest Gene Conservation Association, Superior-Woods Tree Improvement Association and the Invasive Species Centre. This included 380 *Fraxinus nigra*, 210 *Fraxinus americana* and 19 *Fraxinus pennsylvanica* collections. Resulting from seven of the aforementioned public and social media efforts, NTSC received over 1,100 emails and

Figure 1. A retweeted Atlantic CTV News article by Kawartha Conservation in Central Ontario, to boost awareness and facilitate ash seed collection opportunities (*Fraxinus* spp.).

Figure 2. December 2019 team photo with the NTSC crew and visiting technicians, from left to right in front: Donnie McPhee (NTSC Coordinator), Melissa Spearing (Seed Biologist), Jessica Hudson (Land Reclamation Technician, CFS Northern Forestry Centre, Edmonton), Sarah Adams (Seed Bank Technician, Acadian University, Nova Scotia), Katherine Burgess (NTSC Seed Testing Technician), Rachel Henry-Smith (NTSC Technician) and Dibaba Ekangyela (NTSC Technician). Left to right in the back, Peter Moreland (NTSC Senior Technician), and Cole McComber and Kenneth Canadian (Kahnawá:ke First Nation, Quebec).

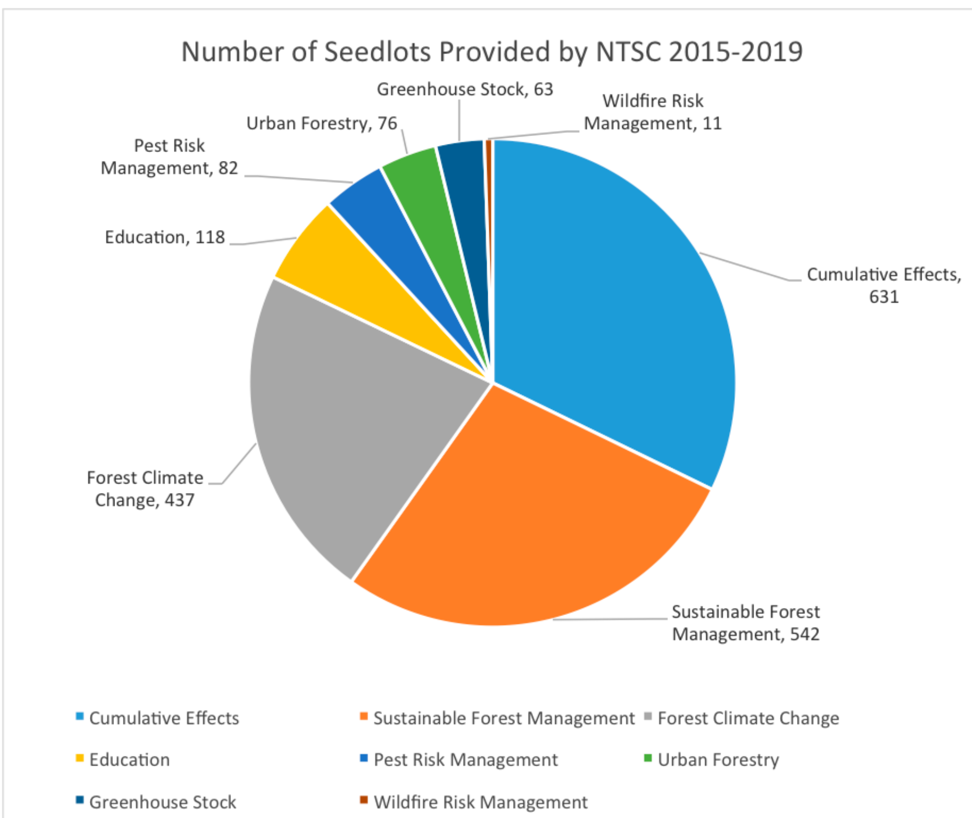

Figure 3. Number of seedlot requests provided by the NTSC for Canadian Forest Service Research Programs 2015–2019. Estimated value at $980,000 ($500/seedlot).

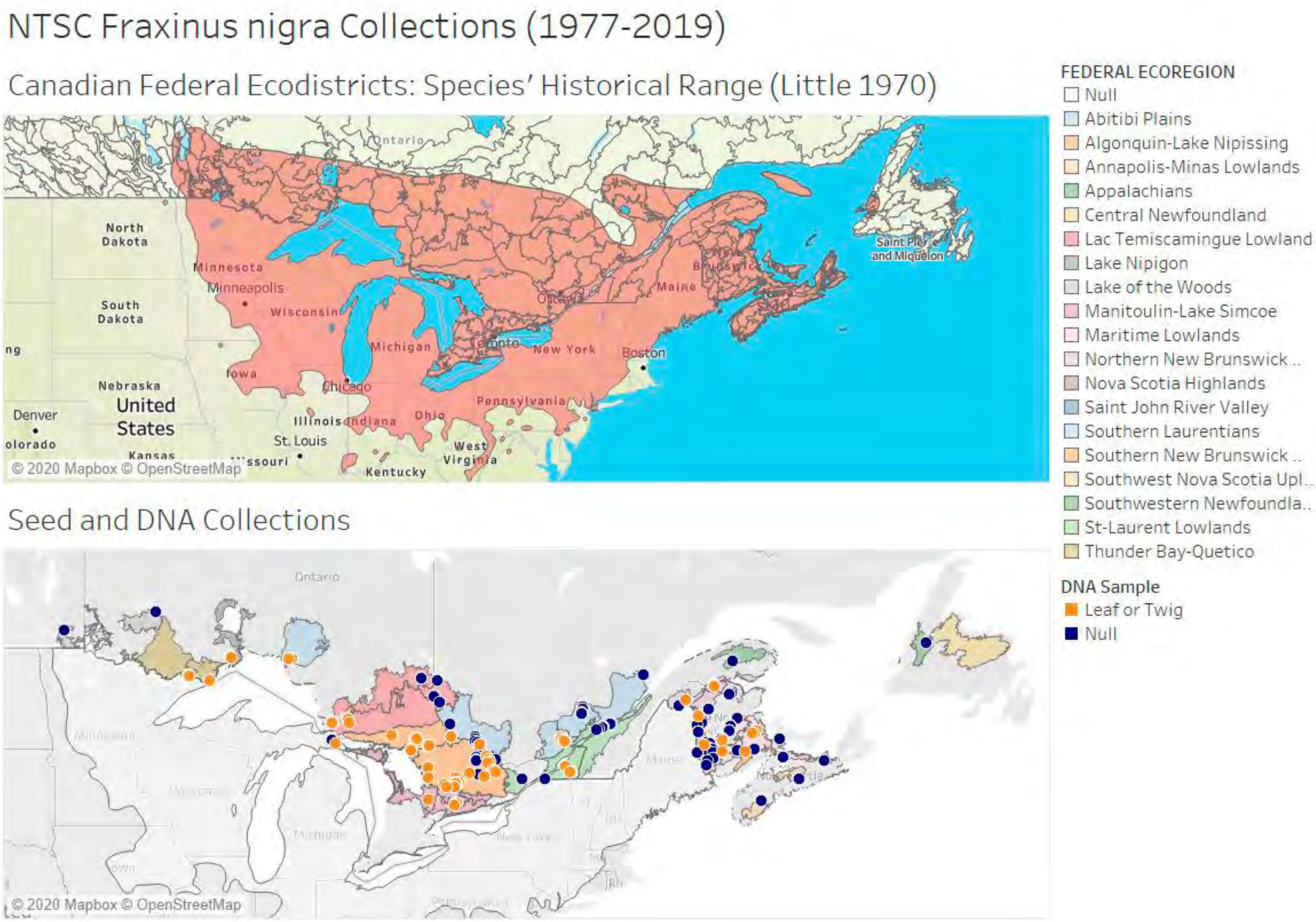

Figure 4. A Tableau dashboard indicates the historical range of black ash (*Fraxinus nigra*) to assess 1977–2019 ex situ Canadian collections by Canadian ecoregions and ecodistricts. Null indicates GPS collections with seed, but not DNA tissues.

250 calls, all responded to and the most promising ones followed up on. While volunteers and private collectors were responsible for only 20% of the collecting, they did account for ground truthing close to 70% of the sites and in gathering vital information and permission to access sites for the NTSC staff.

NTSC also collected or acquired new collections of other Species at Risk or of CONFORGEN concern:

- *Tsuga canadensis* (eastern hemlock, 27 collections from areas impacted or soon to be impacted by hemlock woolly adelgid in Nova Scotia, see Emilson et al 2018)
- *Pinus flexilis* (4 collections from Alberta)
- *Magnolia acuminata* (13 intra-situ collections from the University of Guelph Arboretum's Rare Woody Plants Gene Bank, largest collection NTSC has ever received)
- *Liriodendron tulipifera* (14 intra-situ collections, also from University of Guelph Arboretum)
- *Lechia maritima* var. *subcylindrica* (herbaceous coastal dune species, federal SARA listed) (6 populations)
- *Juglans cinerea* sample from NB

Additional seed donations were received from Department of Indigenous and Northern Affairs Canada, Parks Canada, the Alberta Tree Improvement and Seed Centre, Prince Edward Island Provincial Seed Centre and from the now-closed Ontario Tree Seed Plant. With the closure of the Ontario seed bank, the NTSC also entered an MOU to store first generation clonal white pine seed lots for the Forest Gene Conservation Association and its members.

Successful proposals to three main Canadian Forest Service (CFS) programs – Sustainable Forest Management (SFM), Cumulative Effects (CE) and the Canadian Wood Fiber Centre (CWFC) – along with substantial assistance from the CFS Atlantic Forestry Centre (AFC) management committee provided the funding needed for success. NTSC was able to hire seven additional casual employees to assist the existing staff of three full time NTSC employees.

Due to COVID-19, 2020-21 will certainly have its challenges compared to typical field seasons! However, with strong collaborative relations and input from you, the NTSC plans to lay out a long-term strategy for success, meeting the needs of our users and conserving the genetic diversity of our forests for future generations.

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Eastern White Cedar Seed Storage Experiment

Eastern white cedar (*Thuja occidentalis*) is common in New Brunswick, Québec, and Ontario but can also be found in parts of Nova Scotia and Prince Edward Island. The species is listed as vulnerable in Nova Scotia.

Seed measure 3–5 mm in length and have lateral wings making the seed almost as wide as it is long (Brand and Schopmeyer 2008). Thousand seed weight varies between 0.75 and 1.50 grams. The seed cannot be de-winged and the light seed weight and the attached wing make it difficult to remove empty seed by aspiration. Consequently, seed germination is often mediocre unless very good pollination occurs.

Seed do not require moist chilling (ISTA 2012, AOSA 2002) however; there has been some debate in the literature (Brand and Schopmeyer 2008). Simpson and Daigle (2012) demonstrated that chilling did not substantially improve germination but increased germination speed. The seed are considered orthodox and can therefore be dried and stored in sub-zero conditions. There is uncertainty as to how long *Thuja* seed can be stored and retain viability. Seed should retain viability for up to five years if stored in sealed containers at 0 to 5°C and at a moisture content of 5–10% (Bonner 1991). Seed kept for longer durations should be stored at –18°C (Brand and Schopmeyer 2008). Mean germination of three eastern white cedar seedlots stored at –20°C at the National Tree Seed Centre (NTSC) was 60% after collection, 48% after 11 years and 17% after 21 years. In contrast, four different seedlots collected in a different year had mean germination of 72% after collection, 73% after 10 years and 38% after 20 years. Three seedlots of western red cedar (*Thuja plicata*) stored at –18°C for 24 years germinated between 65% and 80% (Kolotelo 2001).

In 2006, the NTSC received 15 single tree collections of eastern white cedar cones from the Petawawa Research Forest, Ontario. The seed were processed and moisture content and germination were determined. Seed quality was very good and the quantity of seed received provided an excellent opportunity to set up a seed storage experiment. Results after one, two, four and nine years in storage are reported here from a storage trial established at the NTSC.

Material and Methods

Seed from 12 trees were put in 20 ml screw cap plastic vials and placed in Mason jars (250 ml), each containing four vials. The jars were placed in storage at 4°C and –20°C. Seed was also put in 10 ml screw cap cryogenic vials for storage in liquid nitrogen at –196°C. Sufficient seed was stored for germination and moisture content assessments at 1, 2, 4, 8, 16, and 32 years.

At the end of each storage duration (the eight year duration was conducted at year nine), jars were removed from –20°C storage and placed at 4°C for 24 hours. These jars and the ones stored at 4°C were then removed and allowed to warm to room temperature before being opened. For the samples stored in liquid nitrogen a cryo box was removed and placed at –20°C for 24 hours then 4°C for 24 hours and finally moved to room temperature. There was no four year cryogenic storage time point because the cryo box could not be located in the liquid nitrogen tank.

Moisture content (MC) was determined by the oven method using 0.5 to 1.0 grams of seed for each of two replicates. Germination tests were set up by placing four replicates of 50 seed each on moistened Versa-Pak™ in Petawawa Germination Boxes. The boxes were put into a Conviron G30 germination cabinet for 21 days. Germination conditions consisted of a daily cycle of 8 hours at 30°C with light and 16 hours at 20°C without light with a constant relative humidity of 85%. Seed were assessed every two days starting at day nine. A seed was considered to have germinated when the cotyledons were visible and the hypocotyl and radicle were well developed.

Table 1. Mean moisture content (%) of 12 eastern white cedar seedlots before storage and after four periods in storage at 4°C, –20°C and –196°C.

	Time in Storage (Years)				
Storage Temperature	Before storage	1	2	4	9
4°C	6.5	7.6	7.8	6.7	8.9
–20°C	6.5	6.1	6.1	6.3	6.3
–196°C	6.5	6.2	6.2	—	6.0

Results and Discussion

Mean MC of the 12 seedlots at the time of storage was 6.5% (Table 1). The MC of seed stored at 4°C was substantially higher after one, two and nine years in storage while after storage for four years the value was only slightly higher than before storage. The increase in mean MC of seed stored for one, two and nine years was due to an increase for four, three and four seedlots, respectively that were stored together in the same Mason jar at each of the storage durations. It is possible that the lids on these Mason jars were not completely tight allowing moisture from the air in the cooler to infiltrate the jars and then to enter the storage vials. MC of seed stored at –20°C was less than the initial value for each of the four storage durations but exhibited an increase to four years but stabilized after nine years. MC of seed stored at –196°C was lower after one and two years storage and decreased more after nine years in storage.

Seed germination declined with time in storage with the greatest decline occurring for seed stored at 4°C where germination had decreased by 80% after nine years in storage (Fig. 1). Only three seedlots had germination greater than 0.5% (13.5% to 28.5%). After nine years in storage seed stored at –20°C exhibited a decline in germination by 17%. In contrast seed stored at –196°C declined in germination by just over 7% after nine years in storage. This illustrates that eastern white cedar seed is very tolerant of storage in liquid nitrogen. Storing seed from a number of individual tree collections allows for the evaluation of the contribution of genetics from the maternal parent to the storage ability of seed. Two seedlots that had the lowest germination at the beginning tended to also have the lowest germination at each time point. Seedlots that had the highest germination at the beginning tended to have the highest germination at each time point when stored at –20°C and –196°C.

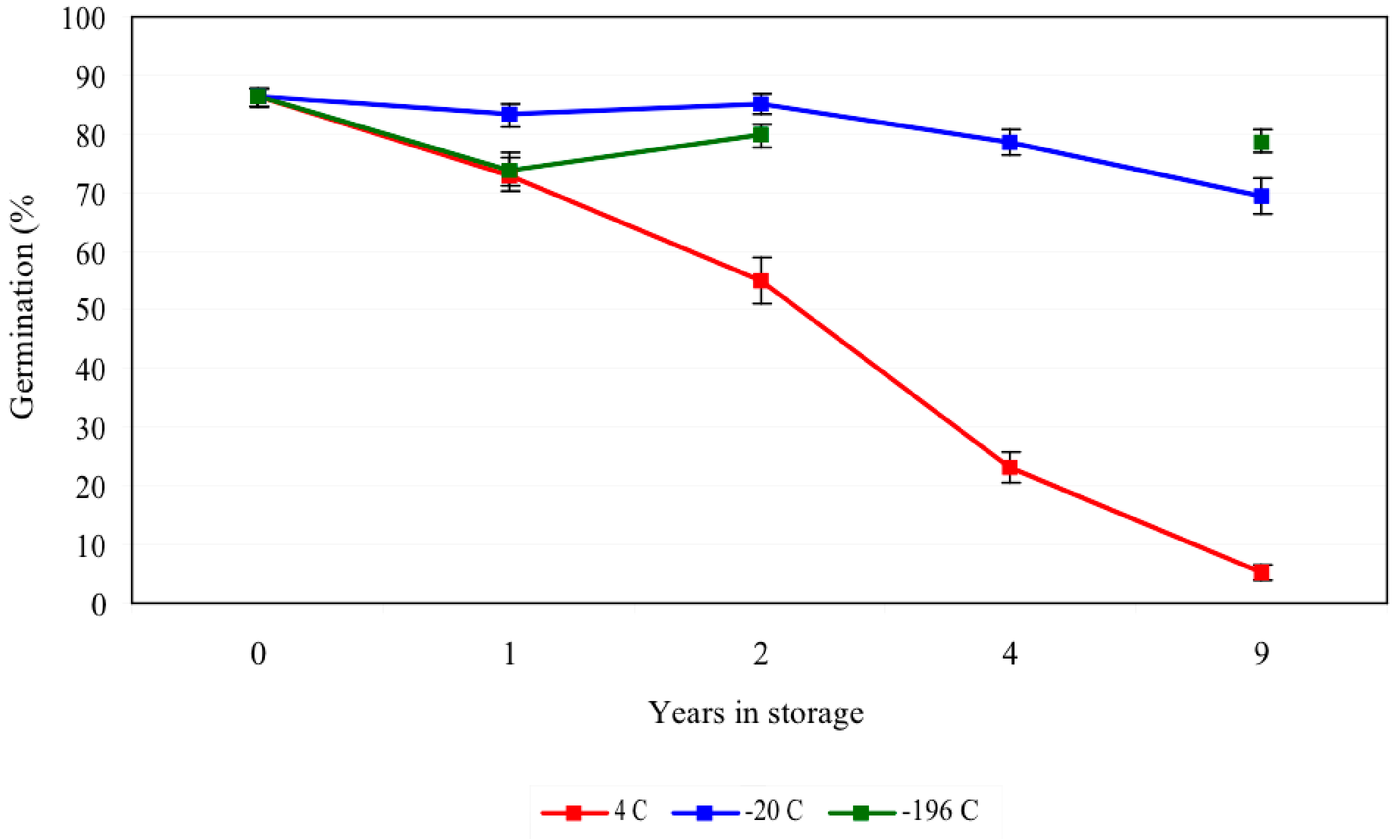

Figure 1. Mean germination over nine years of 12 eastern white cedar seedlots stored at 4°C, –20°C and –196°C.

Table 2. Mean low vigor germination (%) of 12 eastern white cedar seedlots before storage and after four periods in storage at 4°C, –20°C and –196°C.

	Time in Storage (Years)				
Storage Temperature	Before storage	1	2	4	9
4°C	1.3	5.9	9.9	14.8*	15.3**
–20°C	1.3	3.6	2.7	2.6	9.3
–196°C	1.3	6.3	2.7	—	4.8

* includes only 11 seedlots with germinated seed
** includes only 6 seedlots with germinated seed

Table 3. Mean germination time (days) of 12 eastern white cedar seedlots before storage and after four periods in storage at 4°C, –20°C and –196°C.

	Time in Storage (Years)				
Storage Temperature	Before storage	1	2	4	9
4°C	14.9	17.0	17.8	17.3	18.1
–20°C	14.9	16.7	16.6	16.3	17.4
–196°C	14.9	17.1	16.9	—	16.8

The number of low vigor germinants was recorded. A low vigor germinant was one that the cotyledons were not visible or the hypocotyl was not well developed or the radicle was poorly developed. Low vigor germination is a good indicator of decline for a seedlot. The proportion of low vigor germinants was highest after nine years of storage (Table 2). Seed stored at 4°C had the highest proportion of low vigor germinants. The proportion was lower for seed stored at -20°C and –196°C but it still increased over time. Seed stored at –196°C had the lowest number of low vigor germinants; about half that of seed stored at –20°C.

Germination speed is another indicator of seed health and vigor. Mean germination time (MGT) was calculated for each storage temperature and storage duration. Again, seed stored at 4°C had the higher values indicating that seed required longer durations to complete germination (Table 3). After nine years seed stored at –196°C had the lowest MGT, indicating that it still had high vigor albeit lower than before storage.

Conclusions

Eastern white cedar seed exhibit orthodox storage behaviour demonstrated by their ability to germinate after being dried to less than 7% moisture content and placed in –20°C and –196°C storage. Germination of seed stored at –20°C declined by 17% after nine years whereas seed stored at –196°C only declined by 7%. Seed do not store well at 4°C as was evidenced by a steady decline in germination after one year in storage and a steady increase in the proportion of low vigor germinants. Based on the results to date from this storage trial genetically valuable eastern white cedar seed should be stored in liquid nitrogen to maximize its long-term viability.

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Tree Improvement in Atlantic Canada – Over 40 Years and Going Strong

Recently, discussions have been underway in Atlantic Canada around better integrating tree improvement efforts across New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland and Labrador. The motivation across agencies is severalfold - to streamline progeny testing efforts, share resources for data analysis and integration of genomics and to enhance efforts around adaptation to climate change. Representatives from Provincial governments, industry and Natural Resources Canada met in February, 2020 and the meeting began with a reflection back on the evolution and progress in tree improvement. Melissa Spearing thought this might be of interest to readers of the Tree Seed Bulletin.

Work in the Atlantic region began in the late 1950's through the seed source testing efforts of Mr. Mark Holst and Mr.

George MacGillivray of the Federal Department of Forestry and Rural Development. Some of their early provenance tests still exist and have been recently re-measured. Dr. Don Fowler came on the scene in the mid-1960's and others including Drs. M. Khalil and P. Hall began work in Newfoundland and Labrador with the Canadian Forestry Service (CFS). By the mid-1970's tree planting for reforestation was expanding and thereafter, interest in operational tree improvement programs began. Tree improvement programs were underway in NB (New Brunswick Tree Improvement Council), NS (Nova Scotia Tree Improvement Working Group) and PEI between 1976 and 1979 with Don Fowler providing recommendations. Mr. Jim Coles was appointed by CFS to act as technical coordinator. The NB and NS members included the Provincial governments, industry and CFS with PEI tree improvement personnel being invited to attend meetings of both programs. Formal tree improvement efforts got underway in Newfoundland and Labrador in the early 1980's. The impetus for starting tree improvement efforts was captured well in a quote from the Hon. R.C. Boudreau of New Brunswick at the Federal-Provincial Meeting of Forest Ministers in 1977: "*If the existing industrial base was to be maintained and timber made available with the increased consumption required for modernization, then the Province had to embark on a more intensive forestry development program*". While forest management objectives are far more complex in 2020, the same rationale is applicable today.

Substantial financial resources were available in the 1970's and 80's through Federal/Provincial Agreement Funding and the CFS provided scientific guidance and in some cases, coordination of tree improvement efforts. Drs. Don Fowler and Yill Sung Park, along with Mr. Dale Simpson and Dr. R. Smith were heavily involved for many years. Don Fowler released 'Strategies for the Genetic Improvement of Important Tree Species in the Maritimes' (1986). This was adopted across the Atlantic region with updates and modifications over time. There was also an educational component of tree improvement introduced with the hiring of Dr. Kris Morgenstern as an industrial research chair at the University of New Brunswick. Kris trained undergraduates and graduate students for many years, providing a new generation of tree improvement practitioners.

By the 1990's seed orchards were beginning to provide significant amounts of seed for a number of species. The species across the region in improvement programs include white spruce, black spruce, red spruce, Norway spruce, jack pine, white pine and eastern larch. All four Atlantic provinces have continued to conduct scale-appropriate tree improvement. For several species, most seed requirements are met with second generation orchard seed that is expected to yield growth gains of 25%, along with improvement in form and adaptability. At least 750 million improved seedlings have been planted across the region in the last 40 years. For illustration purposes only to provide a sense of scale, 750 million seedlings would plant approximately 340,000 hectares. If we used a very conservative estimate of 220 m^3/ha for expected volume production at rotation age for unimproved stock and a 10% conservative volume gain, this would be equivalent to over 7 million m^3 of incremental wood volume produced as a result of tree improvement. Using another conservative estimate of wood value at \$15/m^3 as a blended stumpage rate, this would be equivalent to over \$100 million. Of course, determining actual gains is much more complex but this calculation serves to demonstrate the significant benefit of 40 years of tree improvement and new benefits accrue with every tree planted into the future.

Coming decades will bring new challenges including climate change, shifting insect and disease dynamics and even changing product goals but the long-term field-testing efforts in the past and future will provide a critical resource for adapting to new conditions. New technologies such as genomic selection offer promise to make testing more efficient and timelier, as well as provide information on hard to measure traits like wood properties. Tree improvement in Atlantic Canada has been a hugely successful study in persistent, collaborative efforts among the provincial and federal governments and industry for over 40 years and one for which the region should be proud.

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2019 CFGA Tree Seed Workshop

In conjunction with our renewed Membership survey and the 36th meeting of the Canadian Forest Genetics Association (CFGA) in Lac Delage, Quebec, the Tree Seed Working Group (TSWG) held a half-day workshop. The theme of the workshop was "*To reaffirm the importance of cone and seed service activities and identify knowledge gaps*". The reality is that cone and seed services across Canada are at stake. We have recently seen the closure of the Ontario Tree Seed Plant, Manitoba's Pineland Nursery and cone processing facility, and various nurseries with seed collection, processing and distribution capacity throughout North America. In 2018, British Columbia had a bumper crop for most species, processed primarily at the provincial facility. The last time we had a crop that size, we had four cone processing facilities operating in BC.

43 members of the TSWG readership responded to our needs survey prior to the workshop; 13 from the US, 8 federal Canadian scientists, 10 from British Columbia, 4 each from Ontario and Quebec, 2 from Alberta and 1 each from New Brunswick and Prince Edward Island. Though far from the 104 respondents in Ben Wang's initial survey, responses ranked their current seed-related issues from 25 general topics. The highest priority needs were (in order):

- Cone and seed collectors: efficiency, shortages, training
- Upgrading seed storage protocols and practices
- Insect pests affecting crops
- Tree seed diversity in practice (variability, predictability)
- Seed orchard management
- Seed germination and viability

Secondary priorities included understanding reproductive biology, seed crop diseases, seed maturity indices, seed and cone yield analysis, and lack of post-secondary education on seed for those entering this specialized workforce. Low priority issues were techniques only a few agencies can afford, but could improve all of the above, including water activity tools, better data management systems and seed pelleting.

We see a time of rapid succession as the baby boomers retire, and their experience, knowledge and wisdom of these highly efficient and still-relevant services are going with them. There are reduced resources dedicated to reproductive biology, collection management and seed treatment in all Canadian provinces. This focus is in glowing contrast to the levels of funding allocated to selection with genomics tools, yet the integration of these tools still requires cones to be

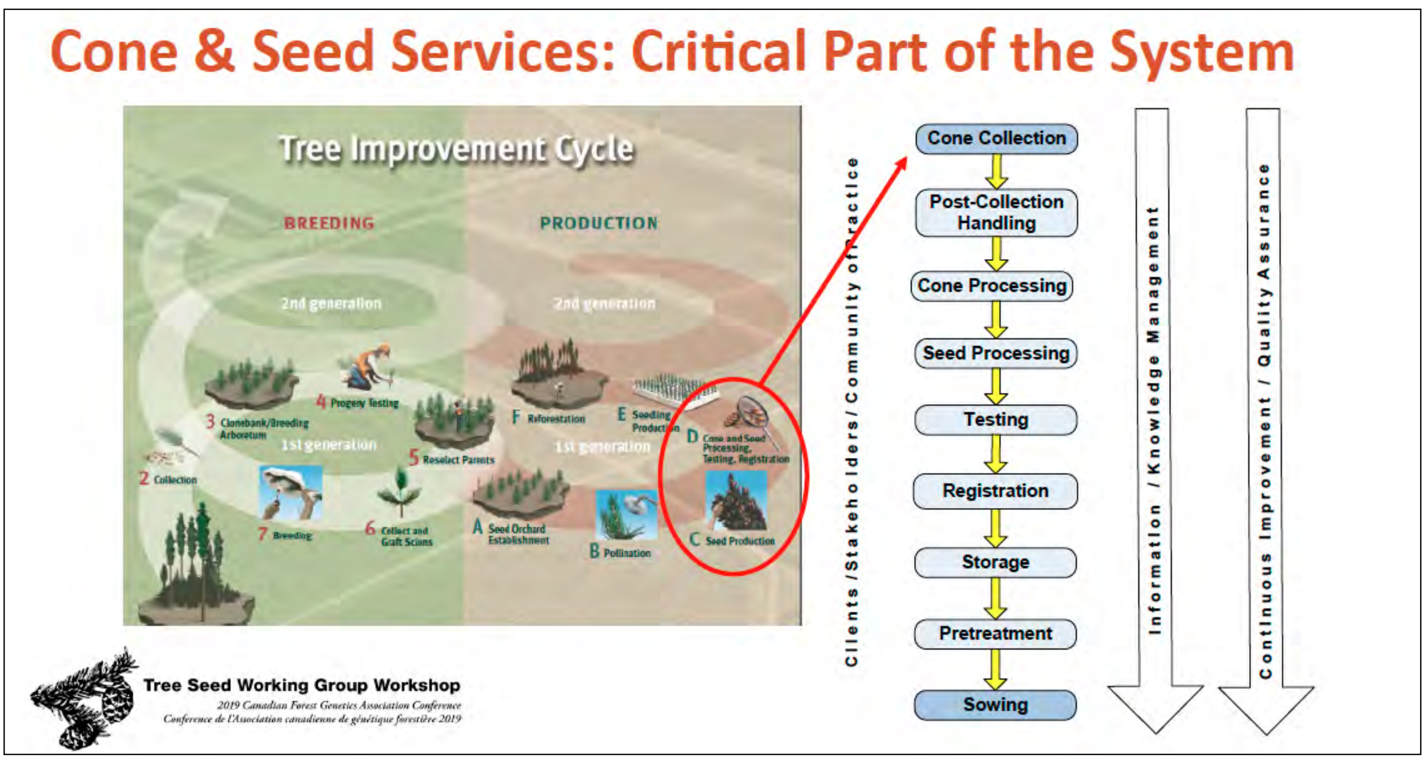

Figure 1. A slide from the Tree Seed Working Group Workshop illustrating the tree improvement delivery system.

collected and processed, seed stored and prepared for nursery sowing. There is a general lack of understanding regarding the capacity of the "*tree improvement delivery SYSTEM*"; mainly that shortening the time to perform selection does not necessarily make the entire system more efficient if the foundational elements are not supported to deliver them (Fig. 1). We should be prioritizing our bottlenecks (problems and information needs) and selecting the appropriate tool; in contrast, it often seems like we are looking for problems for our most sophisticated tools. The reality is that with skilled personnel requirements, highly variable crops, and significant capital funding required to establish a processing facility, it does not make a good business case to establish a cone/seed processing and storage facility today – the provincial governments should be intimately involved.

During the August 19th afternoon session, Dave Kolotelo, Fabienne Colas and Melissa Spearing each presented on two different themes:

- Cone crop development and collection
- Cone crop challenges
- Genetic conservation
- Appropriate facilities and expertise
- Storage, testing and seed preparation
- New tools

Canada needs good quantity, quality and diversity in the supply of seeds to deliver future forests. These subjects were the main focus of our presentation and remain areas in need of additional research/extension and continued education. The full-length workshop and condensed summary presentation can be found here.

Our editor recorded a Youtube video of the Summary presentation below:

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November 2019 Whitebark and Limber Pine Seed Orchard Meeting Summary

In November, Parks Canada hosted an inter-agency whitebark and limber pine seed orchard workshop in Revelstoke, BC. The workshop brought together 30 participants from the provinces of BC and Alberta, the Calgary Zoo, BC Parks, the Nature Conservancy of Canada, the National Tree Seed Centre, the Whitebark Pine Ecosystem Foundation and the Mountain National Parks to collaborate on how to collectively improve our ability to get blister-rust resistant seedlings out on the landscape. Two presenters also phoned in from the Dorena Genetic Resource Centre in Oregon to provide a perspective on lessons learned in the USA.

The participants shared information and updates from their respective agencies including background on seed orchards in BC, clone banks, and the need for ex-situ conservation. Discussions focused on genetic conservation goals, priority seed collection areas, climate based seed transfer and seed orchard site selection criteria. Participants were also asked to contribute suggestions for potential orchard locations, which were then reviewed as a group. A working group is being established to secure funding and tackle the next steps for establishing whitebark and limber pine clone banks and seeds orchards in Canada. We are fortunate to have so many knowledgeable partners to tackle a shared conservation priority.

For those interested, a Google Drive was set up to facilitate sharing of presentations and seed orchard characteristics from the US program: https://drive.google.com/drive/folders/1K1Mt8yADYMl5ataudITh3jUFwR-akbN9

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Mount Newton Seed Orchard Celebrates 40 Years

Mosaic Forest Management's Mount Newton Seed Orchard recently celebrated its 40th anniversary in September 2019, along with the achievement of having produced enough seed for 250 million potential seedlings!

The Mount Newton Seed Orchard has nine orchards, 6,000 seed trees (and growing), four coastal tree species, three full-time staff and up to 20 seasonal workers. It is a foundational component of Mosaic's commitment to sustainable forestry by ensuring seedlings are grown from the best possible seed today to ensure the health and resiliency of future forests, and ultimately the quality of the product produced for customers.

Douglas-fir (*Pseudotsuga menziesii*) is the mainstay of the orchard production, followed by western red cedar (*Thuja plicata*). A small component of western hemlock (*Tsuga heterophylla*) is kept in the orchard, and a western white pine (*Pinus monticola*) block was recently added; this block is expected to produce its first crop of seed in 2020.

The orchard is currently expanding its production to meet the seed needs of both TimberWest and Island Timberlands land bases, which are managed by Mosaic. The target is to increase Douglas-fir seed production from eight million potential seedlings today to 12 million over 10 years. Mt. Newton also provides seed to other coastal seed users. A key focus–and delicate balance–in the expansion is increasing genetic gain at the same time as increasing production.

The success of the orchard is a testament to the longevity and strength of the provincial Forest Genetics Program and the history of collaboration between industry and government in all aspects of tree improvement.

The celebration day itself allowed past and present foresters, managers and colleagues to come together, and reflect on the past, present and future of strong, healthy, resilient BC forests.

Guests enjoy a guided tour of the Mount Newton Seed Orchard, which recently celebrated its 40th anniversary.

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Graduate Research Survey: Native Seed Use Concepts

As a graduate student in the Sustainability Studies program at Trent University, my research focuses on the sustainability of ecological restoration projects. I have chosen to investigate the intersection of native seed production, community consultation and aggregate reclamation in Southern Ontario.

There are thousands of quarries needing reclamation in Ontario, many of them are abandoned making them a unique challenge to reclaim. Innovations in quarry reclamation have re-imagined these previously derelict spaces as opportunities to fulfill contemporary landscape needs; recent projects have involved fruit tree production, botanical gardens, aquaculture, and habitat development for at risk species. It makes sense then, that they could fulfill the increasingly pressing need for native seed in Ontario!

The objective of my research is to investigate if some quarry environments in Southern Ontario can support native seed production and improve the genetic quality and quantity of seeds available for native plant restoration projects. This project will involve working together with local communities and native plant growers to assess the regional seed needs and collaborating with supporting agencies to provide equipment and expertise. Some of the challenges associated with the project include building soil productive enough to support plant growth and ensuring the seeds produced represent the best genetic profile possible.

I have undertaken this research project because after working for several years in post-mining vegetation reclamation I have become poignantly aware of the huge deficit in the supply of appropriate seeds available for reclamation projects. My hope is that this project can provide a model for community consultation and seed orchard establishment in quarry environments. I look forward to contributing to research that works toward increasing access to genetically diverse, appropriate native seed for restoration practitioners, seed banks and community members.

I am seeking to survey restoration practitioners and those supplying seed to Ontario mining reclamation projects this summer. Two links are provided, Part 1 for consent and Part 2 with my research questions.

Part 1: https://www.surveymonkey.com/r/J3QD2CD

Part 2 : https://www.surveymonkey.com/r/QR68VM2

Thank you.

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Upcoming Meetings

Most major meetings have been postponed due to the COVID-19 pandemic, worldwide, at the time of publication. If you have digital conferences or forums planned dedicated to tree seed before the end of the year, please let us know for the next issue.

Recent Publications

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