



Tree Seed Working Group News Bulletin

Canadian Forest Genetics Association
L'Association canadienne de génétique forestière

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Featured in this Issue:

- 4 Cone Moisture Content Monitoring Continued
- 8 Direct Seeding of Scots Pine is a Popular Forest Regeneration Method in Finland
- 12 Frozen Storage May Affect Dormancy of Eastern White Pine Seed
- 15 Mechanical Pruning Large Orchard Ramets
- 17 Long-term Storage and Recovery of Butternut in New Brunswick
- 20 Tree Seed Testing Overview
- 22 ATISC Seed Conservation Course
- 22 Upcoming Meetings
- 22 Recent Publications

Armchair Report #64

Hello and happy holidays to everyone—seems like there is a lot of news to share, so here we go. My highest priority is full of mixed feelings as this will be the last edition of the News Bulletin that Dale Simpson will officially be involved with. Dale plans to retire at the end of March 2017 and he deserves a big thank you for all his efforts with the Tree Seed Working Group and the CTIA/CFGA organization in general. I have known Dale since 1984 and our relationship has changed greatly since I was pinning plus tree locations on the big map for the NB Tree Improvement Council (when I had some extra time from my summer job at the old CFS laboratory in Fredericton). I have greatly appreciated my friendship and working relationship with Dale and I wish him the very best in his retirement.

I would like to highlight a few of Dale's contributions. He has been the editor of our News Bulletin since November 2002 (Issue no. 36) and therefore will have left his imprint on 28 News Bulletins. He assisted in organizing most of our biennial workshops and migrated the News Bulletin to an electronic format which reduced cost and allowed us to get a bit more colourful. Dale has also served as the Executive Secretary of the CTIA/CFGA organization since 1998 keeping some consistency to the Association and meetings that move across the country. He was often the only one that had a firm handle on our by-laws and the process of our business meetings. The truly unglorified contribution has been the large job of editing our conference proceedings since 1998 which saw a change from two to one volume and a name change from CTIA to CFGA. I've always been impressed by Dale's ability to span the gamut from the utterly practical acts of collecting seeds to being able to contribute at the highly technical level on a variety of topics. Thank you for all your contributions—you will be missed, but certainly not forgotten.

Banner photo by Melissa Spearing. Black spruce (*Picea mariana*) seedlot in storage at the National Tree Seed Centre.

CFGA Tree Seed Working Group

Chairperson

Dave Kolotelo
British Columbia Ministry of Forests,
Lands and Natural Resource Operations
Tree Seed Centre
18793 – 32nd Avenue
Surrey, BC V3Z 1A5
Tel: (604) 541-1683 x2228
Fax: (604) 541-1685
Email: Dave.Kolotelo@gov.bc.ca

News Bulletin Editor

Melissa Spearing
Forest Gene Conservation Association of
Ontario, Assistant Coordinator
1393 Hwy 7A
Bethany, ON L0A 1A0
Tel: (416) 909-9755
Email: shadyideatrees@gmail.com

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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 at: goo.gl/p4VQAX

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.

A little bit closer to home, we have had some significant changes in the BC forest genetics community. Jack Woods, who helped develop and spearhead our Forest Genetics Council (FGC) “officially” retired at the end of October, but will continue part-time until the new FGC Program Manager/Select Seed CEO gets up to speed. His replacement is very familiar with the workings of the FGC, most recently serving as FGC co-chair and Director of our Tree Improvement Branch (TIB). Brian Barber made the tough decision to leave government and take up the torch; big shoes to fill and good luck. Pat Martin is currently serving as Acting Director of TIB. At the Tree Seed Centre we are happy to have Dr. Marilyn Cherry as our new Cone and Seed Operations Officer and she is already making a positive impact. Our facility is experiencing a large turnover of staff with about 50% turnover from spring 2016 to 2017 as we approach 60 years of operation in BC.

I would also like to extend a thank you to Ben Wang for all of his contributions to tree seed science and technology. Some may not be aware that Ben has maintained an Emeritus status with the Canadian Forest Service up until now, but will not be renewing it as Ben approaches 90 years in 2017. Ben was the first chairperson of our Working Group dating back to 1983. I'd also like to thank Natural Resources Canada for the classy act of allowing Ben to have a space, computer and remain active and connected for so long after his retirement.

I hope many of you are planning to attend the upcoming joint CFGA and Western Forest Genetics Association (WFGA) meeting in Edmonton, Alberta from June 26–29, 2017. Further information and the preliminary program are available at this link: <http://www.forestgenetics2017.ca>. There will not be a dedicated Tree Seed Workshop, but there will be a keynote seed presentation and sessions currently identified as Tree Seed Biology, Seed Orchard Management, Tree Seed Management and Conservation Genetics which provide opportunities for presentations on tree seed. The keynote speaker for seed will be Dr. Fiona Hay from the International Rice Research Institute and will speak on seed genetics as it relates to longevity and seed banking. The Upcoming Meetings section (pg 22) also lists several other seed-related meetings in 2017. Lindsay Robb is hosting her Seed Conservation Course in Smokey Lake, Alberta again and having attended, I recommend it to anyone wanting to expand their knowledge of seeds and their conservation. This year is a great opportunity to learn more about seeds in North America.

In BC, I have a few other extension items to report on. In the last News Bulletin there was mention of our last BC Seed Orchard Associating meeting and the presentations from that meeting and our previous one (2014) have now been placed on a dedicated webpage: <http://www.fgcouncil.bc.ca/bcsoa/>. We also hope to populate the site with presentations from previous meetings, history of the organization and to use it for advertising future meetings. In BC, we are also happy to make available a set of updated Reproductive Biology diagrams of some of our BC conifers at the attached link (<http://fgcouncil.bc.ca/doc-14-brochuresposters.html>). The appropriate credits are on each and they are available for use in extension, education and communication activities.

I was fortunate to be able to attend an International Seed Testing Association



(ISTA) Method Validation workshop in Zurich, Switzerland this fall which covered a broad range of statistical topics aimed at increasing the efficiency of rule changes. The statistical review component is a current bottle neck at ISTA for implementing new rules. It was great to meet others which I had only communicated with electronically and broaden myself regarding seed testing issues and concerns beyond tree seeds. Dale and I participate in the Forest Tree and Shrub (FTS) Seed Committee within ISTA and there are a few initiatives that may be of interest. Two ISTA publications, the Tree and Shrub Seed Handbook (1991) and the Handbook of Seedling Evaluation (2013) are out of print and the plan is to revise and reprint these guides. A relatively new initiative is a joint ISTA/OECD electronic handbook on seed testing and nursery practices related to trees and shrubs. Additional information on how you could contribute to the third item will be included in our next News Bulletin from Fabio Gorian who heads up our FTS committee and is spearheading this project.

I was also fortunate to combine this workshop with a trip to Finland to visit researchers at the Natural Resources Institute of Finland (LUKE, formerly METLA) and visit their lab, several seed orchards, nurseries and an advanced cone and seed processing facility. You may notice that we have had an article from Finnish scientists in the last two News Bulletins from scientists I met—thank you. I especially would like to thank Dr. Markku Nygren who arranged my very pleasant trip and stay in Finland. I encourage others from outside Canada to contribute articles to the News Bulletin. We are a relatively small community of practice and there are many items that don't make it into the refereed journals, so this is an opportunity to share or seek information on a wide variety of tree seed related topics.

This News Bulletin is actually the first since December 2013 without an article dedicated to water activity (eRH for the purists). Well, Santa Claus came early to BC and we were able to purchase a Rotronic Hygrolab C1 with four probes which will allow us to greatly increase current productivity in this area. The first priority is non-destructively testing our backlog of seed bank samples waiting for freezing storage and then expanded use of this technology to other areas of our facility. I certainly see the whole area of psychometrics as playing a larger role in handling cones and seeds, choosing optimum storage environments, kilning regimes and certainly making seed drying more efficient and repeatable. Thank you Santa, and everyone else who made it possible!

Last, but not least I'd like to welcome and thank our new Editor, Melissa Spearing for taking on that role and bringing some new energy to our group. Melissa has already contributed several articles to the News Bulletin. I'd also like to thank everyone who has contributed articles to the TSWG News Bulletin. Have a wonderful and fulfilling 2017.

Dave Kolotelo
TSWG Chairperson

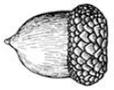
Outgoing Editor's Notes

Well, after editing 28 issues of the News Bulletin I find that it is time to retire my red pen! The Tree Seed Working Group and the News Bulletin have existed for 33 years which is a testimony to the dedication of past and current Chairs and Editors as well as all of you who have contributed articles. Without your submissions the News Bulletin would not have been possible. I am proud to have been a part of this Group for all of these years and for being more intimately involved with the News Bulletin. The Bulletin is emailed to 250 recipients around the world and I believe that it continues to be a useful means for providing timely information on many matters relating to seed.

The incoming editor, Melissa Spearing, has already added some pizzazz to the News Bulletin which is most welcome! I hope that you will support her by submitting articles as often as you can. She is somewhat new to the tree seed world but is excited to be editor and to have the opportunity to expand her little black book of contacts.

I wish you all the best and hope that you have a Happy New Year!

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



Incoming Editor's Notes

Thank you Dale and Dave for the introduction. Though new to the seed science world, a previous career in graphic design dovetailed nicely into this opportunity to assist the News Bulletin upon Dale's retirement. There is an invaluable amount of knowledge transfer in this resource and I would not want to see it discontinued. Did you know when all the previous issues are combined, it is now 1,067 pages of seed history? It is amazing to see the careers I admire criss-cross this chronology and influence my journey. Ben Wang's work solidified proper seed handling in my first seed collection course. Dave has known Dale for over 30 years, yet I only met them in person at the 2015 CFGA conference. Fabienne Colas and Lindsay Robb have given me years of background reading on water activity. Thanks to the TSWG, five weeks spent at the National Tree Seed Centre lab last winter, and a new role with the Forest Gene Conservation Association in Ontario, I know there is more than enough to preserve and pursue here in Canada. I thank Dale for teaching me so much in such a short time and wish him much happiness and adventure in retirement.

As I evolve in this Editor role, please bear with me in my quest for knowledge and publishing perfection. I am more practitioner than researcher compared to previous editors but am committed to sharing your science and experiences with the CFGA community and beyond. I find the new modes of effective scientific communication fascinating. As we polished off this Bulletin and the "Recent Publications" list, I found a YouTube tutorial series that spun out of a paper in *Methods in Ecology and Evolution*. Not many arborists or seed collectors I know have access to that journal, but now my friends on Facebook know about it. Show your field staff and students:



Aim and shoot the bag over your branch

Zdenek, C. 2016, May 16. Basic techniques on collecting leaves and seeds from tall trees: Video Tutorial Series (1 of 3) Youtube. Retrieved from <https://youtu.be/TV0gjIC8ug0>

So I feel an urgency in making your work useful across boundaries and boardrooms, and respect that every jurisdiction has its challenges. At the most basic level, we need forests, species and orchards sustained so we have seeds to use and study. In advanced jurisdictions, research is coming so fast it can be daunting to put it all into practice. When we share in a forum like the News Bulletin, we bridge those gaps together.

Melissa Spearing
Editor

Cone Moisture Content Monitoring Continued

In the last News Bulletin we provided some of our initial results on trends in cone moisture content after collection for 2015 crops at the Kalamalka Seed Orchards facility in Vernon, BC. We repeated the monitoring of cones in 2016 to estimate cone moisture content and also tracked the weight of entire operational cone sacks during interim storage. This article will review and discuss the results of both methods for interior lodgepole pine (*Pinus contorta* var. *latifolia* Dougl. Ex Loud.), western larch (*Larix occidentalis* Nutt.) and interior spruce (*Picea glauca* (Moench) Voss, *Picea engelmannii* Parry ex Engelm and hybrids of the two).

Moisture Content Estimation

The key to estimating cone moisture content is the determination of the oven-dry weight of the cone. This happens after your data gathering is completed and the material can be sacrificed to obtain that oven-dry weight. This value can then be used to convert all previous fresh weight measures to moisture content. In 2015, individual cones were followed in aerated bags and in 2016 each aerated bag contained five cones. Each aerated bag was generally monitored at three to four day intervals. Bag and tag weight measure was subtracted from total weight of each repeated measure. The relative numbers of samples by species with an indication of orchards represented is provided in Table 1.

The available daily data since cone harvest for all 90 bags across both years was averaged for each species (Fig. 1). The results were quite similar between the two years and the pooled data used to maximize the number of data points. The results are similar to those previously seen as cone moisture content stabilized to between 10-15% within two weeks in Vernon, BC. The average cone moisture contents at collection



Table 1. The sample sizes used to estimate cone moisture content following cone harvest in 2015 and 2016.

Species	# Bags 2015	# Bags 2016	Total	# Orchards
Lodgepole pine	18	14	32	2 (230; 307)
Interior spruce	24	9	33	4 (305; 306; 341; 620)
Western larch	19	6	25	2 (332; 333; 994)

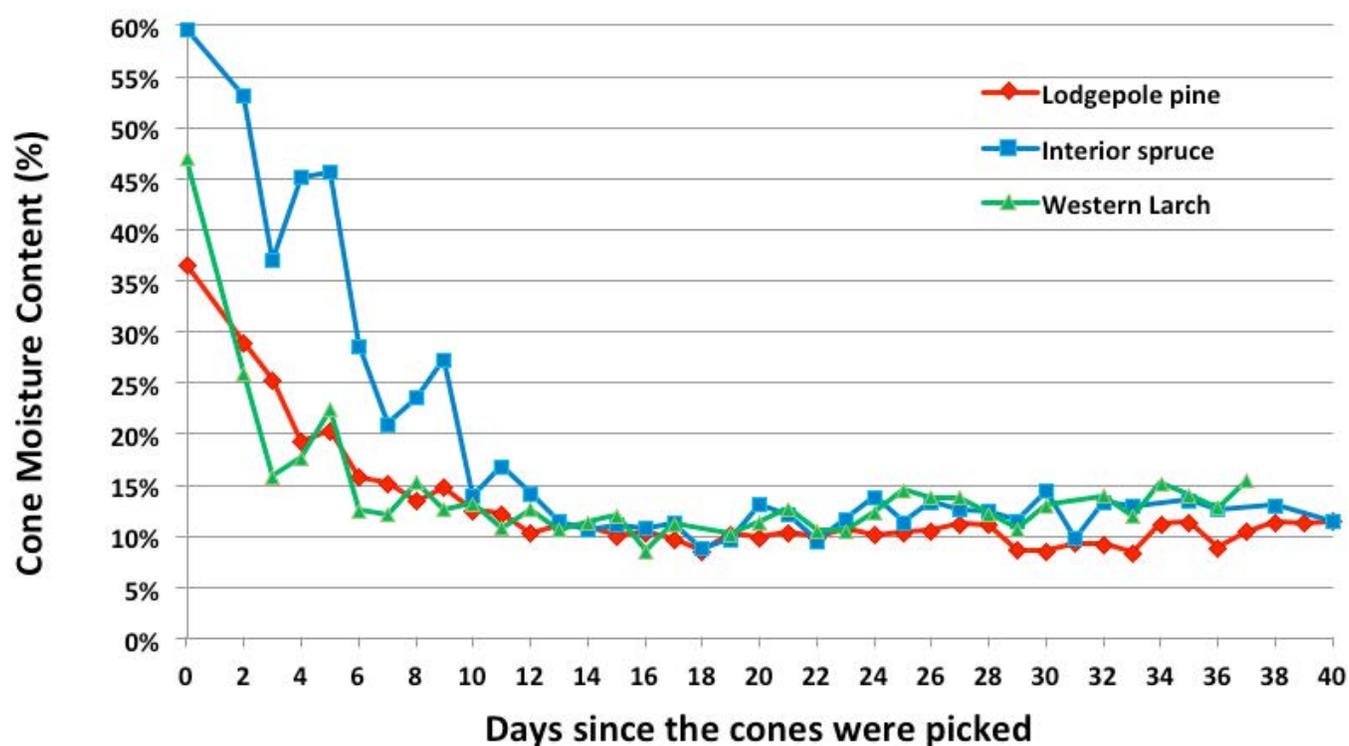


Figure 1. The pattern of cone moisture content averaged across 2015 and 2016 samples for three species at Kalamalka seed orchards in Vernon, BC.

Table 2. The sample sizes used to measure cone sack weight following cone harvest in 2016.

Species	# Bags 2016	# Orchards
Lodgepole pine	41	1 (230)
Interior spruce	54	3 (305; 306; 620)
Western larch	28	1 (333)

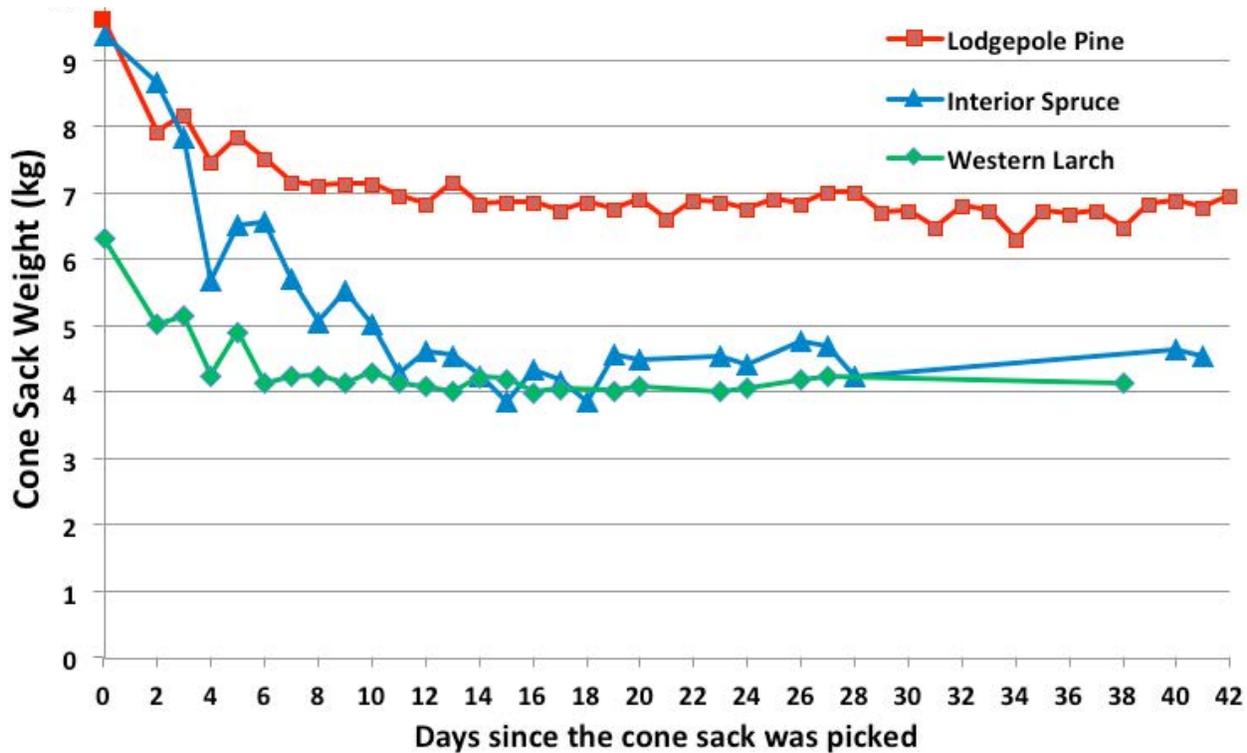
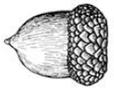


Figure 2. The pattern of cone sack weight in 2016 for three species at Kalamalka seed orchards in Vernon, BC.

have interior spruce significantly moister (60%) followed by western larch (48%) and lodgepole pine (36%). The spiky nature of the species' data patterns is due to different cones being monitored on different days from when the cone was picked. Spikes usually relate to a few or even one cone being used for that number of days since cone picking. I'm reluctant to calculate slopes (drying rates) of the various species based on these spiky data, although initial cone drying seems most rapid in western larch.

Cone Sack Weight

Cone sack weight measurement over time is a very quick and efficient method of tracking moisture status. The objective is to determine when cone moisture content stabilizes and cones can be safely shipped to the seed extractory. Cone sacks were weighted to the nearest 10 g and tag and sack weight subtracted, so presented weights represent cone weight only. Table 2 illustrates the cone sack sample size by species for the 123 cone sacks tracked.

Cone sack weight was measured and averaged by species up to 42 days after collection (Fig. 2). The pattern of cone sack weight stabilization within two weeks agrees with the results seen through the moisture content estimation samples. The pattern of lodgepole pine and its relatively heavy cone sacks

may initially seem odd as all species have equivalent cone volumes of 20 L/sack. The reason is that the oven-dry weight of lodgepole pine cones is approximately two and a half times heavier than either spruce or western larch cones. This shouldn't be surprising for a serotinous species with the additional weight acting as insulation to avoid killing seeds during fires. Lodgepole pine cone sacks stabilize at about 7 kg, while spruce and larch stabilize between 4 and 5 kg with western larch generally being lighter.

There are a wide variety of ways to visualize the data obtained though this monitoring and I wanted to use two additional plots to illustrate some points. The use of days since cone collection was a method to place all cones on a comparable basis even if the actual environment experienced is not the same for each cone or cone sack during drying. Cone sack weights for interior spruce are plotted by calendar date showing three distinct collection periods (Fig. 3). These different collection times do not relate to different maturation times in different seed orchards, but the variability found within orchards. This agrees with the general clonal classification at Kalamalka as maturing early, mid, or late. Similar trends were found with the other species, but interior spruce showed the greatest variability. The earliest collected cone sacks actually dip to a lower weight profile of between three to five kg and this period corresponds

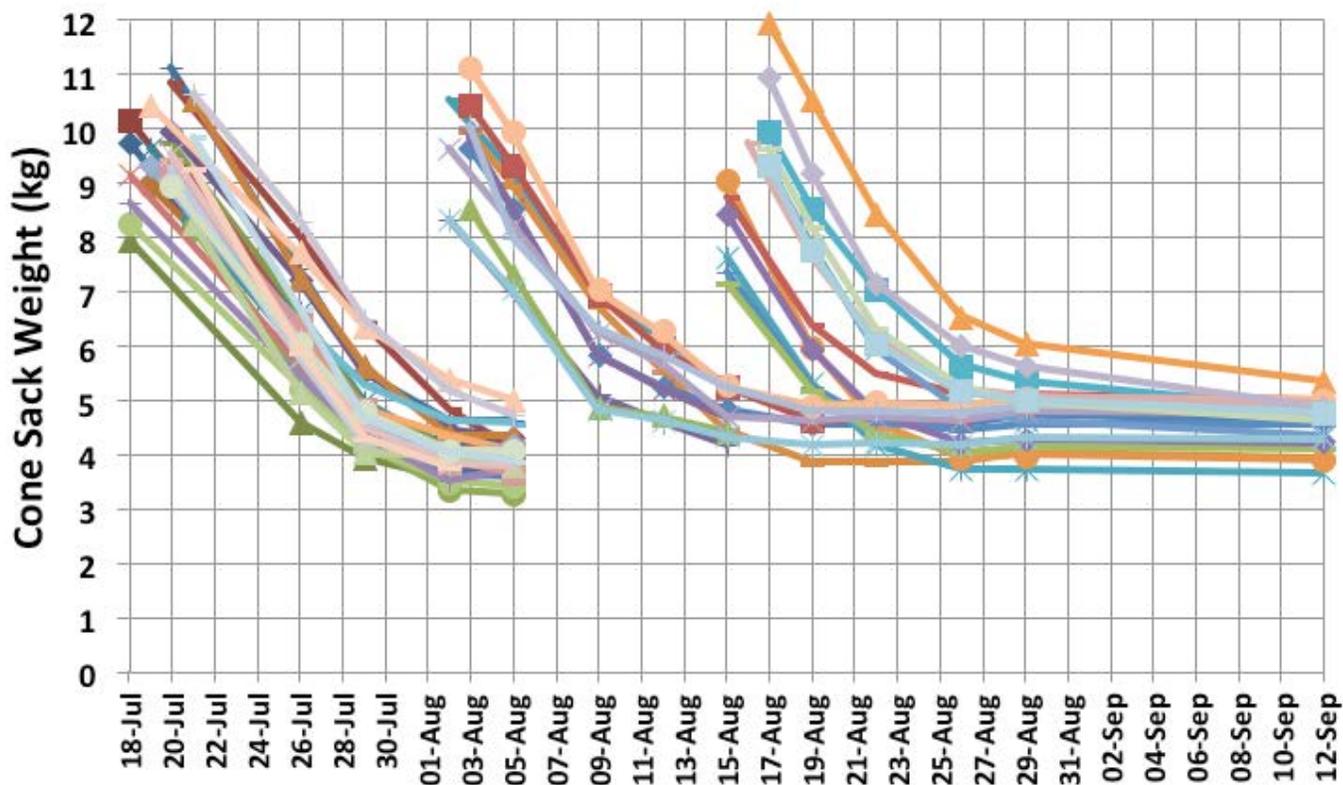


Figure 3. The pattern of individual cone sack weights of interior spruce from collection to shipping by calendar date.

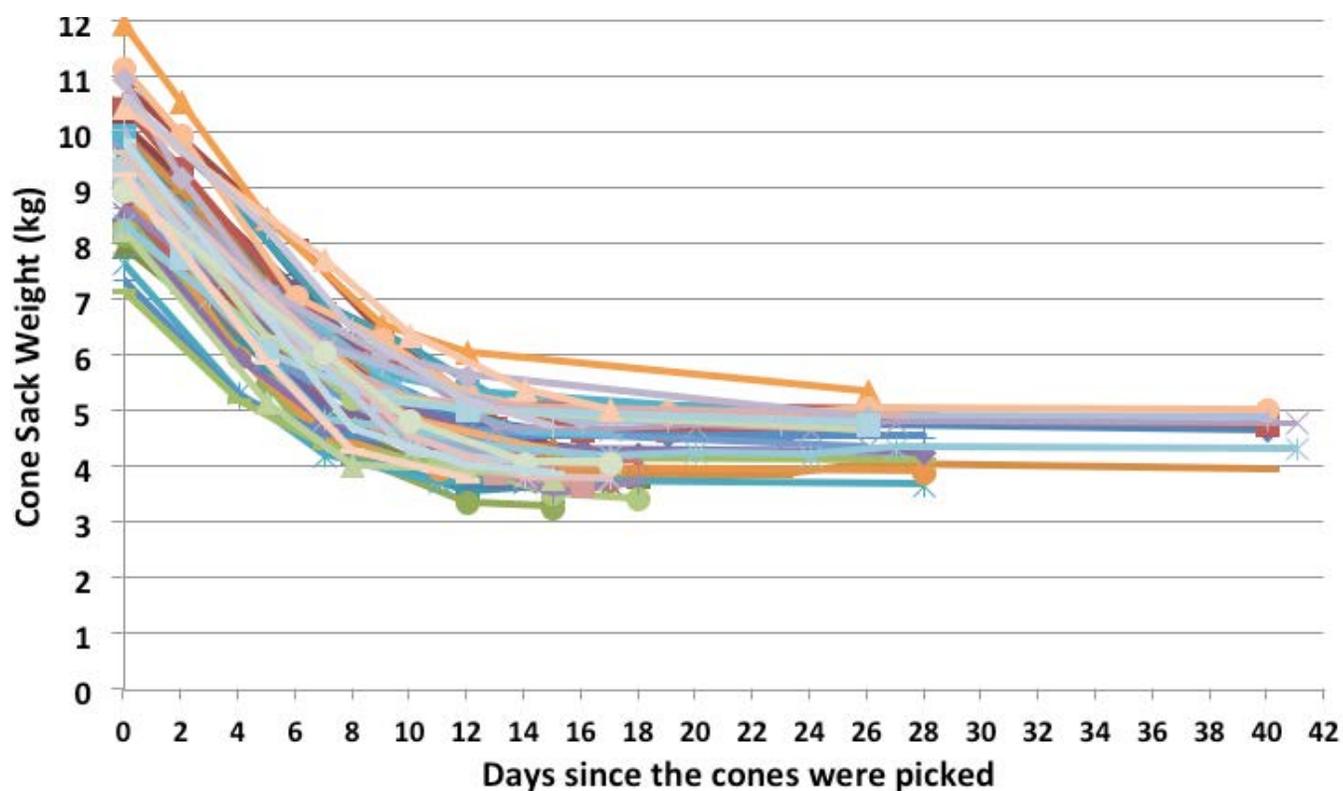


Figure 4. The pattern of individual cone sack weights of interior spruce from collection to shipping by days since each cone sack was picked.



to the lowest annual relative humidity in Vernon¹. Some cone sack weights exceeded 10 kg on all collection dates, but the largest range was seen in that third collection period which was approximately one month after the first cones were picked. There seems to be enough variation to warrant fine-tuning of the collection initiation period as waiting too long can also result in seed loss through cone opening on the tree. The same data on interior spruce was converted to days since the cone sack was picked (Fig. 4). This clearly indicates the large range in initial cone sack weights and generally shows a similar cone drying pattern for all interior spruce cone sacks.

Discussion

The results of cone moisture content and cone sack weight showed similar moisture loss patterns and timing of stabilization for cone moisture level. The advantage of moisture content determination is that results can be used as a physiological marker on the status of cones and aid in decision making beyond shipping. The disadvantage is the samples need to be destroyed (oven-dried) to enable calculation of moisture content and the actual moisture content can only be known after this happens.

Cone sack weight is not dependent on a final oven-dry weight, but does assume that weight is a result of moisture differences and not differences in cone volume per sack. The stabilization of cone sack weight seems like an efficient method to determine when cones are prepared for shipping. The durations reported here are specific to trends in Vernon, BC and drying rates may differ greatly between locations based on daily humidity values. We believe the efforts in this monitoring have been informative and that cone sack weight will become an operational tool to assist in the timing of cone shipments. Cone sack weights may also be used as a rough quality assurance guide indicating when collections may be starting too early. This was probably the case with those 11 to 12 kg cone sacks in Figure 4. At the low end of the range it may also indicate cones which could have been picked sooner.

The cone sacks monitored were not identified by individual clone and may be composed of cones from numerous clones, but this might be a quick method to classify cone maturation sufficiently for operational decision-making by individual clone relatively inexpensively.

Dave Kolotelo

Ministry of Forests, Lands and Natural Resource Operations
Tree Seed Centre
Surrey, BC

Email: Dave.Kolotelo@gov.bc.ca

Gary Giampa and Nancy Vanderlaan

Ministry of Forests, Lands and Natural Resource Operations
Kalamalka Seed Orchards
Vernon, BC

Direct Seeding of Scots Pine is a Popular Forest Regeneration Method in Finland

The total annual forest regeneration area in Finland is approximately 120,000 ha. More than half of this area is regenerated with Scots pine (*Pinus sylvestris* L.). The regeneration methods used for Scots pine are planting, direct seeding and natural regeneration, each covering one third of the area. The choice of method is mainly based on the fertility of the site. Direct seeding, as well as natural regeneration, is most successful on sites with relatively low fertility. Site classification and site selection is based mainly on the indicator species of ground vegetation.

Practically all direct seeding sites are scarified mechanically. The most common soil scarification method is disc trenching, as it has been for the last 40 years. Also patch scarification either with two row Bracke-moulder or excavator is also used especially in Southern Finland. On majority of the area (70%) seeding is done mechanically, i.e. in combination with soil scarification. On state and company forests the degree of mechanization is close to 100%. The development of mechanized direct seeding began in the 1980s. Due to this, seeding devices are nowadays reliable, accurate and safe to use. Manual direct seeding, after mechanical soil scarification, is still quite popular amongst private forest owners. In manual seeding “the seeding device” is usually a 0.5 L plastic bottle with an appropriate amount of holes in the cap for seeds.

Direct seeding is done traditionally in May and June. Before this it is often too cold, and after this too dry for germination. The normal seeding rate is 300 g of germinable seed/ha, which equals 50,000–60,000 seeds/ha. Final seedling establishment is normally between 10 and 20%. Low establishment is mainly due to seed predation (Fig. 1), drought, uncontrolled and heavy

¹ <https://weatherspark.com/averages/27809/Vernon-British-Columbia-Canada>



soil erosion, and frost heaving. In rainy summers some diseases (e.g. pine twisting rust) may also kill young seedlings (Fig. 2).

Because of low establishment rate, there is not enough high quality seed orchard seed for all direct seeding; total annual need is approximately 9,000 kg. Especially in Northern Finland, where most of the direct seeding is done, but where climate is harsh, there's a lack of high quality seed. The total cost of mechanical direct seeding (soil scarification and seeds) is approximately 450€/ha (\$650 CAD/ha), which is less than half of the total cost of planting. Partly because of low costs and partly because of inability to accurately identify suitable sites, direct seeding is often used on sites that are too fertile.

Research activity

The main research aims during the last five years have been:

1. to develop technology with which seeds can be covered controlled in mechanical direct seeding, and
2. to test would it be possible to sow seeds successfully also in autumn.

Hiding seeds

In mechanical direct seeding, seeds often remain visible on the top of the exposed mineral soil for a while (Fig. 3). This delays germination and exposes seeds to seed predation and drying. On the basis of hand-sown direct seeding experiments we knew already that covering seeds lightly may increase seedling establishment considerably. Two different methods are currently being tested to cover seeds in mechanical direct seeding.

The first method is based on soil erosion occurring in the seedbed soon after scarification. To achieve controlled covering of the seeds due to erosion, a special blade was designed to create shallow furrows and pits on the surface of the seedbed. The blade was manufactured by Swedish company Bracke Forest and it was attached to the two-row Bracke moulder equipped with TTS Sigma seeding device (Fig. 4).

A test-drive in June 2016 showed that the new scarification blade worked as planned. The surface of the seedbed was quite different compared to the old blade, which is normally used in scarification of direct seeding areas (Fig. 5). Unfortunately, due to defects in the seeding device, we were not able to get results concerning seedling establishment yet. However, we will continue testing next spring. Small modifications will also be made to the blade.



Figure 1. Chaffinch (female centre and male above right) is a notorious seed eater on direct seeding areas. It is the second most common bird in Finland.



Figure 2. Pine twisting rust (*Melampsoria pinitorqua*) attack on few-week-old pine seedlings in July 2012. All infected seedlings died soon after this.



Figure 3. Scots pine seeds on the surface of the seedbed straight after mechanical direct seeding with two-row Bracke moulder and TTS Sigma seeding device.

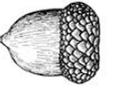


Figure 4. Bracke moulder equipped with new scarification blade (on the left) and old blade (on the right). Grey metal box in the cargo area of the forwarder is the seeding device (TTS Sigma).



Figure 5. The surface structure of the seedbed straight after scarification with the new scarification blade.



Figure 6. New excavator bucket designed specially for seeding and controlled covering of the sown seeds with rotary screen. Seeding device is the grey, round-shaped piece (arrow), next to the hydraulic motor that operates the screen.



The second method is to try to cover seeds directly. For this a special excavator bucket with rotary screen and electrical seeding device was designed (Fig. 6). The bucket was constructed by Finnish company Vipermetal/Ajutech. In this method a shallow mineral soil patch is first made with the edge of the bucket. After that seeds are sown in the patch and finally, a rotary screen is used to cover seeds with a thin soil layer.

Generally this method increased seedling establishment, but it was soon discovered that the thickness and composition of the cover had great impact on establishment. The best result was achieved with a very thin (approximately 1 cm) layer of humus and small particles of ground vegetation. A mineral soil layer exceeding 2 cm in thickness slowed down seedling emergence considerably or prevented it completely. The bucket can also be used for mounding and ditching if necessary.

Is autumn seeding an option?

Occasionally, germination of Scots pine seeds sown in spring is delayed by one or even by two years. This demonstrates that pine seed is (at least to some extent) able survive over winter in the ground.

To test whether it would be possible to successfully sow seeds in autumn, an experiment was established on a former sandy nursery field in Central Finland. Sowings with high quality seed orchard seed were made in September, October and November in four consecutive years (2012–2015). Half of the seed spots were covered with a thin soil layer and the other half were left uncovered. Total live seedlings were counted every autumn.

Seedling establishment (the number of live seedlings in relation to sown germinable seeds) was low in September seedings. In 2012, 2013 and 2015 seeds germinated in autumn. However, most of the seedlings froze to death in November. Due to low precipitation in autumn in 2014, seeding in September succeeded to some extent because seeds did not germinate until the next spring.

In October and especially in November seedling establishment was much higher than in September (Fig. 7). However, there was a considerable year-to-year variation in results. For example, seedling establishment was 66% in 2012, but only 10% in 2013 when seeds were sown in November. Covering seeds increased establishment considerably in autumn. In October and November, the temperature was usually too low for germination before winter. However, some of the moist ungerminated seeds probably froze to death during

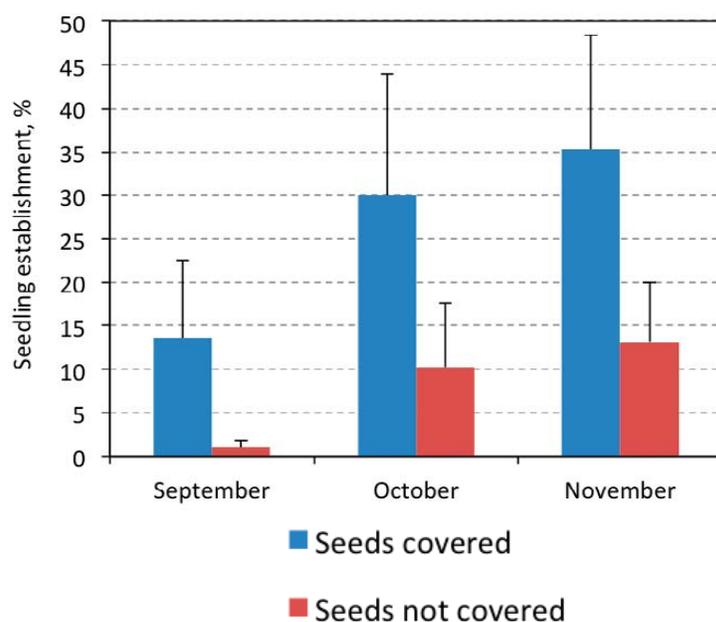


Figure 7. Seedling establishment for seeds sown with or without soil cover in September, October and November. Columns represent the average of four years (2012–2015).

winter. In 2012 permanent snow cover fell early, which probably explains high seedling establishment that year.

Excluding September, these results indicate that seeds may also be sown in autumn in Central Finland, especially if they are covered with a thin soil layer. Sometimes seedling establishment may even be higher than in spring seeding. However, the risk in autumn seeding is always greater than in spring.

Concluding remarks

When the site is right for direct seeding and when methods enhancing controlled covering of the seeds are used, I conclude that at least 30% reduction in the quantity of seed sown is possible. Such a reduction equals a 15% reduction in the total cost of direct seeding. Sowing less seed also provides an opportunity to increase the proportion of high quality seed orchard seed in direct seeding or to substitute some of the natural regeneration with direct seeding.

Pekka Helenius

Natural Resources Institute Finland (LUKE)
Helsinki, Finland

E-mail: pekka.helenius@luke.fi



Frozen Storage May Affect Dormancy of Eastern White Pine Seed

Introduction

Eastern white pine (*Pinus strobus* L.) is a valuable tree species in North America and it has suffered from over-harvesting and serious pest problems posed by white-pine weevil (*Pissodes strobi*) and white pine blister rust (*Cronartium ribicola*). However, there has been increasing interest in artificial regeneration of this species. For successful regeneration, seed storage is important, as good natural seed crops of eastern white pine occur at 3- to 5-year intervals in Canada (Wang 1974) and 3- to 10-year intervals in the United States (Krugman and Jenkinson 2008). White pine seed are naturally dormant. In order to maximize germination, seed are given a 28-day (ISTA 2012) or 28–42 day (AOSA 2002) moist chilling treatment before germination. According to Simpson et al. (2004), eastern white pine seed had 80% germinability after being stored at -20°C for 25 years. However, Wang (1982) discovered that seed of this species became more dormant after storage at -18°C for 12 years. This phenomenon of change in dormancy during frozen storage (Wang et al. 1993) and storage at 4°C (Beardmore et al. 2008) was also found in white spruce (*Picea glauca*) seed. If this phenomenon is widespread, it could impact how seeds held in frozen storage for long periods of time are treated prior to germination testing or sowing in a greenhouse or nursery.

The purpose of this study was to evaluate the effect of frozen storage on seed dormancy using 27 seedlots of eastern white pine and to discuss its implication for seed testing.

Methods

The seed was collected in Quebec for reforestation purposes. Seven seedlots were collected in 1990 and ten each in 1996 and 1998. Germination tests were conducted on chilled and unchilled seed prior to storage to evaluate dormancy. The seedlots were stored at -3°C at the Centre de semences forestières de Berthier, Québec Ministère des Forêts de la Faune et des Parcs until 1999 when samples were transferred to the Canadian Forest Service's National Tree Seed Centre in Fredericton, New Brunswick. Here, the seed were stored at -20°C for 10 years and tested in 2009 for germination with and without moist chilling, following established standard procedures used at the National Tree Seed Centre (Simpson et

al. 2004). Four replications of 50 seed were sown on moist Versa-Pak™ germination medium in Petawawa Germination Boxes (Wang and Ackerman 1983). Moist chilling was conducted in the dark by placing the boxes in a cooler at 3°C for 28 days. Germination conditions consisted of 8 hours light at 30°C and 16 hours in darkness at 20°C , with constant relative humidity of 85%. Germination was assessed every third day beginning at day 10. A seed was considered germinated when the cotyledons were visible and the hypocotyl and radicle were well developed. The degree of dormancy is expressed as the difference in germination between moist chilled seed and unchilled seed. When the difference in germination was negative or only up to 5% positive, the seedlot was considered to be non-dormant.

Results and Discussion

Data for each of the seedlots by collection year are presented in Table 1. Initial testing of the 1990 collections showed that mean germination was 6% greater for unchilled seed indicating that these seedlots exhibited shallow dormancy but each of the seedlots was classified as being non dormant. After storage for 18 years (8 years at -3°C and 10 years at -20°C) germination had declined and mean germination of chilled seed was 3% greater than for unchilled seed indicating that there was no dormancy. However, on an individual seedlot basis, two seedlots (102 and 103) became dormant while the other five remained non dormant. Mean germination of chilled and unchilled seed was substantially less after 18 years of storage which may be attributed to initial storage at -3°C for eight years which started the ageing process that continued even though the seed were stored for 10 years at -20°C which is considered an optimum temperature for long-term storage. Initial seed quality may also have been a factor.

Testing of the 1996 collections prior to storage showed little difference in mean germination between chilled and unchilled seed. On an individual seedlot basis there was one seedlot (306) that was dormant, one (311) with shallow dormancy and the remainder were not dormant. After storage for 11 years (1 year at -3°C and 10 years at -20°C) the germination of chilled seed was 17% greater than unchilled seed. Thus the seedlots were dormant on average. Three seedlots (304, 308 and 311) were deeply dormant.

Initial tests of the 1998 collections showed that seedlots were dormant with mean germination of chilled seed being 12% greater than for unchilled seed. Six seedlots (356, 357, 358, 362,



364 and 365) were dormant, two had shallow dormancy and two were not dormant. After 10 years of storage at -20°C the difference in mean germination between chilled and unchilled seed was over 40% and eight seedlots had become deeply dormant.

The data show that dormancy increased as storage time decreased with the 1998 seedlots exhibiting the deepest dormancy. Edwards (2001) stated that eastern white pine is known to become more deeply dormant when stored at -18°C (or lower) for more than six months and Wang (1982) found the same trend.

We did not evaluate dormancy following the seed being stored at -3°C and before storage at -20°C so there is a possibility of a confounding effect of seed deterioration and effect of storage at -3°C particularly for the 1990 collections. Nevertheless, the results indicate that there are changes in seed dormancy during frozen storage, with 81% of the seedlots exhibiting dormancy greater than 5%. This could be the reason for the 30- and 60-day moist chilling recommendation by Krugman and Jenkinson (2008) for germination testing fresh and stored eastern white pine seed, respectively.

The degree of dormancy in tree seed is genetically variable (Farmer 1997). Fowler and Dwight (1964) demonstrated that provenance (genetic) and environmental effects were confounded. In our study, each seedlot represents a different provenance with a few exceptions. Seed from three provenances collected in 1996 and 1998 (305 and 364, 306 and 357, 312 and 363) exhibited varying degrees of dormancy before and during storage. Annual environmental differences such as temperature and moisture possibly had an impact as well as timing of collection and cone processing.

Conclusions

In our evaluation of the 27 seedlots, we observed that eastern white pine seed in frozen storage became more dormant, on average, particularly those in storage for the lesser duration of 10 and 11 years. This phenomenon could have a practical application for germination testing seed stored for long-term *ex situ* conservation by the possible need to increase the duration of moist chilling in order to alleviate dormancy in all the seed. We hope that our results will promote further interest in research to identify factors affecting the induction of dormancy during frozen storage, and its impact on storage longevity and duration of moist chilling treatments required to alleviate dormancy after prolonged storage.

Acknowledgments

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Table 1. Percentage germination and dormancy of 27 eastern white pine seedlots, collected in three years, before storage and after 10–18 years in frozen storage. Dormancy is expressed as the difference between germination of chilled and unchilled seed. When the difference was negative a value of 0 was applied.

Seedlot	Germination (%) and dormancy (%) before storage			Germination (%) and dormancy (%) after storage		
	Chilled	Unchilled	Dormancy ¹	Chilled	Unchilled	Dormancy ¹
1990 collections				Stored for 18 years		
100	75	71	4 ND	66	70	0 ND
101	79	76	3 ND	33	43	0 ND
102	45	81	0 ND	58	37	21 D
103	59	65	0 ND	59	45	14 D
104	53	51	2 ND	43	41	2 ND
105	53	51	2 ND	34	32	2 ND
106	64	71	0 ND	40	47	0 ND
Mean	61	67		48	45	
1996 collections				Stored for 11 years		
303	65	65	0 ND	56	45	11 D
304	73	85	0 ND	90	60	30 DD
305	66	66	0 ND	76	64	12 D
306	79	66	13 D	82	67	15 D
307	88	86	2 ND	81	72	9 SD
308	63	71	0 ND	85	51	34 DD
309	58	64	0 ND	70	62	8 SD
310	75	70	5 ND	71	53	18 D
311	67	59	8 SD	92	64	28 DD
312	56	67	0 ND	74	68	6 SD
Mean	69	70		78	61	
1998 collections				Stored for 10 years		
356	94	70	24 D	89	42	47 DD
357	96	75	21 D	90	30	60 DD
358	94	71	23 D	85	34	51 DD
359	92	87	5 ND	95	73	22 D
360	48	69	0 ND	83	75	8 SD
361	78	68	10 SD	80	36	44 DD
362	72	55	17 D	84	30	54 DD
363	75	68	7 SD	90	45	4 DD
364	91	74	17 D	82	40	42 DD
365	89	75	14 D	82	30	52 DD
Mean	83	71		86	44	

¹ ND = not dormant (0–5%), SD = shallow dormancy (6–10%), D = dormant (11–25%), DD = deep dormancy (>25%)



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Ben Wang

Natural Resources Canada, Canadian Forest Service
Canadian Wood Fibre Centre, Petawawa Research Forest
Chalk River, ON

Email: Ben.Wang@canada.ca

Dale Simpson and Bernard Daigle

Natural Resources Canada, Canadian Forest Service
Atlantic Forestry Centre, National Tree Seed Centre
Fredericton, NB

Email: Dale.Simpson@canada.ca

Mechanical Pruning Large Orchard Ramets

Well known to orchard managers is the problem of orchard ramets growing to a size where pickers cannot reach cones from ladders, crowns close, and easily-reached branches begin to die, moving the cone crops ever higher in the trees. In addition to the greater costs of harvest using lifts instead of ladders, tall crowns become increasingly less accessible for managing pests with ground-based sprayers.

Managing ramet size through pruning is a well-known technique. Ramets eventually reach a size, however, where crown management carried out by hand pruning becomes prohibitively expensive. This is a particularly acute problem

with lodgepole pine orchards in British Columbia due to the large number of ramets (some over 5,000 ramets) and the relatively low value of the seed crop produced by each ramet.

For SelectSeed Co. Ltd., a not-for-profit seed orchard company wholly owned by the Forest Genetics Council of BC¹ in British Columbia, the problem of crown management is particularly important due to our interest in nine lodgepole pine orchards containing a total of nearly 30,000 ramets. Following the lead of methods developed for agricultural crops such as avocados and used in some conifer seed orchards in Sweden, SelectSeed initiated a project to find and purchase a mechanical pruning system capable of cheaply shaping and maintaining crowns at a height that can be reached safely from a 12 ft (3.66 m) ladder. After extensive review of available options, suitable equipment was located and purchased from Kirogn (pronounced kerr-own), a company located in Villexavier, France. Kirogn pruners are used for a variety of agriculture pruning tasks and, notably, for pruning the crowns of large urban trees, including the sycamores with flat tops and straight sides lining parks and streets in Paris and other French cities.

SelectSeed purchased the following Kirogn equipment (Fig. 1):

- Mini-Lem 6-blade pruner (50 cm diameter hydraulically-driven blades) (2.4 m total cut width)
- TA500 articulating arm
- 90 l PTO-driven hydraulic pump

Pruning orchard trees must be done carefully to avoid damage. Therefore, the articulating arm and pruner were mounted on the front-end-loader arms of a tractor. This places the cutting unit in front of the operator while driving along orchard rows so the pruning can be accurately and safely monitored by the operator. Front mounting was problematic, however, as most equipment of this sort is designed for either less-mobile use (i.e. cutting all sides of a large tree in a park), or for road-side vegetation management with rear or side mounted cutters. To meet our objective for a front-mounted unit, we designed and had manufactured an attachment to that allows the TA500 arm to be mounted on the front-end loader arms of an already-owned 90 hp New Holland 4wd tractor. The hydraulic drive was mounted on the rear PTO and hydraulic lines installed to feed the TA500 arm and Mini-Lem cutter.

This system has proven robust and highly functional. The six-blade pruner can be positioned horizontally for cutting

¹ <http://www.fgcouncil.bc.ca>



Figure 1. Kirogn Mini-Lem 6-blade pruning unit and TA500 articulating arm front mounted on the loader arms of a New Holland 90 hp tractor. Top cutting, shown here, is normally done at about 4.3 meters to allow safe picking access from a standard 12 ft (3.66 m) orchard ladder.



Figure 2. Lodgepole pine ramets following top pruning to about 4.3 m and side pruning.

the tops of ramets at any height up to 5 meters (more if lifted on the front-end loader arms, but stability becomes an issue). Side cuts can be made from ground level to over 7 m in height. Each pass with the machine will remove a 2.4 m wide swath of branches. Branches and tops with diameters of up to 10 cm can be cut, but diameters greater than about 7 or 8 cm require a reduction of tractor speed. The six 50 cm blades rotate at about 2,000 rpm, and cut very quickly. Tractor travel speed with stem diameters of 8 cm or less is not restricted by the ability to cut quickly enough, rather it is restricted only by how fast the tractor can safely and reasonably drive on the often rough ground of the orchard. Passes with the pruner are normally done at a much higher driving speed than with mowing equipment.

Typical pruning will involve three or four passes. Depending on crown width and species, one or two passes are made to remove tops at about 4.3 m. One pass is then made on each side of a row of ramets to remove side branches in the height range of about 1.5–4 m. Any lower branches can be cheaply removed by hand while cleaning up the pruning debris. There is no pruning done between ramets within a row (i.e. pruning is only done on the sides facing into the lane between rows). An outcome of this method is that orchard rows will take on the appearance of long hedges after several prunings (Fig. 2). For some species, crown morphology and cone-bearing sites may not be favoured with this technique. However, variations in pruning frequency and intensity can be made to accommodate most species. We have successfully pruned lodgepole pine, Douglas-fir, and spruce orchards.

As a cooperative not-for-profit company supporting forest genetics activities in British Columbia, we offer the pruning service to other orchards at a price of \$1.80 CDN/ramet for large ramets (three or four passes), plus transport. This rate recovers operating and capital costs to SelectSeed Ltd. Given that pruning is only done every 3 to 5 years, this cost is very reasonable and extends the functional life of orchard ramets far beyond what would be possible with hand pruning.

Jack Woods

Forest Genetics Council of BC and SelectSeed Co. Ltd.
Vancouver, BC

Email: jwoods.fgc@shaw.ca



Long-term Storage and Recovery of Butternut in New Brunswick

Butternut (*Juglans cinerea*) is a tree species native to the United States (US) and Canada and is under serious threat from an introduced fungal disease (*Ophiognomonia clavigignenti juglandacearum* (OC-j)). Butternut decline was first reported in 1923 in the United States (Nair et al. 1979), initially identified as *Sirococcus clavigignenti juglandacearum* in 1979 (Nair et al. 1979) and finally reclassified into the genus *Ophiognomonia* in 2011 (Broders and Boland 2011). In Canada, the first report of canker was in Quebec, 1990 (Innes and Rainville 1996), then in Ontario, 1991 (Davis et al. 1992) and in 1997, was found in New Brunswick (NB) (Harrison, Hurley, and Ostry 1998). Butternut canker infects all sizes and age classes of trees on all sites and, infection can occur through buds, leaf scars and various wounds (Ostry 1997). In 2003, mainly due to butternut canker, butternut was listed under the federal Species at Risk Act as endangered (Neilson et al. 2003). In 2010, a recovery strategy for butternut was prepared with a long term goal to “ensure conditions that will allow for the restoration of viable, ecologically functioning, and broadly distributed populations within its current range in Canada” (Environment Canada, 2010).

At NRCan (Natural Resources Canada) – CFS (Canadian Forest Service) AFC (Atlantic Forestry Centre) we have an ongoing project to investigate various areas of concern with respect to butternut. This project includes components such as:

1. a provincial (NB) range-wide assessment of butternut populations as well as evaluating the health of these populations,
2. genotyping NB populations to evaluate the level of genetic diversity and how it compares to other populations throughout its range, and
3. conservation of butternut through *ex situ* conservation of nuts in the form of cryopreserved embryonic axes.

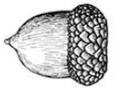
The extent of the range of butternut in New Brunswick is predominantly located along the Saint John River (SJR) Valley, and also along the banks of the South West Miramichi River and the Aroostock River (all part of the SJR system). The SJR is the largest river system in the Maritime peninsula of Northeastern North America which rises on the border of Quebec and the US State of Maine and flows east, then south, for 675 km to empty into the Bay of Fundy. We have successfully surveyed these

watersheds in NB and have developed a searchable database to identify butternut populations. This database, which is consistently updated with new data, was developed in three sections:

1. a tree identification section that includes location and genotyping data,
2. a tree health assessment section that includes tree physical and health parameters (canker presence, diameter at breast height, crown vigor, etc.), and
3. *ex situ* collection of nuts that includes seed numbers, storage data and seed measurements data.

The genetic diversity of butternut found in Ontario, Quebec and NB indicates the NB populations are genetically distinct from that in the other two provinces and in the United States (Hoban et al. 2010; Hoban pers. comm. 2015). However, the geographic coverage for butternut in Canada is limited as these results are based on a very limited number of populations (Hoban et al. 2010). Given this, it is difficult to conclusively state that NB populations are genetically distinct from the rest of the species’ range in Ontario and Quebec. A previous butternut range wide assessment of 29 populations including three NB populations indicated that NB butternuts are highly divergent from those in the US (Hoban et al. 2010). Over the last three years of surveying, we were able to collect over 600 samples from over 40 sites in NB that will be fully genotyped in the near future. This new genetic data should enable us to evaluate the uniqueness of NB populations as well as potentially determine why NB populations are more genetically diverse than throughout the rest of its range. Given the apparent distinctiveness of butternut in NB due to its disjuncture from the rest of the range in North America, it is relevant to consider if any historical or, current factors or practices have had a significant impact on the state of butternut in NB. This is currently being researched for a paper to be published on the history of butternut in NB and implications for the conservation of butternut in NB.

Growing trees from nuts is a common practice for butternut but conserving seed to ensure for a supply of future material for propagation is limited since butternut seed only remains viable in storage for 2-3 years (Forest Service 1948) due to their inability to withstand drying. We are currently maintaining an *ex situ* cryopreserved (low temperature storage in liquid nitrogen) collection of butternut germplasm representative of the diversity found within NB which could be used to



support future research and recovery efforts. Over the last three years (2013–2015), over 28,000 nuts have been collected and approximately 21,500 embryos were stored in liquid nitrogen. In 2016, approximately 6,000 nuts were collected and processing will be done shortly to add to those axes already in storage (Fig 1). If disease resistance is not found in the species and depending on how the disease impacts nut production, this genetically characterized *ex situ* collection could potentially become one of a few resources available to researchers for the research and restoration of the species using next generation technologies.

Another challenge with whole seeds is that there is evidence that the canker can be present inside the nut as part of the seed coat (Broders et al. 2015). An additional funded proposal from the Northern Nut Growers Association (NNGA) has enabled us to examine through experimentation how to grow butternut without the canker being present. Our present method to ensure this outcome is to grow the embryonic axes under sterile conditions which requires the use of specialized equipment (autoclave, laminar flow hood, etc) to maintain sterile conditions at all times to avoid contamination. Although our success rate for germinating these axes under cell culture lab conditions is over 90%, this method can be expensive due to laboratory and material costs. In this project, we are trying to adapt the method to be efficient and economical without the use of any specialized lab equipment. To do this, we will be experimenting with two methods. The first method involves germinating the nuts under different treatments (bleach, fungicide) to try and mitigate butternut infection by the canker that could already be present inside the nut. The second method involves germinating the embryonic axes under non-sterile conditions as well as simplifying the media recipe to economically produce canker free trees. To achieve these results, we will be using various fungicides to try and mitigate contamination since the goal is to grow these axes in media under non-sterile conditions (Fig. 2). Minimizing the number of components in the media recipe is another goal we are trying to achieve that would simplify the process and make it more economical for users interested in growing trees from embryonic axes. This is a 2-year study and we are in the first year of experimentation. So far we have reduced the methodology in the laboratory such that any nursery operation could grow the nuts successfully without the presence of the canker growing on the plantlets with a few modifications to the technique currently used. The pre-treatment experiments at the greenhouse will be carried out this spring with nuts collected from the 2016 season. Our butternut research has been ongoing for the last three years and

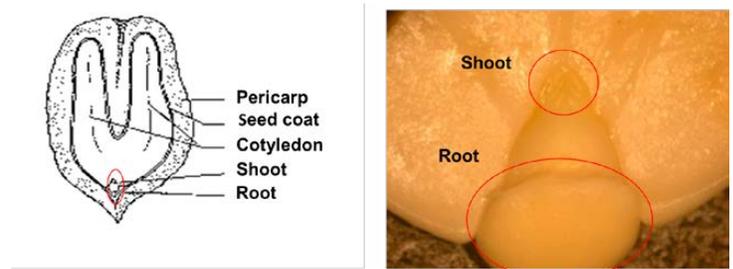


Figure 1. Embryo axis anatomy as prepared for tissue culturing.



Figure 2. Axes from phytatrays are transplanted into growing media and acclimatized in the greenhouse.

is hopefully helping in creating awareness at multiple levels of government and non-government agencies. This research project was established with collaborators such as: Interdepartmental Recovery Fund (Environment and Climate Change Canada 2016), NB Department of Energy and Resource Development, Notre Dame University, The Fundy Model Forest (FMF), Nature Trust of New Brunswick and the Nature Conservancy of Canada, Meduxnekeag River Association, First Nations of New Brunswick - The Maliseet Nation Conservation Council (MNCC), The Northern Nut Growers Association and all the NB private landowners that either helped collect nuts or locate trees and granted us access to their properties so we could do our work. We have produced a pamphlet detailing a few components of the project and a plan for the conservation of butternut's future.



Butternut conservation

Planning for the future

Butternut (*Juglans cinerea*) is a native tree species of central and eastern North America that is under serious threat from an introduced fungal disease (*Ophiognomonia clavignenti-juglandacearum*). In Canada, butternut can be found in southern Quebec and Ontario and in New Brunswick. The butternut populations in New Brunswick are considered to be the most genetically diverse and contain some of the last remaining uninfected butternut trees in North America.

The fungus infects butternut trees through buds, leaf scars, insect wounds and other openings in the bark. It is believed that rain splashing can move the fungal spores from infected branches to other branches and that insects and birds may inadvertently carry the spores to the trees. A characteristic sign of infection in a butternut is cankers that leak a blackish fluid from cracks in the bark after a rainfall or in humid weather. These cankers coalesce and eventually girdle the main trunk, killing the tree. Controlling infected trees is not possible. This fungal disease is a fundamental threat to butternut and has caused this species to die out throughout much of its natural range.

In 2005, butternut was listed as Endangered by the *Species at Risk Act (SARA)* in Canada. A federal recovery strategy was developed for butternut in 2010 and notes that recovery will likely depend on finding canker-resistant trees, conserving genetic material and instituting a program to restore viable populations. The work currently being carried out in New Brunswick is a key component of this recovery strategy.

Butternut canker has been found across the entire geographic range of butternut. It has killed up to 90 percent of the butternut population in some areas of the United States.

Butternut project

The butternut project is using seeds to conserve butternut in the long-term. Butternut seed cannot withstand much drying, and because of this, remains viable for only up to two or three years. Although whole seeds cannot be stored, research has shown that part of a butternut seed, the embryo, can be cryogenically preserved for many years in liquid nitrogen (-196°C). The National Tree Seed Centre in the Atlantic Forestry Centre in Fredericton, New Brunswick, has a cryogenic facility that can store close to 50,000 butternut samples.



Processing butternuts for storage

Butternut recovery strategy

Collecting seeds and preserving embryos in liquid nitrogen are key components of the SARA butternut recovery strategy. Cryopreservation will ensure long-term storage of viable material that will be available for future butternut recovery work. The SARA butternut recovery strategy includes:

- Developing reliable methods for screening materials that appear to be resistant.
- Investigating the genetic basis of resistance.
- Developing genetic markers to help identify resistance and hybrids.
- Assessing environmental factors related to canker resistance.
- Establishing breeding orchards.



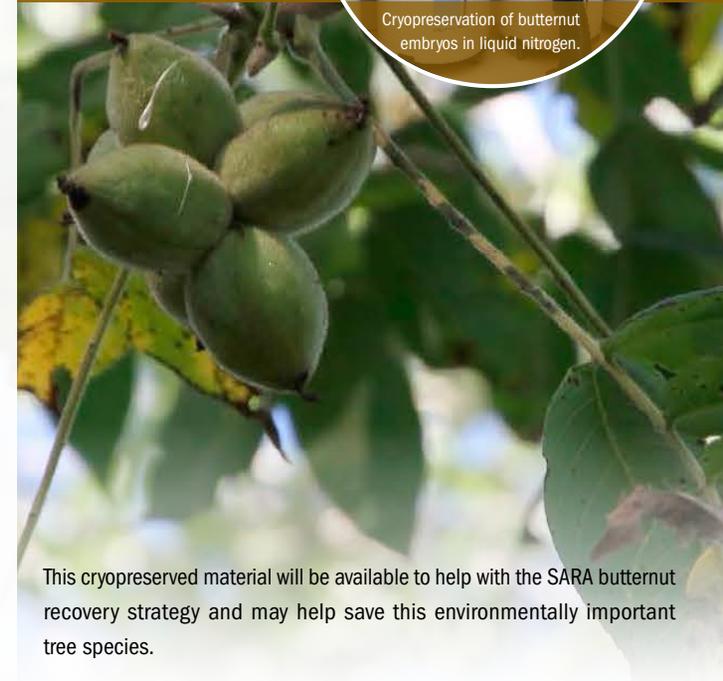
Collecting butternut seeds at Gilbert Island, New Brunswick

Butternut project activities in a nutshell

- Collect butternut seeds primarily from populations in New Brunswick.
- Perform DNA fingerprinting of all of the trees from which seed is collected. This will determine if the trees are pure butternut or hybrids and give us information about butternut genetic variation.
- Treat the butternut seeds so that they can tolerate cryopreservation and then place them in cryogenic storage (liquid nitrogen at -196°C) for long-term conservation.



Cryopreservation of butternut embryos in liquid nitrogen.



This cryopreserved material will be available to help with the SARA butternut recovery strategy and may help save this environmentally important tree species.

For more information, contact us at butternut@canada.ca.

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Tannis Beardmore, Kathleen Forbes and Martin Williams

Natural Resources Canada
Canadian Forest Service
Atlantic Forestry Centre
Fredericton, NB

Email: Martin.Williams@canada.ca

Tree Seed Testing Overview

Last August, Michèle and I asked, through the CFGA Google group, questions about germination tests. The Berthier Tree Seed Centre had to buy a new germination cabinet, and we wanted to know, from the people involved in testing, the following information:

- Which germination cabinet do you use (model) and how many do you have?
- Germination box (model, dimensions)?
- At which stage do you consider a seed as germinated (radicle, cotyledon)?

We received many answers. Dave Kolotelo suggested that we share this information in the Bulletin. Here it is (summarized on the next page).

We thank all the people who took time to answer us. We think that this group is an excellent communication tool in our seed community and that we all should use it more often!

Fabienne Colas and Michèle Bettez

Direction de la recherche forestière
Ministère des Forêts, de la Faune et des Parcs du Québec
Québec, QC

Email: fabienne.colas@mffp.gouv.qc.ca

Email: michele.bettez@mffp.gouv.qc.ca



From	Country	Organization	Germination cabinet	Germination box	Germination stage
Michèle Bettez	Canada	Berthier Tree Seed Centre (Quebec)	Conviron G30 (5 units)	Petawawa (Spencer Lemaire)	Visible cotyledons
Markku Nygren	Finland	Natural Resources Institute Finland (LUKE)	Flohr GC 10/11	Petri dish	4x length of a seed
Ulfstand Wennström	Sweden	Skogforsk	Jacobsens apparatus	Filter paper and germination bells on top to prevent direct evaporation.	The length of the seed
Heidi Rosok Bye	Norway	Norwegian Forest Seed Centre	Jacobsens apparatus	Filter paper and germination bells on top to prevent direct evaporation.	The length of the seed
Dale Simpson	Canada	Canadian Forest Service, National Tree Seed Centre	Conviron G30 (8 units) Conviron A-1000G (1 unit)	Petawawa	Laboratory Germination Vigour Class 3 for conifers
Greg Adams	Canada	JD Irving	Conviron	Spencer Lemaire Food container	Strong radicle emerging from seed (≥ 2.5 mm)
Peter Goodine	Canada	Atlantic Forest Seed Centre (Kingsclear Forest Nursery)	Conviron G30 (2 units)	Petawawa	Seed germinated when the radicle is one time length of seed.
Derk Herman Sluiter	Canada	Ontario Tree Seed Plant	Room germinator	Germination box from Seedburo 7 $\frac{7}{16}$ x 5 $\frac{5}{16}$ x 3 $\frac{3}{4}$ in Substrate = mix of half sterilized sand and half Perlite	Laboratory Germination Vigour Class 3 for conifers
Dave Kolotelo	Canada	BC Tree Seed Centre	Conviron G30 5 with CMP 3244 controller (one currently not functioning) 2 with CMP 3023 controller	Hoffman catalogue no. 91C, transparent polystyrene container with lid, 4 $\frac{5}{16}$ x 4 $\frac{5}{16}$ x 1 $\frac{1}{8}$ in	Radicle 4x length of seed coat, except Amabilis and Noble fir counted at 2x radicle length.
Lindsay Robb	Canada	Alberta Tree Improvement	ThermoScientific Model 818 (3759) – x2 Model PR505755L – x2 Conviron G30 – x3	Hoffman polystyrene 11 x 11 x 2.8 cm	4x seed length (with some exceptions)
Victor Vankus	US	USDA Forest Service	Percival GR-66L, 12 units (use walk in germ. rooms for most tests)	Two sizes of plastic containers from Tri-State Plastics, Inc., Latonia KY 049c 17 x 12 x 6 cm 195c 27 x 19 x 10 cm	Seedlings evaluated when large enough for the cotyledons to be clearly seen.



ATISC Seed Conservation Course

The Alberta Tree Improvement & Seed Centre (ATISC) is once again giving a free 2-day Seed Conservation Course in early 2017. The course covers topics right from seed assessment before harvest and correct seed handling, all the way through to understanding seed storage longevity, germination issues and techniques. There is a cut testing lab to look at seed morphology and how this can inform germination testing plus a group germination problem solving exercise to help everyone feel more comfortable using their new knowledge in a practical way.

The course instructor is the Provincial Seed Specialist at ATISC. Lindsay gained an MSc in premeditation working with green alders and mycorrhizae on the Sudbury Barrens in Ontario and then spent five years as germination & longevity specialist at the Millennium Seed Bank, part of the Royal Botanic Gardens, Kew. She has taught both in-house and traveled to many countries around the world training others in seed conservation management and science.

Attendance for the course is free but space is limited and the date is 27 & 28th February from 8:30 - 16:30 both days. Attendance for only one day is not permitted. To sign up or if you have any questions or concerns about course content and applicability, please send an email to Lindsay Robb at lindsay.rob@gov.ab.ca

Lindsay Robb

Alberta Agriculture & Forestry
Alberta Tree Improvement & Seed Centre
Smoky Lake, AB
Email: lindsay.rob@gov.ab.ca

Upcoming Meetings

National Native Seed Conference

February 13–16, 2017 Washington, DC
<https://nativeseed.info/>

International Seed Testing Association (ISTA) Annual Meeting

June 19–22, 2017 Denver, Colorado
<https://www.seedtest.org/en/ista-annual-meeting-2017-content--1-1482-970.html>

Forest Genetics 2017 (joint CFGA / WFGA Conference)
Forest Health and Productivity in Changing Environments
June 26–29, 2017 Edmonton, Alberta
<http://www.forestgenetics2017.ca/>

International Society for Seed Science Conference
September 10–14, 2017 Monterey, California
<http://seedscisoc.org/category/events/>

Whitebark Pine Ecosystem Foundation Annual Workshop
September 21–22, 2017 Jasper, Alberta
<http://www.whitebarkpine.ca/jasper-2017.html>

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