Tree Seed Working Group Workshop

The Importance of Cone & Seed Services

2019 Canadian Forest Genetics Association Conference
Conference de l'Association canadienne de génétique forestière 2019

August 19, 2019, Lac Delage, Quebec, Canada

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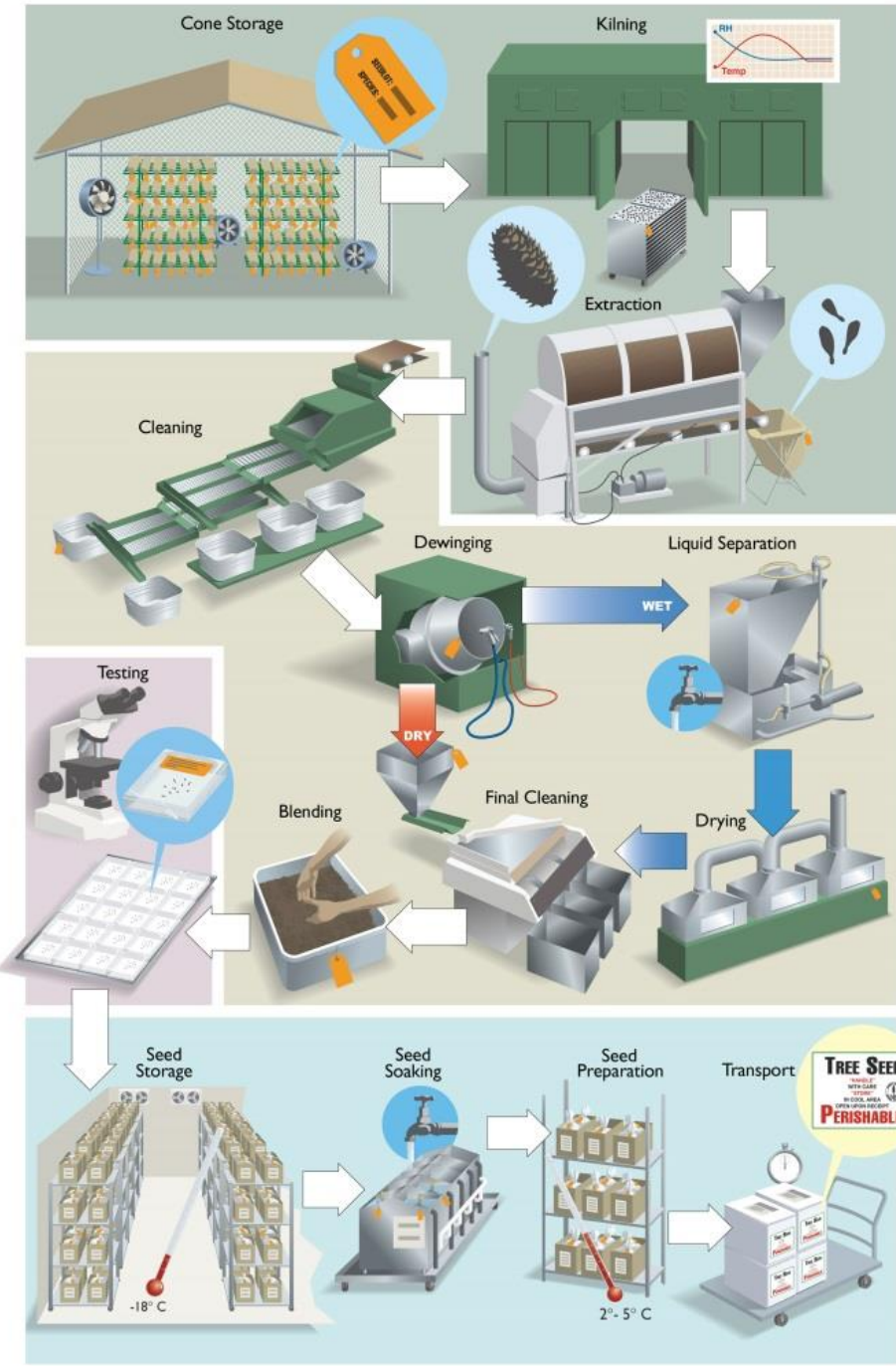
Workshop Outline

- **1:00** **Tree Seed Working Group (TSWG) Overview**
- **1:10** **In Memoriam, Anniversaries & Facility Closures**
- **1:15** **Issue Background and Survey Results**
- **1:30** **Crop Development and Training:** Melissa Spearing
- **1:45** **Cone Crop Challenges:** Fabienne Colas
- **2:00** **Genetic Conservation:** Dave Kolotelo
- **2:15** **BREAK**
- **2:30** **Appropriate Facilities & Expertise:** Melissa Spearing
- **2:45** **Storage, Testing & Seed Preparation:** Fabienne Colas
- **3:00** **New Tools:** Dave Kolotelo
- **3:15** **Questions / Discussion**



Cone & Seed Services: Critical Part of the System

Clients /Stakeholders/ Community of Practice

Cone Collection

Post-Collection Handling

Cone Processing

Seed Processing

Testing

Registration

Storage

Pretreatment

Sowing

Information / Knowledge Management

Continuous Improvement / Quality Assurance

Please Join the Tree Seed Working Group

- Active CTIA/CFGA Working Group since 1983
- Main activities: News Bulletin published biannually (280+ subscribers) and CFGA workshop held biennially
- News Bulletin is recognized by Library & Archives
- Canada as a “part of Canada’s published heritage”
- Archive hosted on BC TSC website: [www2.gov.bc.ca/[…]/tree-seed-working-group](www2.gov.bc.ca/[…]/tree-seed-working-group)

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CFGA's Tree Seed Working Group has four objectives on promoting tree seed science and technology through:

- **Seed research from bud initiation to seed use**
- **Identification of seed problems relating to tree improvement and forest management**
- **Exchange of information on seed related problems**
- **Advising on implementation practices**

We need to continue knowledge transfer in our specialized and evolving field to support both the scientific and applied information needs.

This is an important compliment to the refereed journals to extend practical information, knowledge and wisdom to those dealing with tree seed.

In Memoriam (2017-2019)

Ben Wang (Canadian Forest Service, CFS Seed Scientist)

Heather Rooke (BC Tree Seed Centre)

Dr. Michael Carlson (BC Tree Breeder)

Jim Corrigan (BC Provincial Seed Orchard Pest Biologist)

Dr. John Russell (BC Tree Breeder)

John Ogg (BC Cowichan Lake Research Station)

Dave Wallinger (BC cone collecting and tree planting pioneer)

Dr. Marek Krasowski (UNB Professor)

Ted Cormier (The Seed Source, Ontario seed collector)

The TSWG News Bulletin is a potential forum for honouring colleagues not only their passing, but for their achievements too!

Major Anniversaries (2017-2019)

CFS Petawawa Research Forest – 100 years

BC Tree Seed Centre – 60 years

J.D. Irving – 60 years, over 1 billion trees planted

Wooddale Provincial Tree Nursery, NL – 45 years

TimberWest Seed Orchards – 40 years

PRT (Pacific Regeneration Technologies) – 30 years

Vernon Seed Orchard Company – 30 years

Why Our Theme?

Reaffirm the importance of cone and seed services and identify knowledge gaps

Facility Closures

- Ontario Tree Seed Plant, Pineland Nursery, many nurseries in Canada and USA
- In BC, the last time we had a cone crop this large we had four seed processing plants

Rapid Succession

- Baby boomers – reductions in government programs / responsibilities
- Loss of practical wisdom , expertise, and field knowledge

Services Taken for Granted

- Lack of understanding of the tree improvement **delivery system**
- Lack of funding in research, extension in practical seed production / processing
- We don't know it all and our product is changing (with climate change / orchard seed)

A Tree Seed Centre requires large capital investment

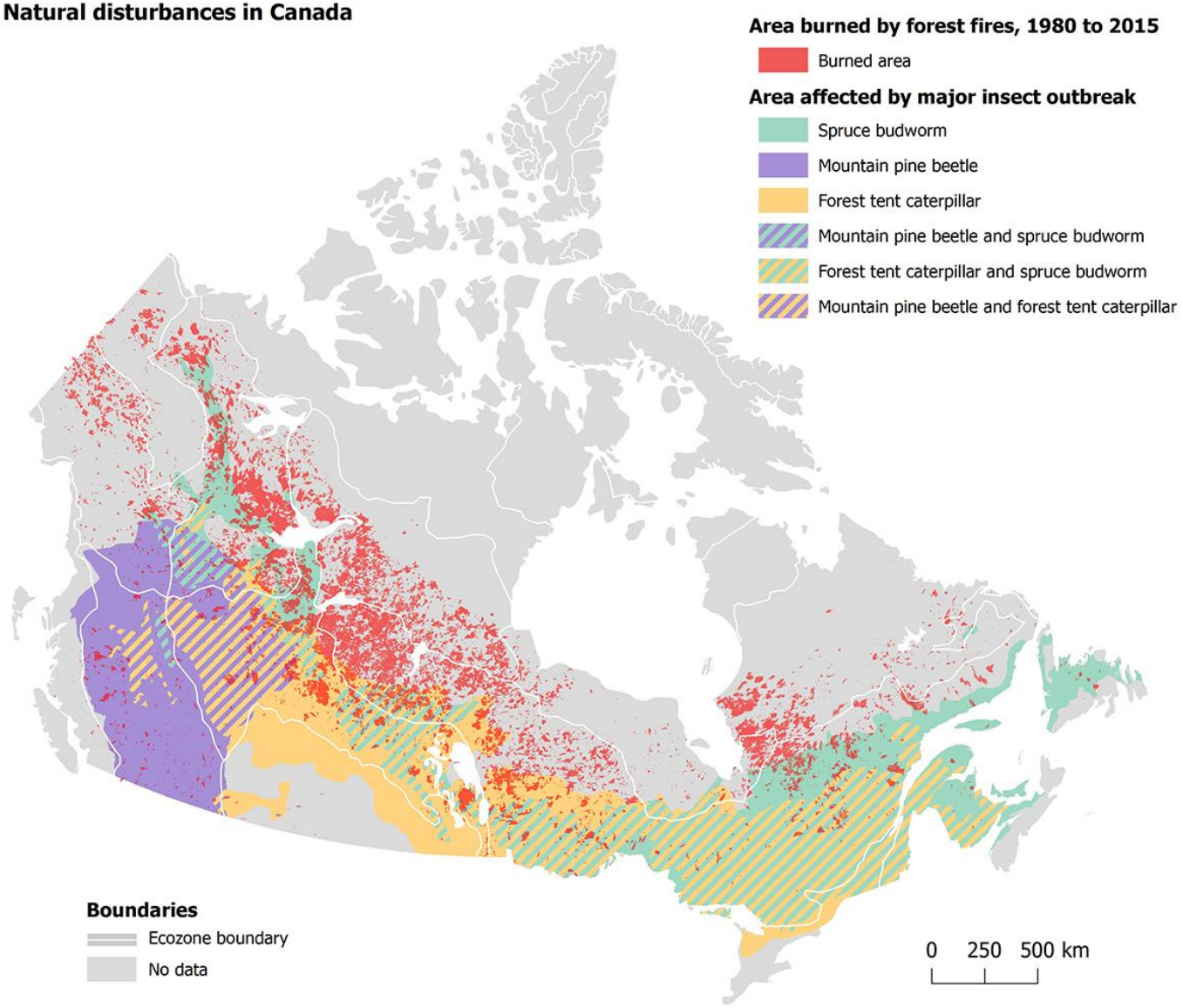
- Not a great business case: highly variable crops, lack of substantial export markets
- The public sector should be involved as part of their **stewardship** mandate

Where does the TSWG want to be in 2049?

Is Canada's seed and orchard system ready for more stressors on regeneration needs?

What contingency plans are in place for seed production and services?

Map 2.3
Natural disturbances in Canada



Notes: Areas affected by major insect outbreaks represent the geographical range of insects. Burned areas regenerate over time and therefore will be in varying stages of succession.

Sources: Natural Resources Canada, 2015, "Where do forest fires and insect outbreaks affect Canada's forests," *The State of Canada's Forests,* 2015, http://cfs.nrcan.gc.ca/publications?id=36108 (accessed July 2, 2017); Natural Resources Canada, 2017, *Canadian Wildland Fire Information System,* http://cwfis.cfs.nrcan.gc.ca/datamart (accessed August 16, 2017); Statistics Canada, Environment, Energy and Transportation Statistics Division, 2018.

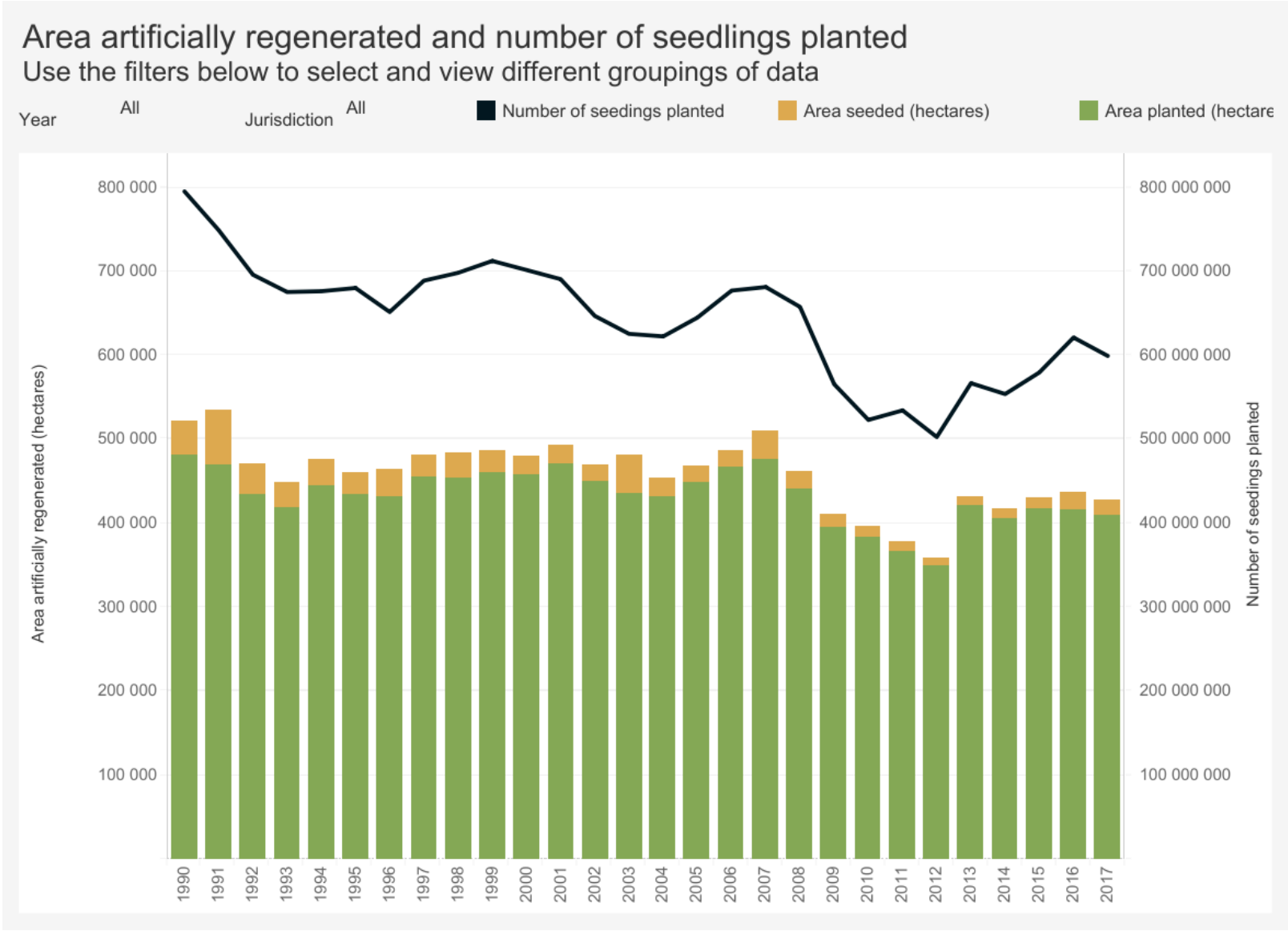
Seed: Whose Responsibility Is It?

- **Champion TEAMS (private or public sector) make this work!**
- Policy and decision-making tools must be easy science to implement
- **Who is doing cost-benefit analysis of seed production for large programs/jurisdictions?**
- **Without public support, private sector focus and capacity narrows**

Ministry of Forests… Forest Improvement and Research Management Branch	**Licensees/BCTS**	**Academia**
Research	Harvesting	Research
Tree Breeding	Silviculture	Education
Seed Orchards	Seed Planning	(Climate modelling)
Policy and Planning	Seed Orchards	(In situ catalogue)
Tree Seed Centre	Reporting	
Information Systems		
Region/Districts	**Private Companies**	
Authorizations	Seed Orchards	Cone collections
Silviculture	Seedling Nurseries	Stock Coordination
Compliance and Enforcement	Field test measurement and maintenance	Planting

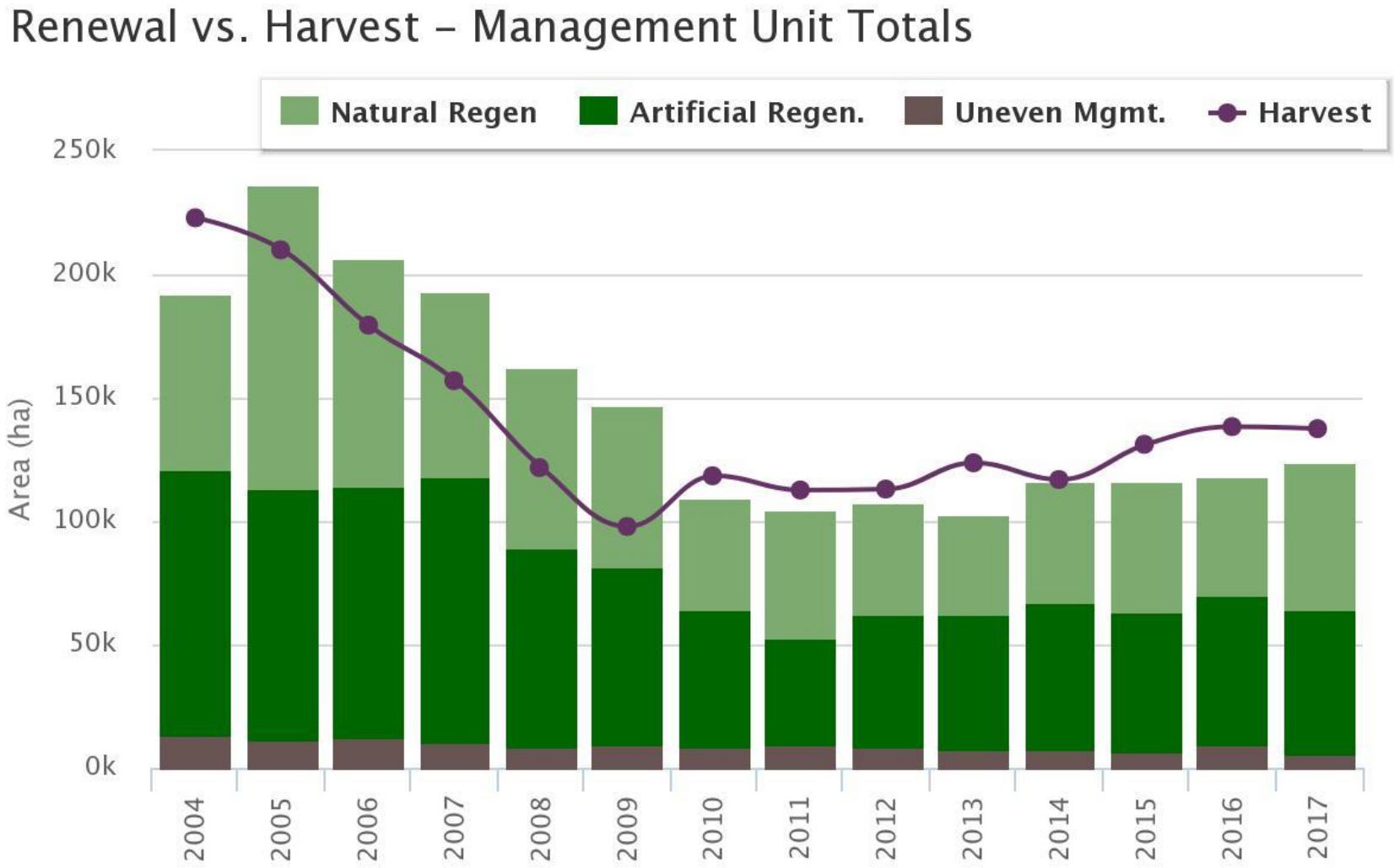
1990-2017 Canadian Artificial Regeneration Area (ha) and Number of Seedlings Planted and Aerial Seeding (ha)

Source:
http://nfdp.ccfm.org/en/data/regeneration.php#tab621



Regional Perspective: Ontario

- ~50% natural regeneration, higher in Great Lakes-St. Lawrence forest, offers less opportunity to affect large ha with climate-ready genetics than boreal cuts
- Tree planting viewed as costly treatment
- **Contingency planning for seed now falls entirely on Crown land licensees, FGRM Associations and private seed services**
- **What happens if [__]?**



TSWG Membership Survey: 1985 vs 2019

- 1985 Member Directory (TSWG News Bulletin No. 3)
- Intention to recreate Ben Wang's survey with each jurisdiction having current geneticists, seed policy staff, seed technicians, orchard managers, pest/pathogen, and private sector suppliers listed for a new Directory.
- Comparison below with voluntary responses to date (*other includes CFS/NRCAN staff and other countries):

YR	NL	NS	PEI	NB	QC	ON	SK	MB	AB	BC	USA	Other *	Total
1985	4	3	1	14	9	14	2	0	7	24	7	19	**104**
2019	0	0	1	1	4	4	0	0	2	10	13	8	**43**

TSWG Membership Survey 2019

- Please fill out the survey (pre-Conference Qs will be removed): https://forms.gle/EQ9Y5mZW1q57xEtf7
- Answers will help guide future TSWG themed issues and request expertise on challenging topics
- Ideas for TSWG engagement across new platforms (webinars, virtual conferences) in this age of travel restrictions/budget/carbon accounting – better cross-pollination between members.

TSWG Membership Priorities

Survey includes priority-setting on 25 seed-related issues.
Of 43 current survey respondents, the top ranked priorities for each category are:

High Priority	Medium Priority	Low Priority
1. Cone and seed collectors – efficiency, shortages, training, etc	1. Reproductive biology and seed population ecology	1. Electrical conductivity and role in predicting seed germination
1. Upgrading seed storage protocols and practices	2. Diseases affecting seed crops	2. Water activity tools for seed handling and storage
2. Insect pests affecting crops	3. Seed biochemistry or physiology	2. Applied genomic tools
2. Tree seed diversity in practice	3. Seed maturity indices	2. Seed pelleting technology
3. Seed orchard management	**3. Post-secondary education (seed)**	3. Data management tools
3. Seed germination & viability	4. Seed and cone yield analysis	4. Filling ex situ conservation gaps

US State Nursery & Seed Trends

A 2016 survey of issues facing state nursery managers and foresters aligns with many issues in our TSWG survey.

21 states do not have a tree improvement/genetics program within their agency, but 30 agencies manage seed orchards.

Source:
https://www.stateforesters.org/wp-content/uploads/2018/08/NASF-Report-National-Survey-of-State-Operated-Tree-Seedling-and-Tree-Improvement-Programs.pdf

What are the main challenges that your nursery operation faces? Check all that apply

Answer Options	Response Percent	Response Count
Decreasing seedling demand	65.5%	19
Increasing seedling demand	17.2%	5
Pressure from commercial interests to shut down	27.6%	8
Budget pressure to cut funding	41.4%	12
Budget pressure to offset more of costs from increased sales revenue	24.1%	7
Difficulty hiring skilled personnel	58.6%	17
Shortages of laborers	58.6%	17
Difficulty procuring source-identified seed for native species	34.5%	10
Difficulty obtaining genetically improved seed	10.3%	3
Access to methyl bromide	17.2%	5
Need for more technical information around planting/tending/seed treatment requirements for specific species	20.7%	6

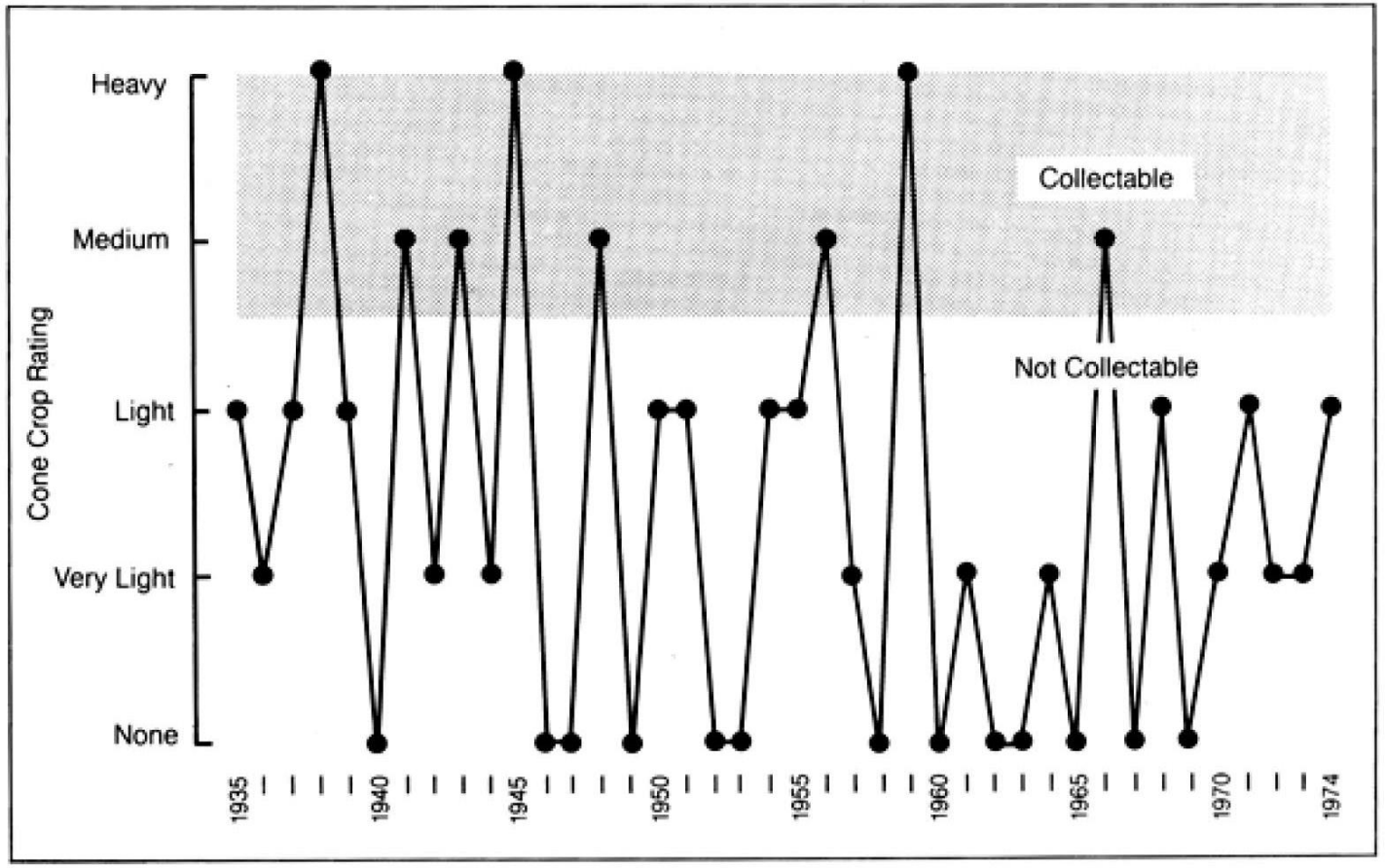
Crop Development & Training

Species	May	Jun	Jul	Aug	Sep	Oct
Eastern White Pine *(Pinus strobus)*						

Photos by Brian Swaile, Melissa Spearing, Barb Boysen, Sean Fox and Glenn McLeod.

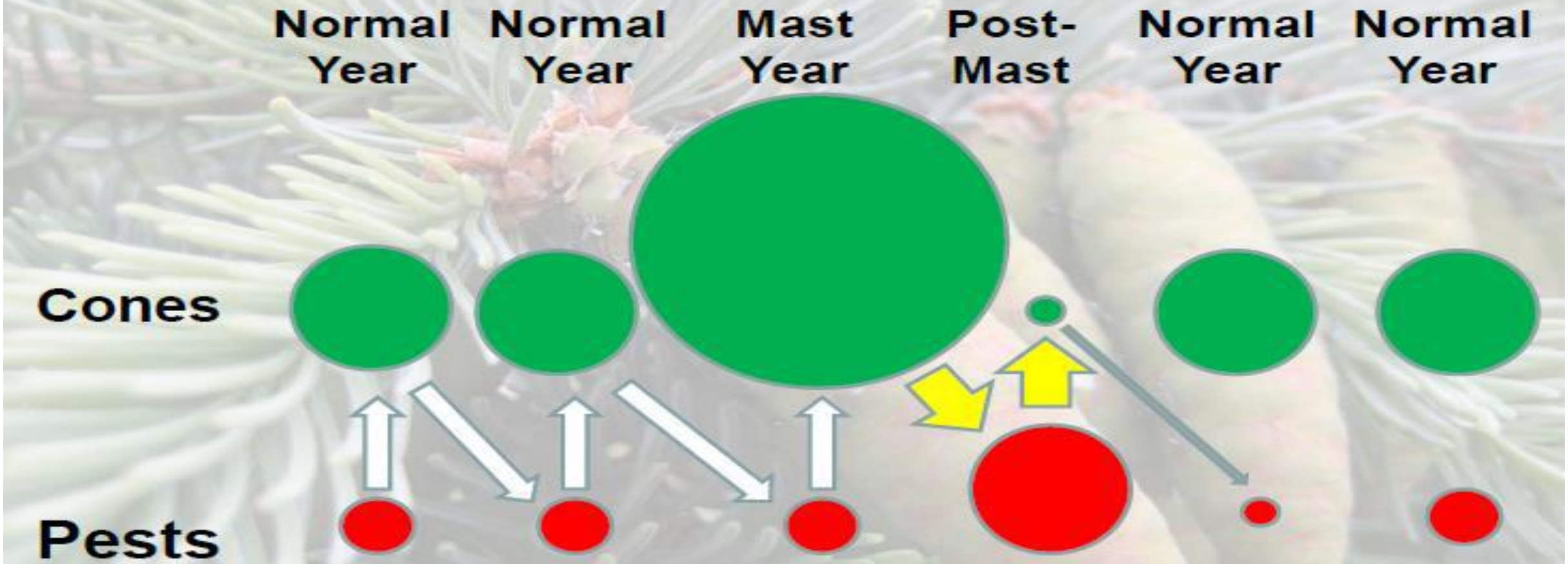
Decades-Long Learning Curve

- **1930-1970s:** wild stand periodicity and cost to collect alleviated with orchards and flowering induction
- **Competition for labour** amongst forestry, agriculture, horticulture, cannabis and seasonal industries will require innovative solutions or more $$$ to maintain capacity
- **2020-2040: delivering genomic discoveries and climate-based seed transfer will again rest on operational staff and programs**



Douglas Fir collection records. From the Province of BC, Ministry of Forests, Lands and Natural Resource Operations.

Big Crop – Small Crop Ecology

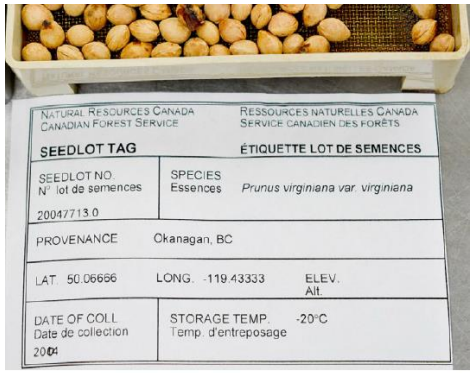


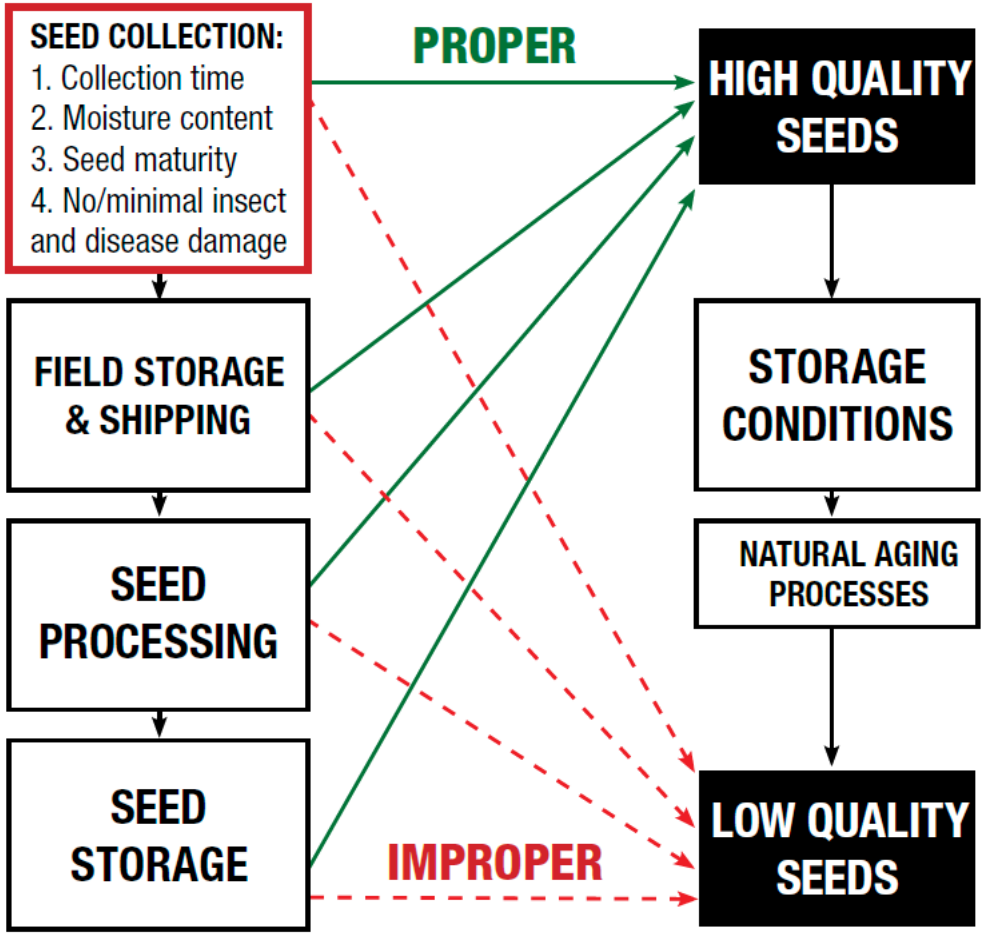
Notes: In normal years, the pest population takes a small proportion of the crop. The mast crop overwhelms the pest populations' abilities to exploit a large volume of host material, but all the pests find cones for reproduction. In the post-mast year, unusually large pest populations are attacking an unusually small cone crop. While this crop will be devastated, the small number of cones available for attack in the post-mast year reduces the pest populations to very low levels for the next growing season.

Quality & Source ID Depends on the Collector

Factors to Maintain Physiological Quality

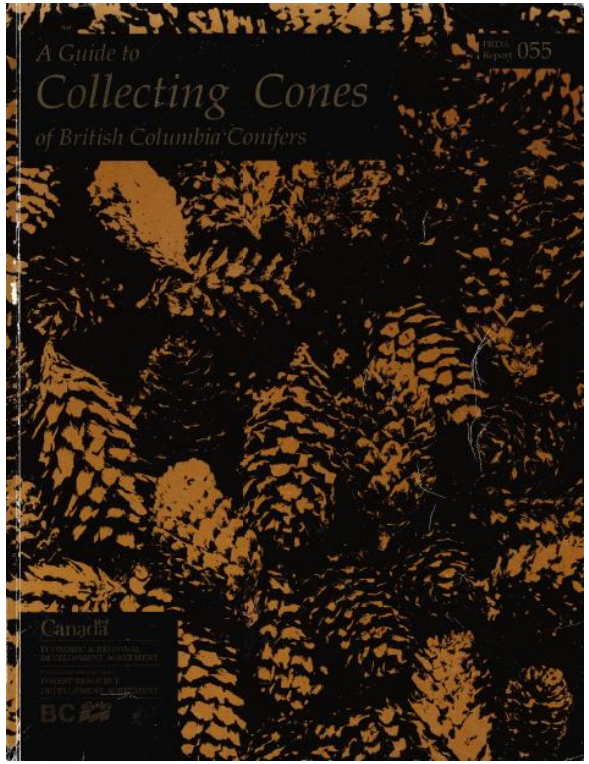
The final quality factors collectors control!



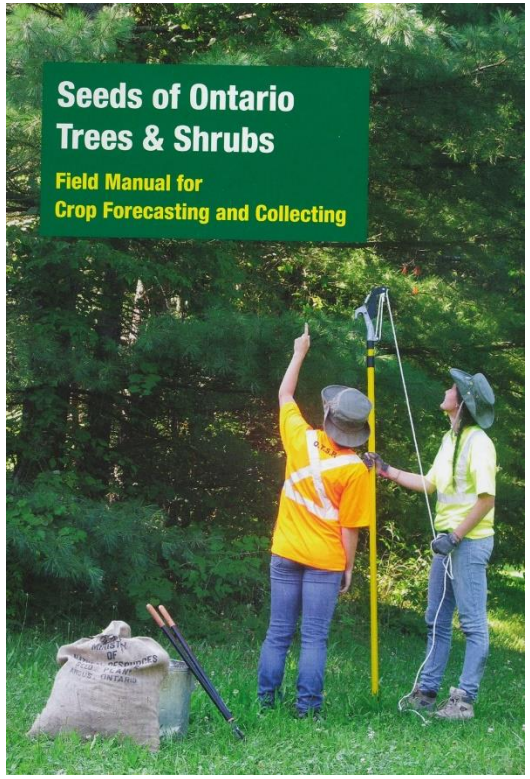


Guides for Training New Collectors

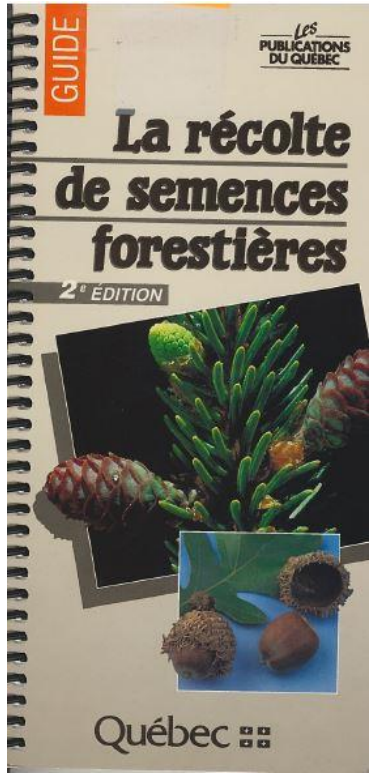
British Columbia



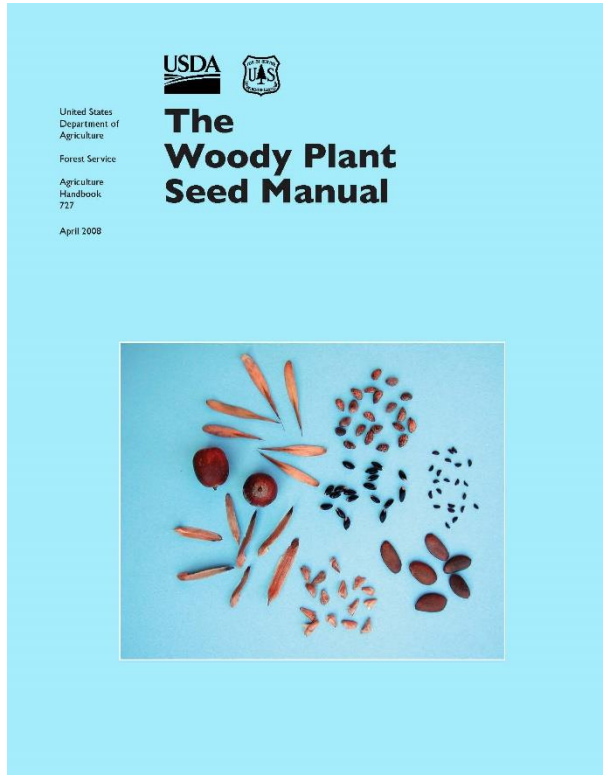
Ontario



Québec



US Forest Service



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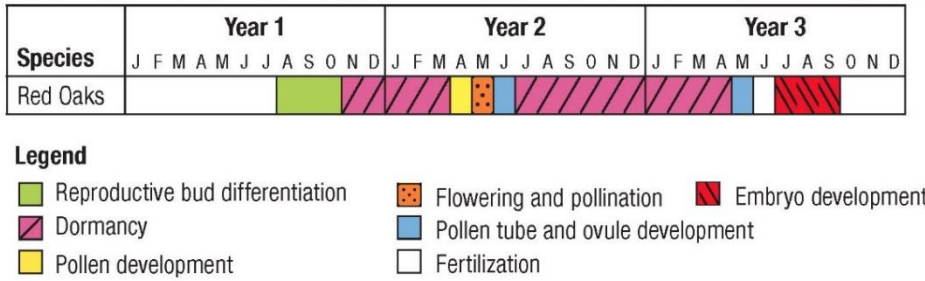
SEEDS OF SUCCESS

Low Volume, High Complexity Hardwoods

Red Oak Group: 3-Season Cycle



Tulip Tree: Low filled seed %, inbred, fragmented stands


Photo by Melissa Spearing
112


Photo by Brian Swaile


Photo by Melissa Spearing


Dewinged seed. Photo by Melissa Spearing
113

White Oak Group: Predation, often germinates in 36 hours!


Photo by Melissa Spearing
178


Photo by Melissa Spearing


Photo by Melissa Spearing

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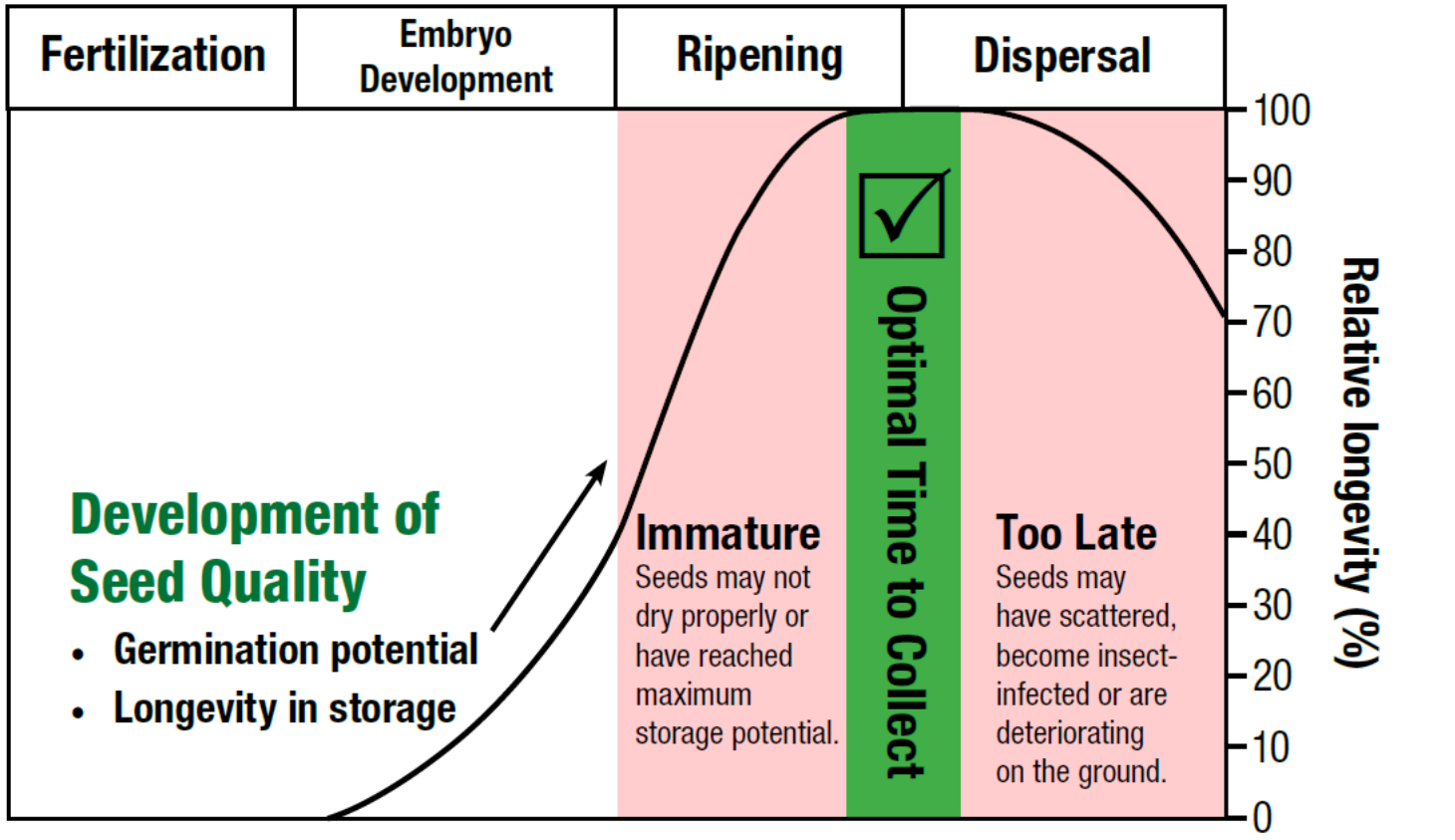
Investment in small grafted hardwood seed orchards would improve germination % and infuse *Ne*/genetic diversity.

When to Harvest?

- It's human-nature to "jump the gun"!
- Immature seeds and cones are more susceptible to damage in processing
- **Even the best collectors push early if the season is busy!**



Adapted from Seed Conservation Techniques Course, Seed Quality Presentation. Copyright 2014, Board of Trustees RBG Kew.

When to Harvest?

Sugar Maple filament

White Spruce (1000-1300 GDDs (base 5C) or Fireweed

Limber Pine (*Pinus flexilis* E.James) Seed Harvest Timing and ex situ Cone Maturation

Windy Point		Embryo length	Initial Germination	Desiccation Tolerance	Longevity	Growing Degree Days
1 8 Aug	in situ					662
	ex situ					
2 21 Aug	in situ					767
	ex situ					
3 4 Sept	in situ					862
	ex situ					
4 18 Sept	in situ					943
	ex situ					

Prairie Bluff		Embryo length	Initial Germination	Desiccation Tolerance	Longevity	Growing Degree Days
1 9 Aug	in situ					734
	ex situ					
2 22 Aug	in situ					834
	ex situ					
3 4 Sept	in situ					942
	ex situ					
4 16 Sept	in situ					1035
	ex situ					
5 13 Oct	in situ					1144
	ex situ					

Lindsay Robb, Provincial Seed Specialist
lindsay.robb@gov.ab.ca
Alberta Tree Improvement & Seed Centre, Smoky Lake, Alberta, Canada, T0A 3C0

Alberta Canada

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Field Cut Tests

Ontario Tree Seed Plant

Acceptable ½ Counts:

White Pine: 8-12

Red Pine: 4-8

White Spruce: 10-14

Norway Spruce: 12-16

Hemlock: 4-6

European Larch: 4-6

$/hL to collector reduced if less

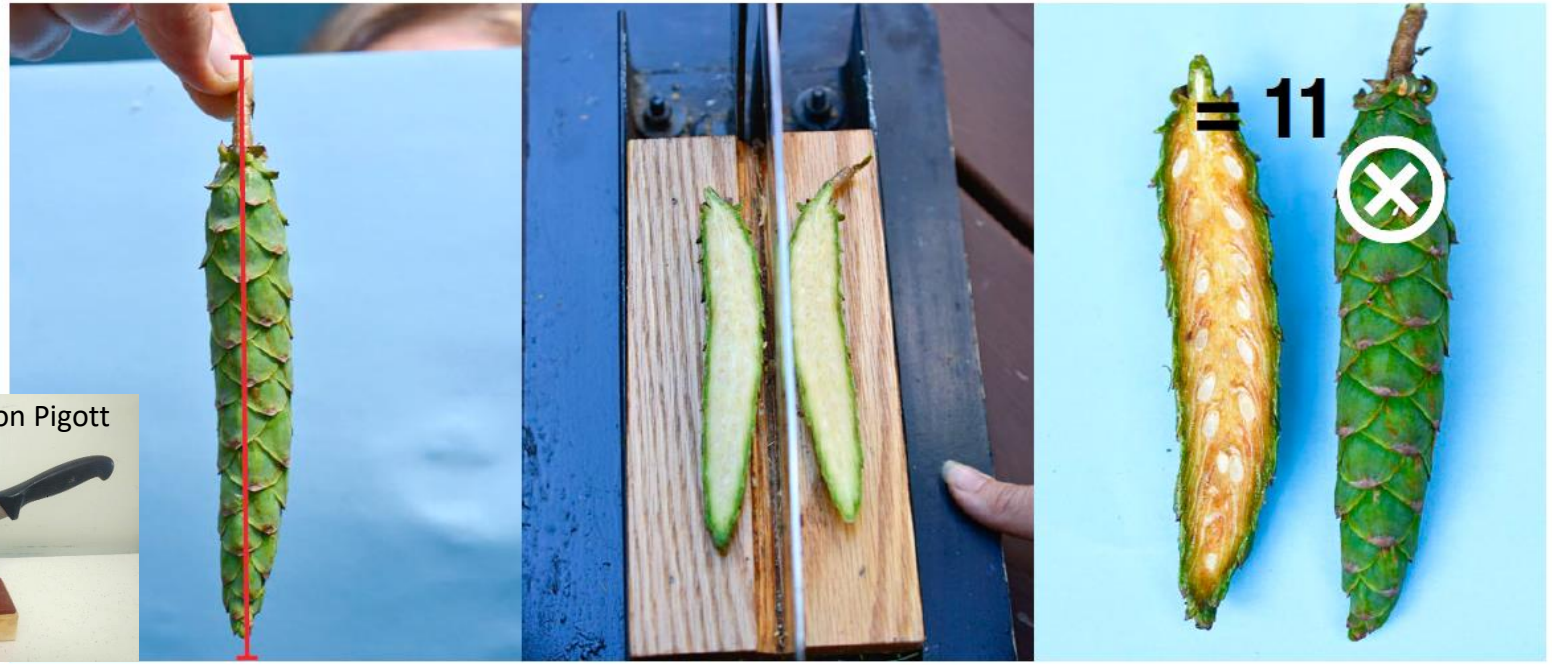
How to Cut Cones

Refer to Page 32

1) Align vertical axis with a sharp blade.

2) Cut cleanly in half. Watch your fingers!

3) Turn one side over and count only one half section.

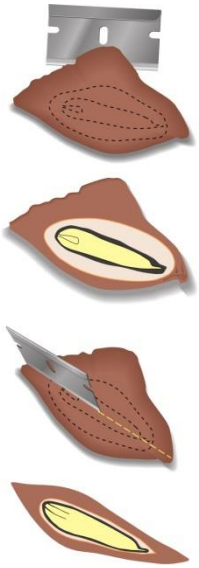


Photos by Melissa Spearing

Cone Cutter: Don Pigott

Kalamalka Seed Orchard (Chris Walsh and Gary Giampa) – Douglas-Fir

- Cutting tests are the basis of our operational decisions in collection timing, processing and ‘problem’ seedlot investigations
- Low tech = **everyone can do them** – razor blade and magnifier
- **Viable / Non-Viable classification** to more complicated classifications



Date of Tests		Viable	Questionable Viability			Immature		Non-viable	
Tests Performed by:					EMBRYO				
		Good	Normal	Normal	Deteriorated translucent rubbery	Development problems	Development problems	Rotten	Comments/other
Seedlot/ Sample	# of seeds				MEGAGAMETOPHYTE				
		Good	Slight discolouration	Grey/Yellow deteriorated	Grey/Yellow deteriorated	Normal	Shrunken/ discoloured	Rotten	

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The Good, The Bad & The Uncertain

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Seeds can be classified based on anatomy (viable / non-viable), but it is not always possible to determine what happened to the seed

Lodgepole Pine Cone Classes for Collectors

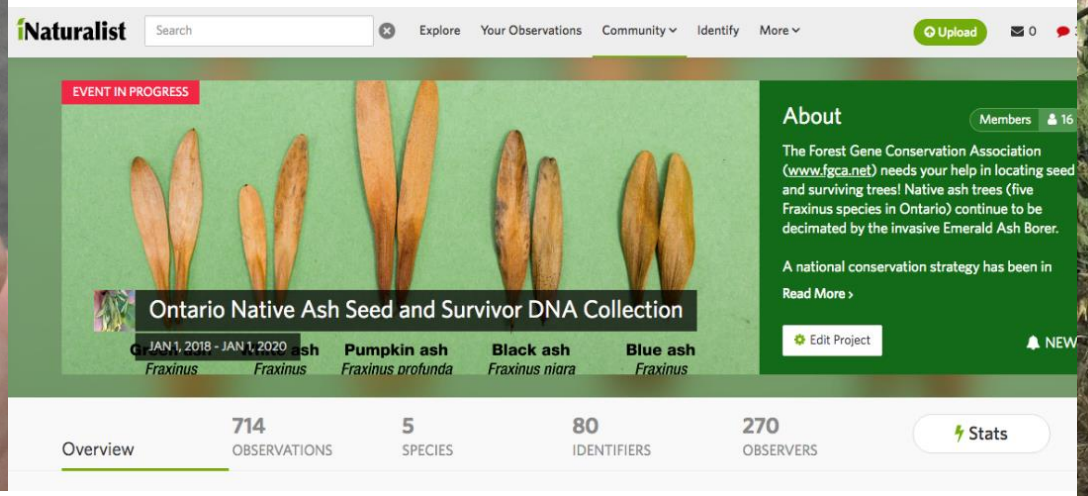
This is a rock!

How to Harvest

- Permits, safety, insurance
- Proper equipment
- Helicopter rake
- Ladders/lifts/climb
- Slash from harvest blocks
- Hand-pick/shake/topping
- Squirrel caches
- Ground collections (hardwoods)

Special Collections

- Only the most trusted collectors, botanists or specialists; “citizen scientists” or volunteers often used for low $ but research utility variable
- Need budgets for regulars to forecast, travel



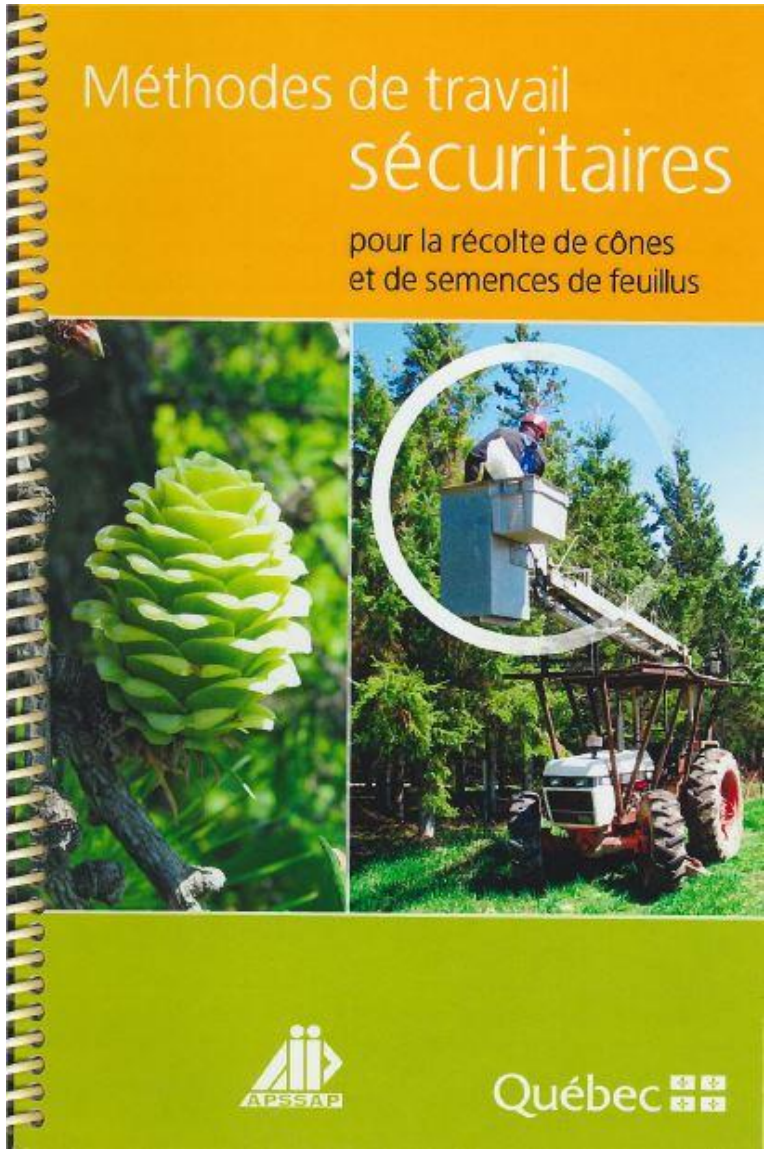
Always Think Safety!

Often seed collecting is a team effort but be **PREPARED** and **ORGANIZED** whether you are collecting alone or leading others. Plan ahead for:

- Sun exposure and heat stress
- Bug bites, bee stings and ticks (Epi-Pen?)
- Poison ivy
- Very hot or cold weather
- Cuts, bruises or more (bring a first aid kit!)
- Hunting season (wear high-vis vests)
- Wildlife encounters
- Ladder use
- Road safety
- Physical limitations of young and young-at-heart
- Cleanliness (soap and water, pitch cleaner)
- Emergency exit routes and a charged cell phone

Sun Safety

Poison ivy



British Columbia:
https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/tree-seed/cone-collection-workshops/cone_collection_safety__methods.pdf

What Keeps People Collecting?

- Money, sure…
- Hope for the future, worry about climate impacts
- Desire to not see knowledge or familiar species disappear
- Time outdoors; working with like-minded folks, teaching the next gen
- Satisfaction you've done something important

Dale Simpson in NTSC Freezer >

< Melissa Spearing, dead white ash

Kim Creasey

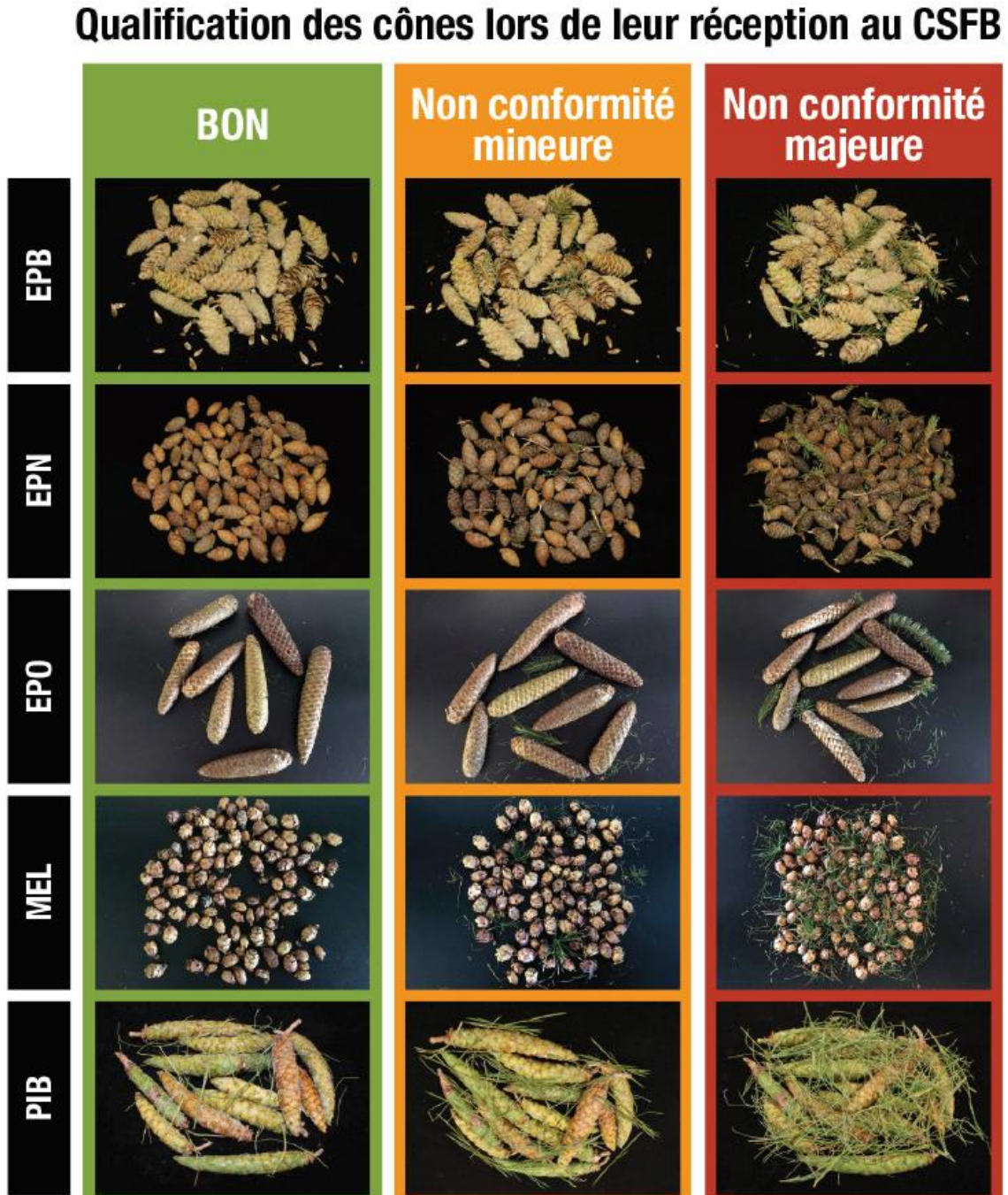
Eric Davies: Toronto Ravine Heritage Tree Seed Collections

Cone Crop Challenges: Quality Obtained

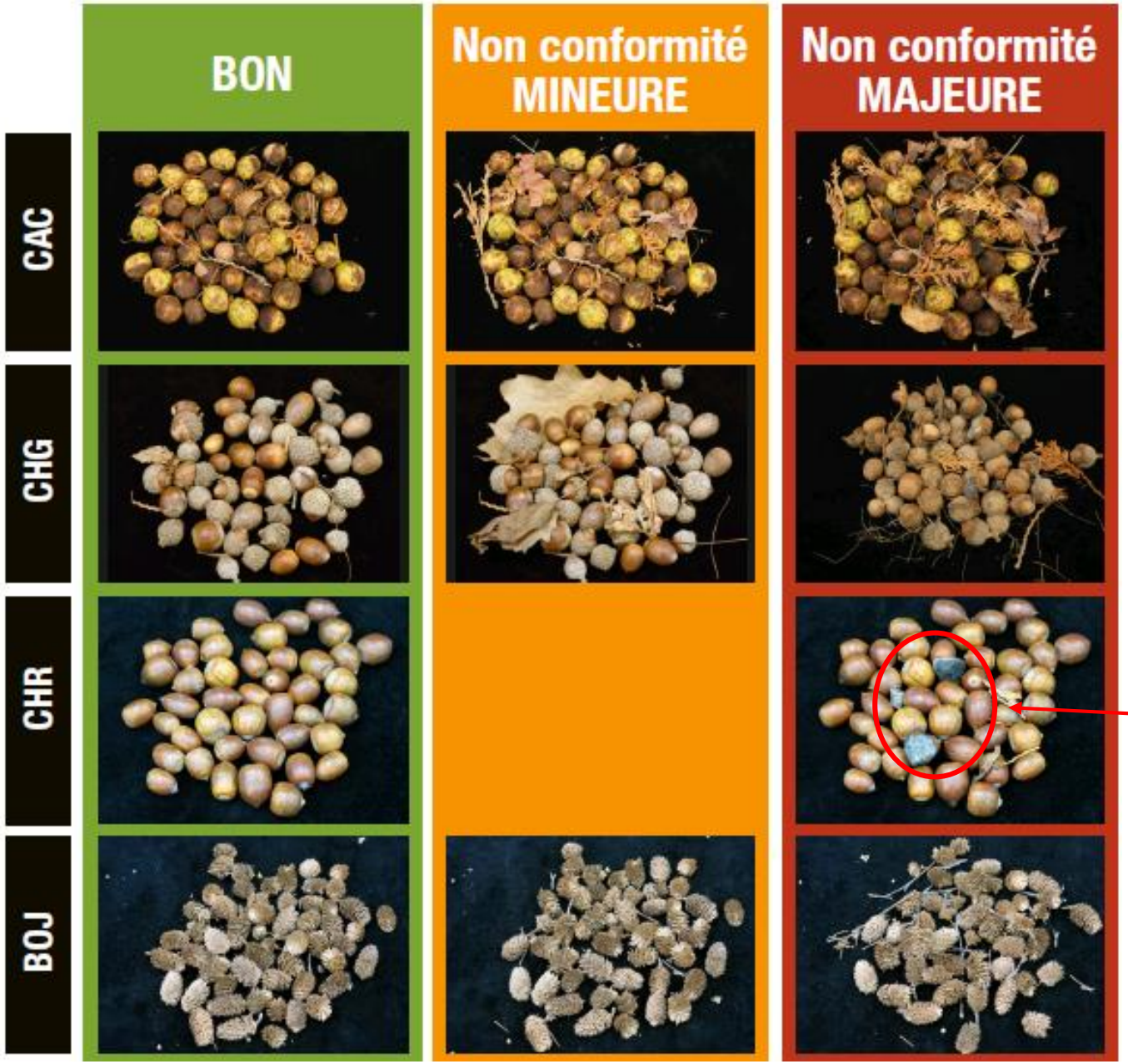
- Cone and seed qualification at the TSC
- The cleaner, the better.
- Standards established with ISO certification.
- We pay for good cones and seeds, not for needles, rocks…

Collecting and cleaning red oak (Quercus rubra) acorns; it is perfectly acceptable to rake up debris but should be floated off before shipping. Photos by Ron Thayer.

CONIFERS


Qualification des cônes lors de leur réception au CSFB
BON
Non conformité mineure
Non conformité majeure
EPB
EPN
EPO
MEL
PIB

HARDWOODS


BON
Non conformité MINEURE
Non conformité MAJEURE
CAC
CHG
CHR
BOJ
Rocks!

Cone Crop Challenges: Quality Obtained

Traceability

- Accuracy of information: where, when?
  - Standard label
  - Need to double check
- How to control harvest?
  - Trust the collector or certify in the field?

Cone Crop Challenges: Transfer to Seed Centre

- Time lap between harvest and transfer (cost reduction)
- Conservation in temporary sheds: temperature and humidity control.
- Protection from rodents and weather
- Need attention mainly with moist cones.

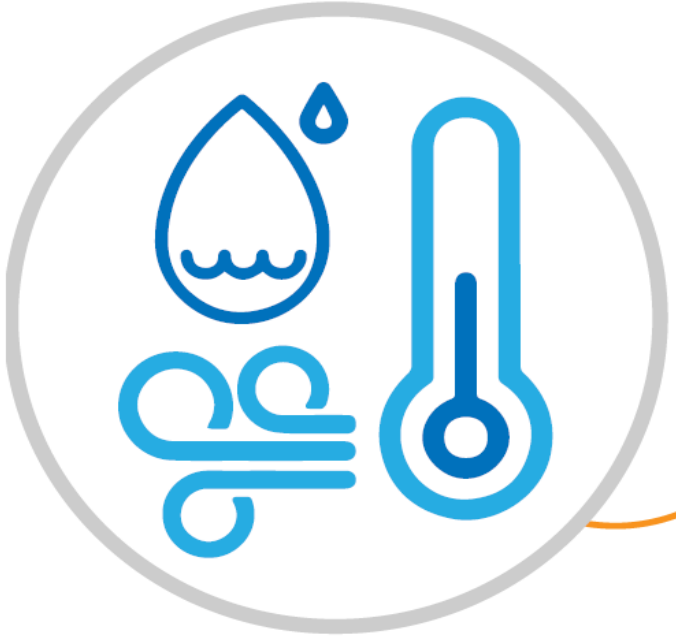


Image of overheating white spruce cone bags. Photo by Sarah Drabble-Biegould, MNRF.

Evolution of Cone MC and Weight

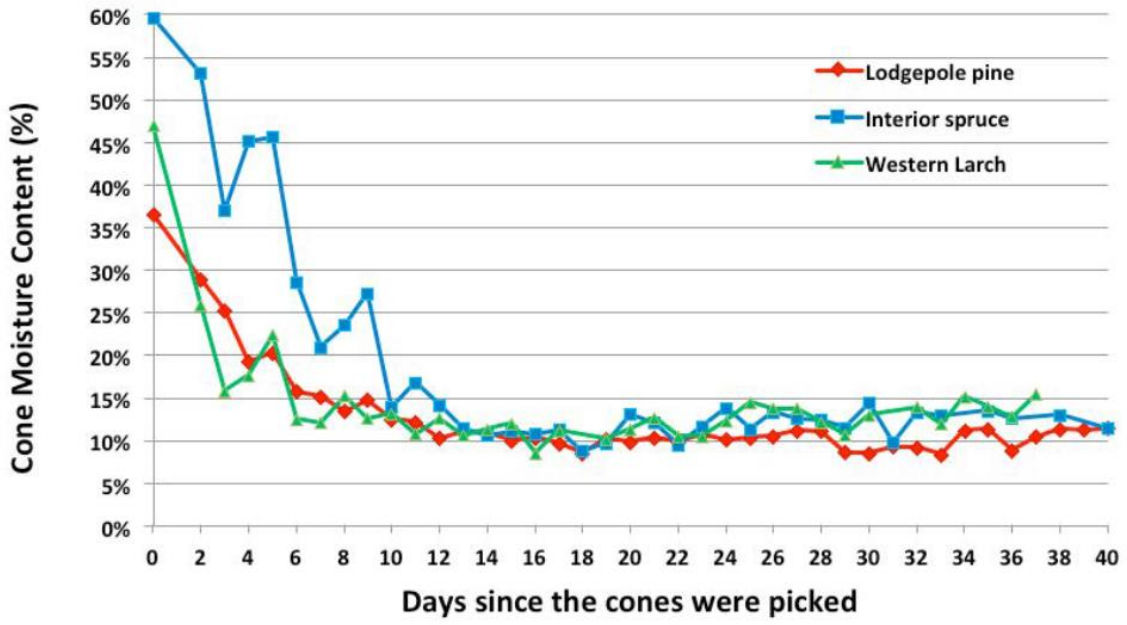


Figure 1. The pattern of cone moisture content averaged across 2015 and 2016 samples for three species at Kalamalka seed orchards in Vernon, BC.

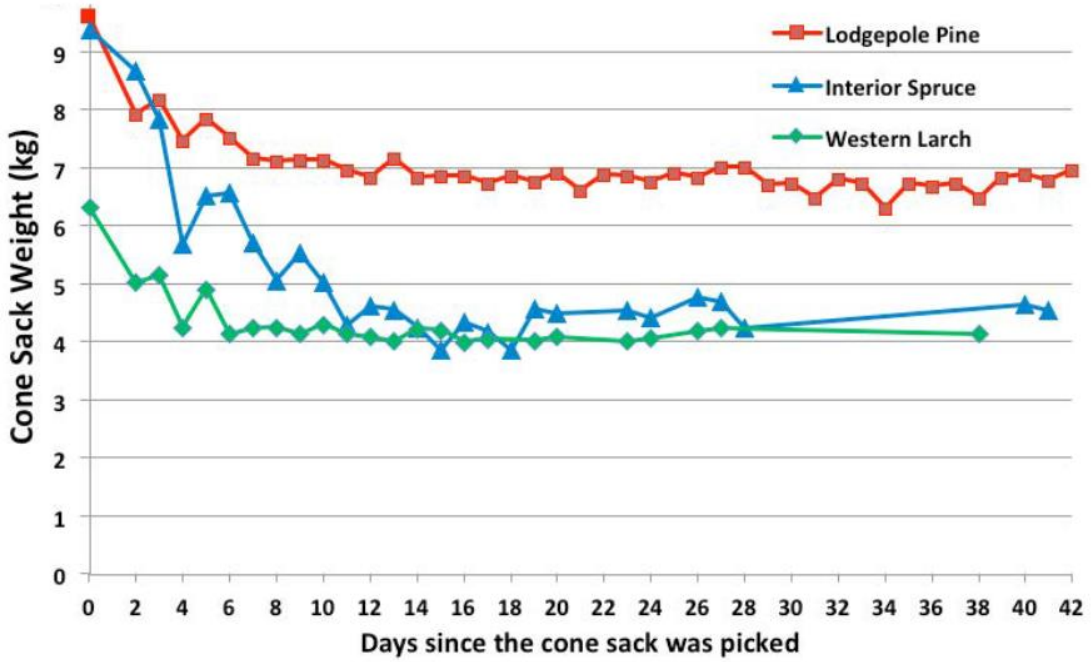
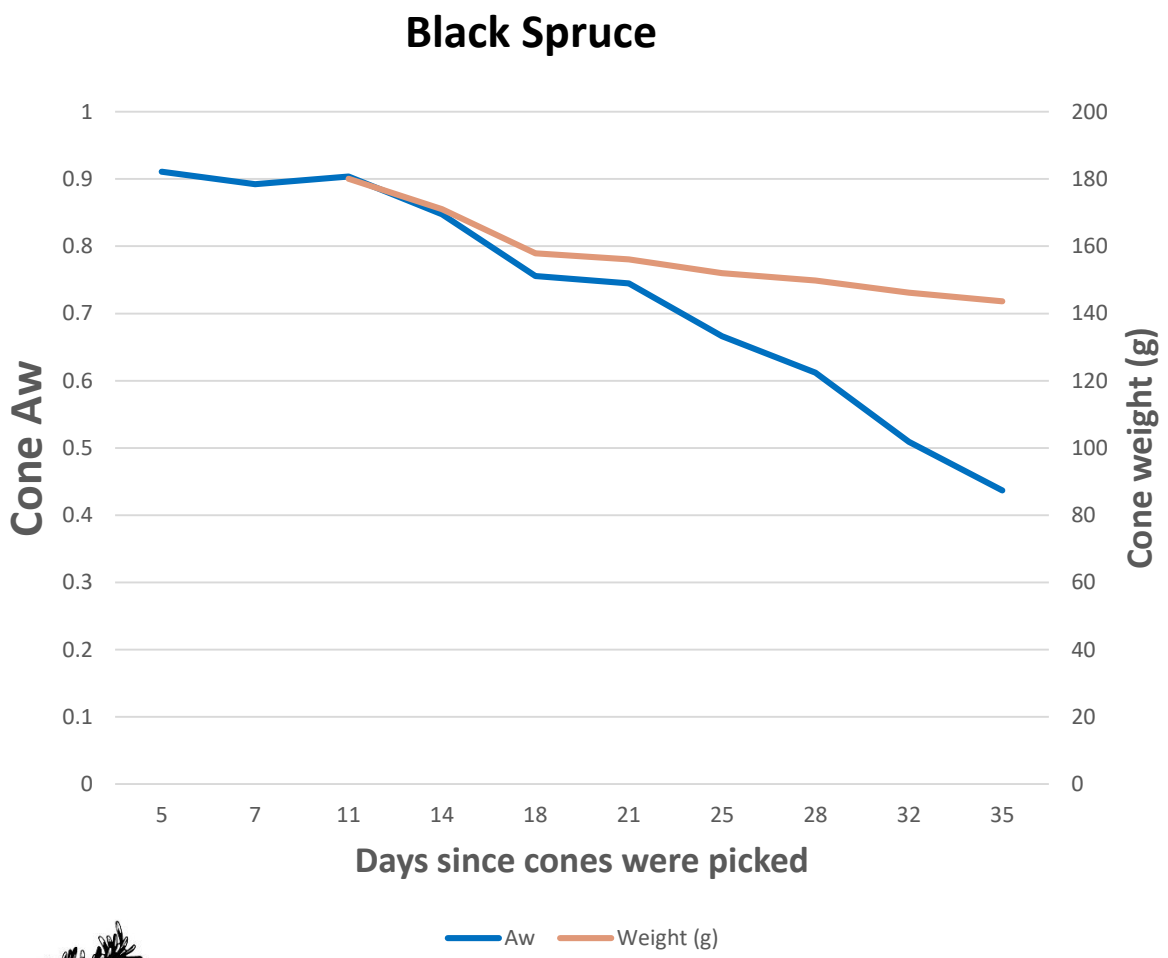
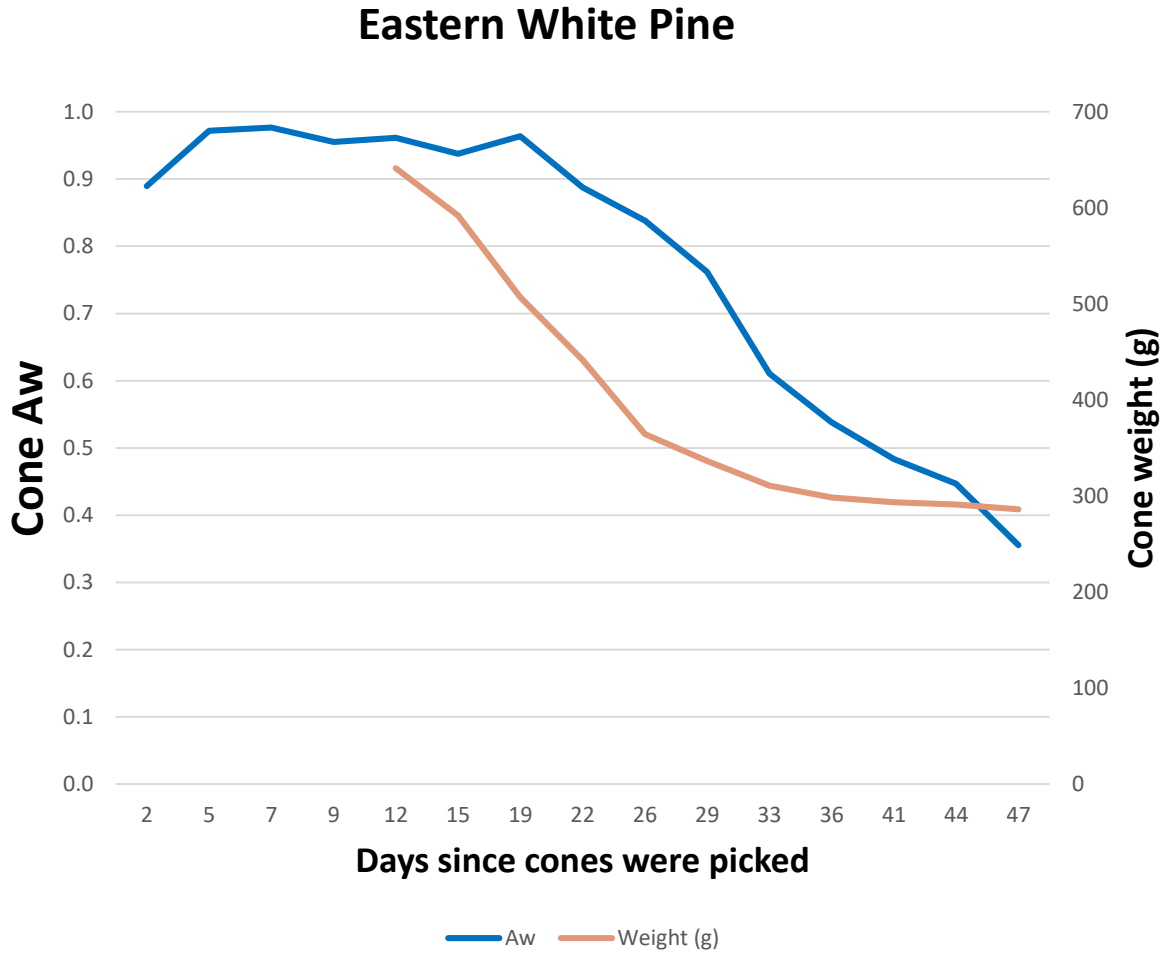


Figure 2. The pattern of cone sack weight in 2016 for three species at Kalamalka seed orchards in Vernon, BC.

Kolotelo, Giampa and Vanderlann, TSWG Newsbulletin 64, 2016

Evolution of Cone MC and Weight



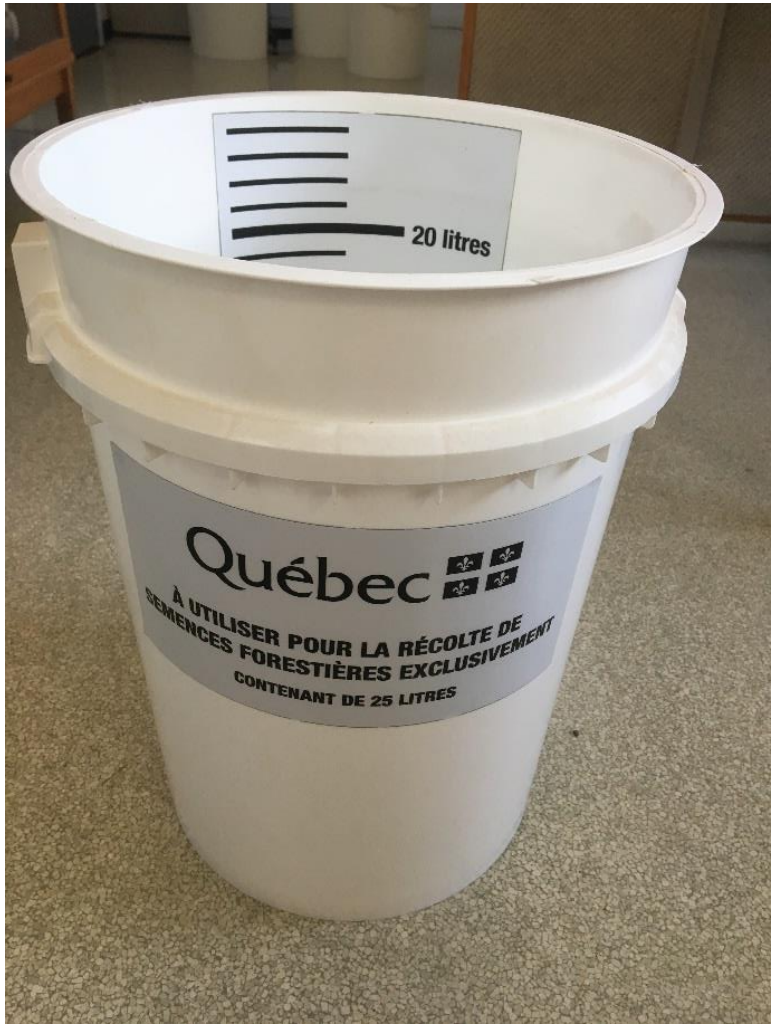


Cone Crop Challenges: Transfer to Seed Centre

Cones and some species shipping from further distances can become quality and TSC efficiency issues.

Cone Crop Challenges: Evaluation of Quantity

- Seem to be easy but quite challenging
- No uniformity in measuring. Cones / seeds are paid by volume…
- Information needed to determine yield.



Cone Crop Challenges: Entomological and Pathological Threats

- Depending on the province, not a lot of support for identification, pesticide label expansion or research (BC the exception).
- Lack of monitoring, specialists and research: we can only react and not anticipate.
- Important lack of formation at university on this topic. Focus is on new threats (CC).
- Need for field-based shared information (collaboration).

Cone Crop Challenges: Entomological and Pathological Threats

Main threats for cones (alphabetic order)

- Chalcids (spruce or larch; *Megastigmus*)
- Eastern spruce budworm *(Choristoneura)*: eats also a lot of pollen ☹
- Red and white pine cone borer (*Eucosoma*)
- Spruce and fir coneworm *(Dioryctria)*: destroys almost all the seeds in a cone
- Spruce cone maggot *(Strobilomya neanthracina)*: gets in the cone while receptive. Very difficult to detect.
- Spruce seed midge *(Mayetolia thujae)*
- Western conifer seed bug (*Leptoglossus occidentalis)*
- White and red pine cone beetle (*Conophtorus*): conelets or mature cones.

Dioryctria damaged Douglas-fir and the beast

Leptoglossus on Douglas-fir

Not So Fun-gal 2009 Cone Collections (BC)

Cone Crop Challenges: Entomological and Pathological Threats

- Few control tools. Mainly chemical pesticides.
- Challenge to deliver in natural stands.
- Trunk injection with systemic insecticide
  - Better control of the quantity
  - Less environmental consequences
  - Good efficiency (broad spectrum)
  - Quite fast execution time.

Cone Crop Challenges: Entomological and Pathological Threats

- Tests with biological products
- Couldn’t obtain funds for R&D since not in the research priorities.
- Contracts with researcher
  - Bt with spruce coneworm: efficient but not already formulated for such use.
  - Pheromone (reproductive confusion) with White pine cone beetle: irregular efficiency.

Cone Crop Challenges: Entomological and Pathological Threats

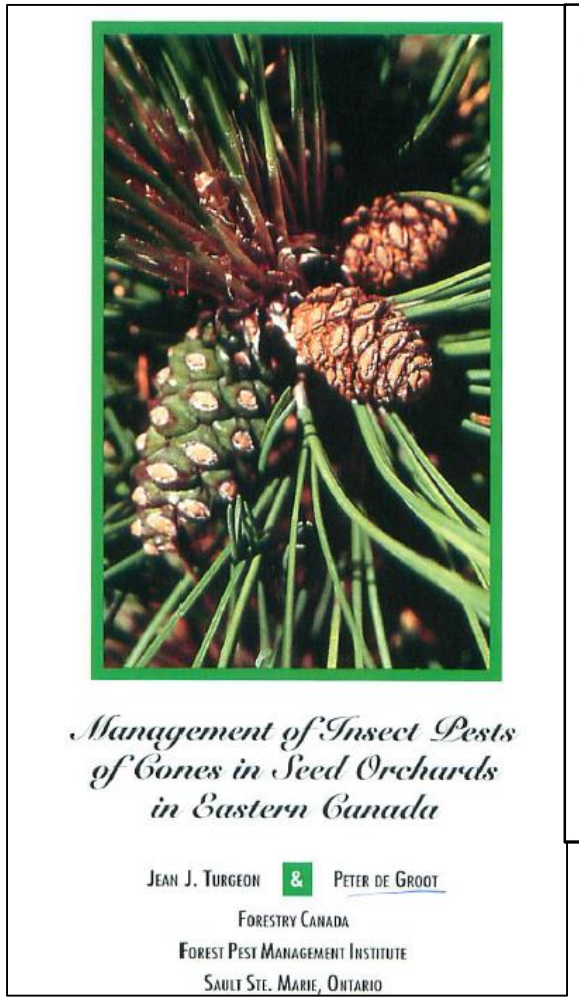
Essential References:

FGC Cone & Seed Pest Leaflets (14)
http://www.fgcouncil.bc.ca/doc-09-pestmaninfo.html

Turgeon & De Groot, 1992:
https://cfs.nrcan.gc.ca/publications?id=22152

Turgeon, De Groot & Sweeney, 2005:
https://cfs.nrcan.gc.ca/publications?id=33708

MFFP (French) Insect Guides:
https://mffp.gouv.qc.ca/forets/fimaq/insectes/fimaq-insectes-insectes.jsp



Cone Crop Challenges: Entomological and Pathological Threats

- Some fungal problems associated with collection in squirrel caches, primarily *Caloscypha fulgens*.

Table 2. Summary of fungal assay results conducted by the BCMoF Tree Seed Centre between 1992 and 2005

	Caloscypha	*Fusarium*	*Sirococcus*
Sample size	1 277	3 553	889
% of Program	22	62	16
% Seedlots affected	13.5	37.7	15.5
Affected average	3.8	1.8	0.6
Overall average	0.5	0.7	0.1
Maximum value	37.6	75.4	7.8

Kolotelo, 2005. TSWG News Bulletin 41:10-15.
Special Issue: Cone & Seed Pests.

Genetic Conservation

- **Why do it?** How much should I spend on it?
  - Genetic variability is the basis for most of our programs
  - We don't know which genes will be important in the future
  - "The first law of intelligent tinkering is to keep all the parts" Aldous Leopold
- International focus on agricultural seed = security of our food supply!! $60 B/yr
  - ***Svalbard, Kew Garden & Milleniun Seed bank, Canadian NTSC***
- Challenging to quantify **benefits** of Conservation and Resilience vs. Value **(% gain)**
- Similar challenge at TSC quantifying 'stewardship' vs. cost-recovery activities

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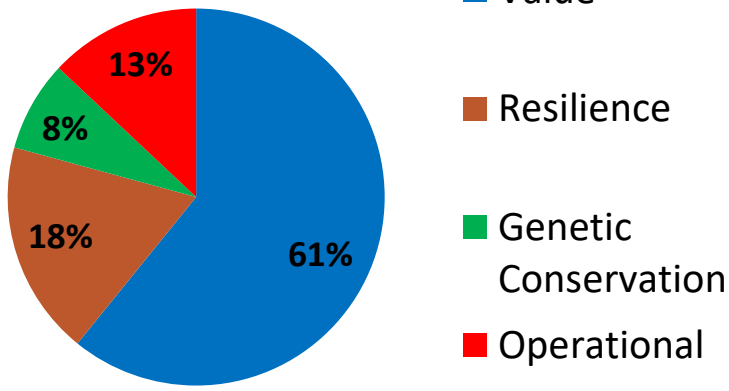
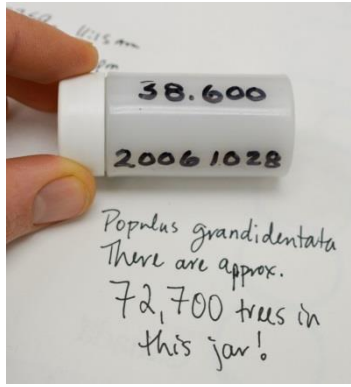


Types of Genetic Conservation

Types of conservation to protect the genetic resource can be classified as:

- In situ : protection of a local population in their natural habitat (e.g. Parks)
  genomes allowed to 'evolve' under current conditions
- **Ex situ**: protection outside their natural habitat (e.g. seed banks, clone banks)
  genomes captured at a point in time
  very efficient (≈50 000 genotypes in a handful of spruce seed) **cheap**
  amazing longevity of many of our conifers (1957 - BC) [100 years]
- Inter situ: protection of local populations in a common environment
  genomes allowed to 'evolve' under current conditions
  "represent natural variability within a panmictic local population"
  ✘ wide ranging provenance test
  ✓ progeny test



A balanced genetic conservation program will integrate all three components

Adequately conserve the genetic diversity of representative populations of all forest tree species (42) native to BC by 2020, through a combination of *in situ*, *ex situ*, and *inter situ* conservation.

"Adequately conserve" is defined as conserving representative populations of a species that are of **sufficient size and redundancy** so existing levels of genetic variation can be maintained.

Genetic Conservation Considerations

- **Global** geographic range / existence of disjunct populations
- Abundance / rarity and distribution
- Problems with natural regeneration
- Harvesting or other means of reducing population size
- Successional status and current vs. historic disturbance regime
- Lifespan and generation length
- Habitat conversion (*Southern Ontario & Vancouver Island*)
- Existing genetic conservation initiatives
- Knowledge about population genetic structure
    - Pollination mechanisms
    - Dispersal mechanisms

Species at Risk = risk of extinction

Federal Species at Risk Act (SARA) - most provinces also have similar legislation ☹

Endangered

America chestnut; **Butternut**; Cherry Birch, Cucumber tree; Eastern Flowering dogwood; Red mulberry, Whitebark pine; Limber pine (COSEWIC)

Threatened

Blue ash; Black Ash; Kentucky coffee-tree

Ex situ conservation is a great tool for 'orthodox' tree species

For **butternut**, a recalcitrant species, there has been great advances made with the cryo-storage of embryonic axis in liquid nitrogen

Butternut Recovery

- >90% mortality to *Ophiognomonia clavigignenti-juglandacearum*
- FGCA has 117 parents grafted in five orchards; 17 of 25 ecodistricts in Ontario sampled
- NTSC cryopreservation facility capable of holding 60,000 excised embryos
- Specific expertise required to maintain momentum

Blue Ash = response to invasive pests

Most Genetically Diverse Blue Ash (*Fraxinus quadrangulata*) seed collection made in Canada October 2013, University of Guelph Arboretum

Blue Ash Gene Bank, 2013, University of Guelph. Photo by Melissa Spearing

Southern Ontario:
>94% original forest cover lost = need for population conservation for 35+ tree species (CONFORGEN)

Shumard Oak: S3 (Special Concern)

Shumard oak acorns from the felled parent tree.

You

Like Comment Share

Shumard oak stump (Q. shumardii)
-an S3 species (Special Concern status in Ontario)

2 Comments

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Whitebark Pine

- **Whitebark Pine Ecosystem Foundation** (Canadian & International)
- White pine blister rust, mountain pine beetle, fire, competition, Climate Change
- Lots of effort underway in BC & AB (see TSWG News Bulletin #68)
- 481 individual tree collections performed in 2018 in BC !!
- Blister rust screening underway (slow) / talking about seed orchards
- Parks Canada interest in Management (including orchards) ☺
- Deeply dormant, immature seed – slow to grow in nurseries – few nurseries

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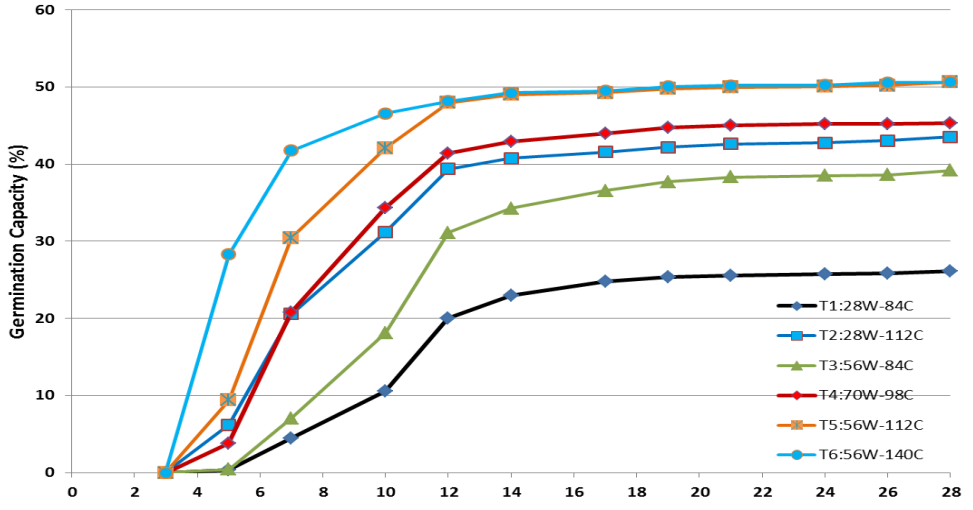
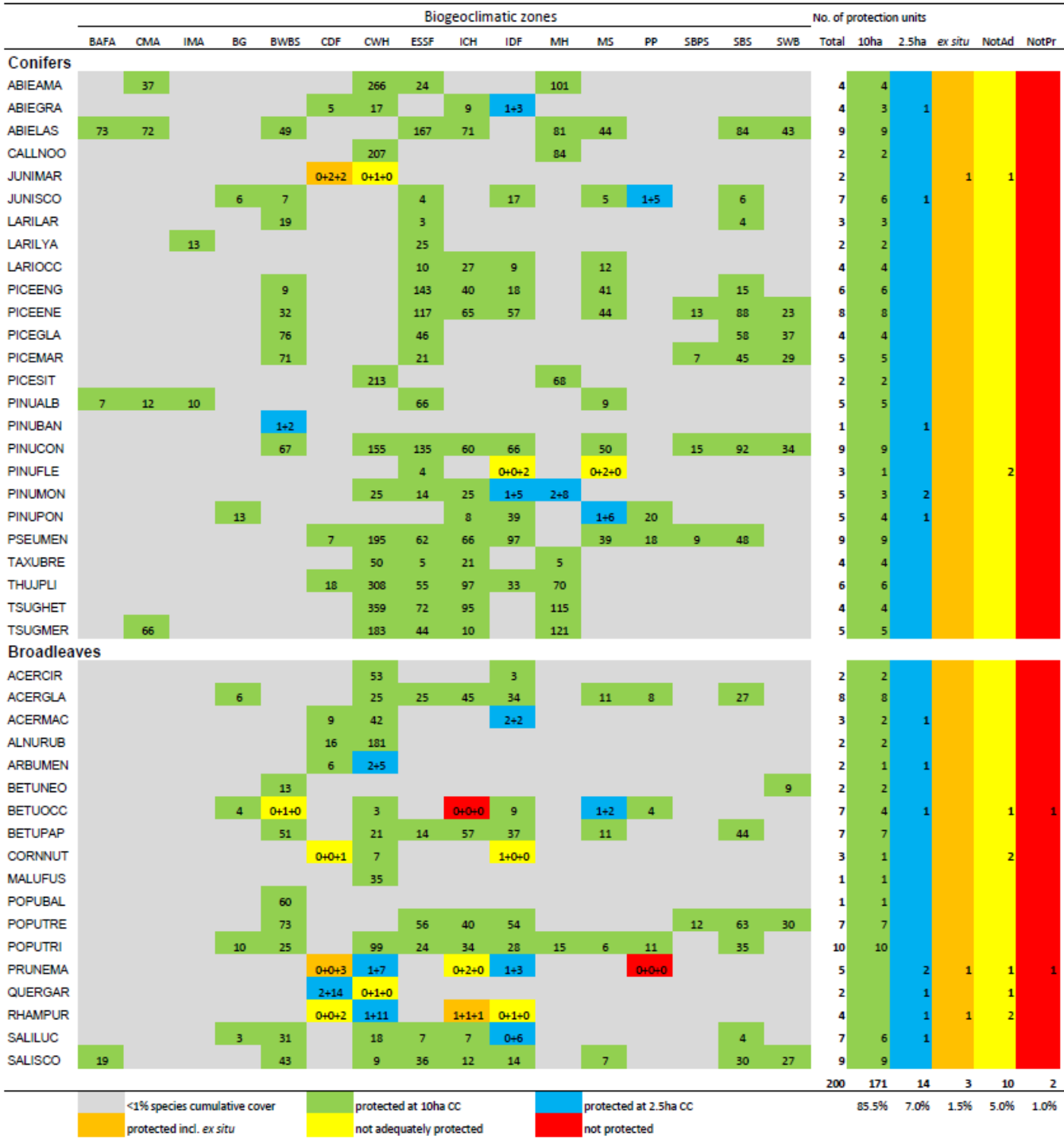


BC GC Catalogue Efforts

- Primarily the work of Dr. Tongli Wang
- 43 600 ecological plots to determine crown cover by BEC variant
- Application of crown cover (CC) to Protected Areas (PA's) in BC
- Are there 3 PA's with > 10 ha of cumulative CC per BEC zone
  - 10% CC needs 100 ha for 10 ha CCC
  - Adjustment for rare species (>2.5 ha)
- Next consideration is the presence of ex situ collections



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DRAFT

Ex situ Collections

- Funded from BC Forest Genetics Council ($25 K annually) – *fill the gaps*
- Fortunate to have help of Don Pigott (*Yellowpoint Propagation*)

- **Representative & Covering Ecological amplitude**
  - 3 populations from each ecological (BEC) zone the species exists
  - Each population should be from 20 parents spaced at least 50 m apart (*earlier collections 10 parents*)
- **Adequate Quantity**
  - 'Commercial' species – 1000 viable seeds – lots of in situ/ inter situ reserves
    - would like 2000 seeds as initial sample to allow for deterioration
  - "Non-Commercial" – current focus is on increasing number of individuals per population (20+ vs. 10) and would also like 2000 seeds per individual
  - For rarer species it is difficult to get 20 individuals per population and 2000 seeds per parent – we try our best

Other Provinces: Genetic Conservation

- Remove a small sample at time of seedlot registration
- Done in Quebec, initially for the genetic improvement program
- In Alberta this is part of their Registration standards (strategic)
- Used to be done in BC, now focus is on non-commercial species (42) and also to have a reference base for deployed seed orchard material (next)
- Ontario proposing Genetic Archive in Sault Ste. Marie; many Ontario research collections already stored or backed up at NTSC from Petawawa era
- Even without a dedicated seed bank, seed not used will be a resource for research and restoration purposes

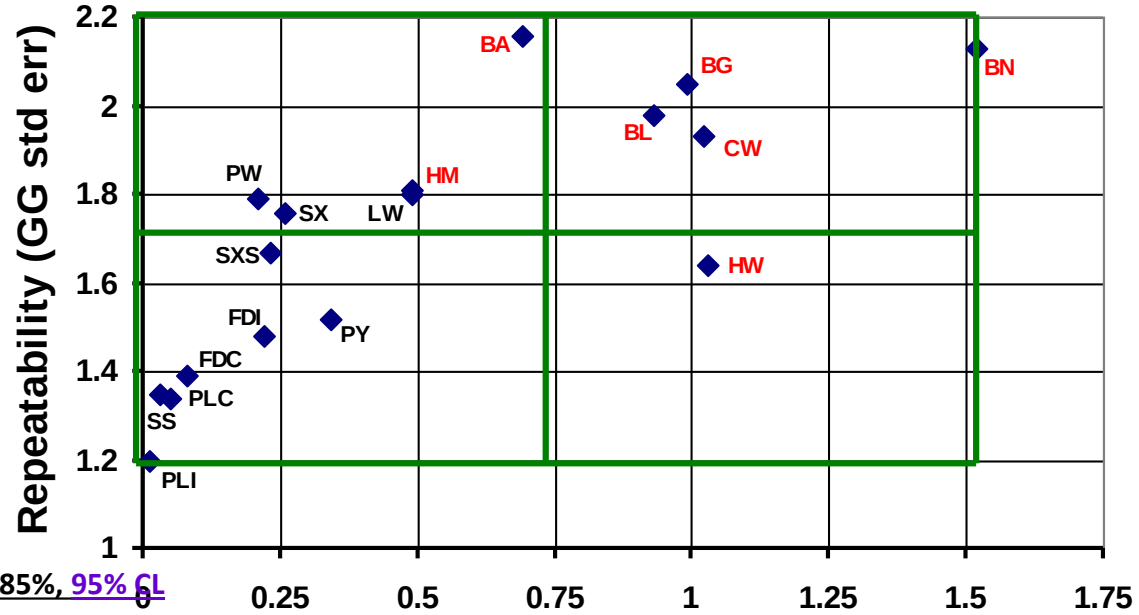
Basic Principle for Orthodox Seed Storage

Lower temperature is better (-20 C)

Lower Moisture content (4-8%) fw

Seed Longevity

- Many of our tree species exhibit good longevity – most are orthodox – **100 years** !!
- Specific challenges with recalcitrant and very small seeded species (Populus spp)
- Resin vesicle species (*Abies, Tsuga, Thuja, and Juniperus*) appear to deteriorate more quickly



GC =85%, 95% CL

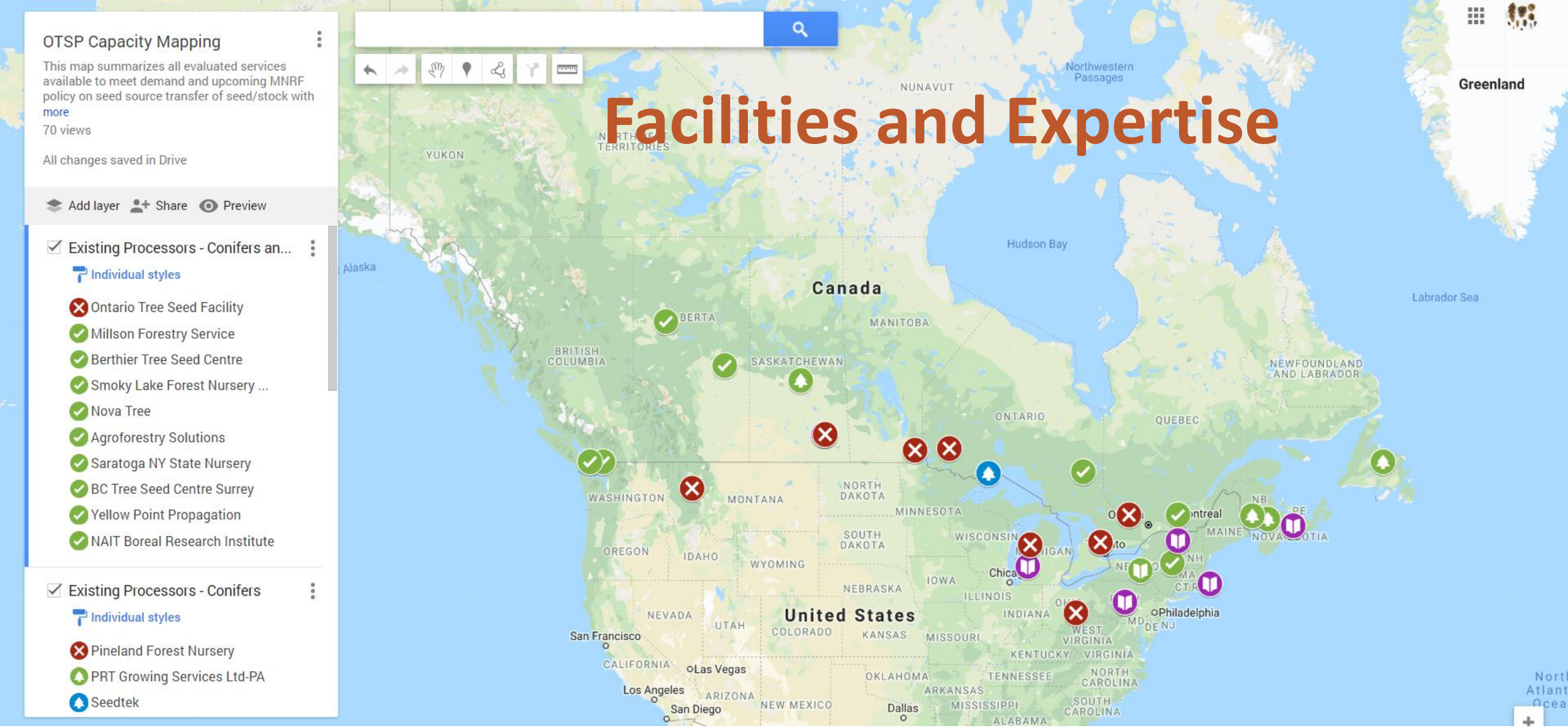
se=1.2 → 81 to 89%
se=2.2 → 78 to 92%

Species	Years in storage (NTSC)	Best Seedlot Germination (%)
Betula alleghaniensis	48	79
Abies balsamea	39	72
Picea glauca	40	90
Picea rubens	45	80
Pinus banksiana	40	87
Pinus contorta var. latifolia	33	90
Pinus resinosa	42	83
Fraxinus americana	40	70
****Tsuga canadensis***	30	97

Genetic Conservation

- Try to maintain existing levels of genetic diversity (*we are still close to wild*)
- Future uncertainty (climate change) should point us to portfolio diversity
- Ex-situ conservation is relatively cheap to implement
- Protected areas and tests are already contributing (inventory/documentation issues)
- It can be challenging to justify; cost of failure is too great – we don't have adequate 'accounting' practices
- **Conservation programs aren't a 'tree-hugger' thing – it is due diligence and our insurance policy for Canada's forest genetic resources**

Facilities and Expertise



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Annual Canadian Processing Capacity

Typical & Max Year Hectolitres (hL) Cones/Fruit per Seed Centre

BC Tree Seed Centre (BC):	3,500 / 14,192 hL max (DK 2015)
Smoky Lake Forest Nursery (AB):	7,000 hL (DK 2015)
PRT Prince Albert (SK):	1,400 / 5,100 hL (DK 2015, PRT 2019)
Millson Forestry Service (ON):	1,800 / 6,000 hL (DK 2015)
Berthier Tree Seed Centre (QC):	1,500 / 3,350 hL (DK 2015)
Kingsclear Forest Nursery (NB):	540 / 3,607 hL (TSWG No. 11)
J.D. Irving Parkindale (NB):	500 / 730 hL (TSWG No. 11/38)
Wooddale Tree Nursery (NL):	360 hL (TSWG No. 11)
Pinelands Forest Nursery (MB):	**3,000 / 4,000 hL** (MS 2017)
Ontario Tree Seed Plant (ON):	**2,500 / 30,245 hL** (MS 2017)

22,100 hL typical, 74,584 maximum!

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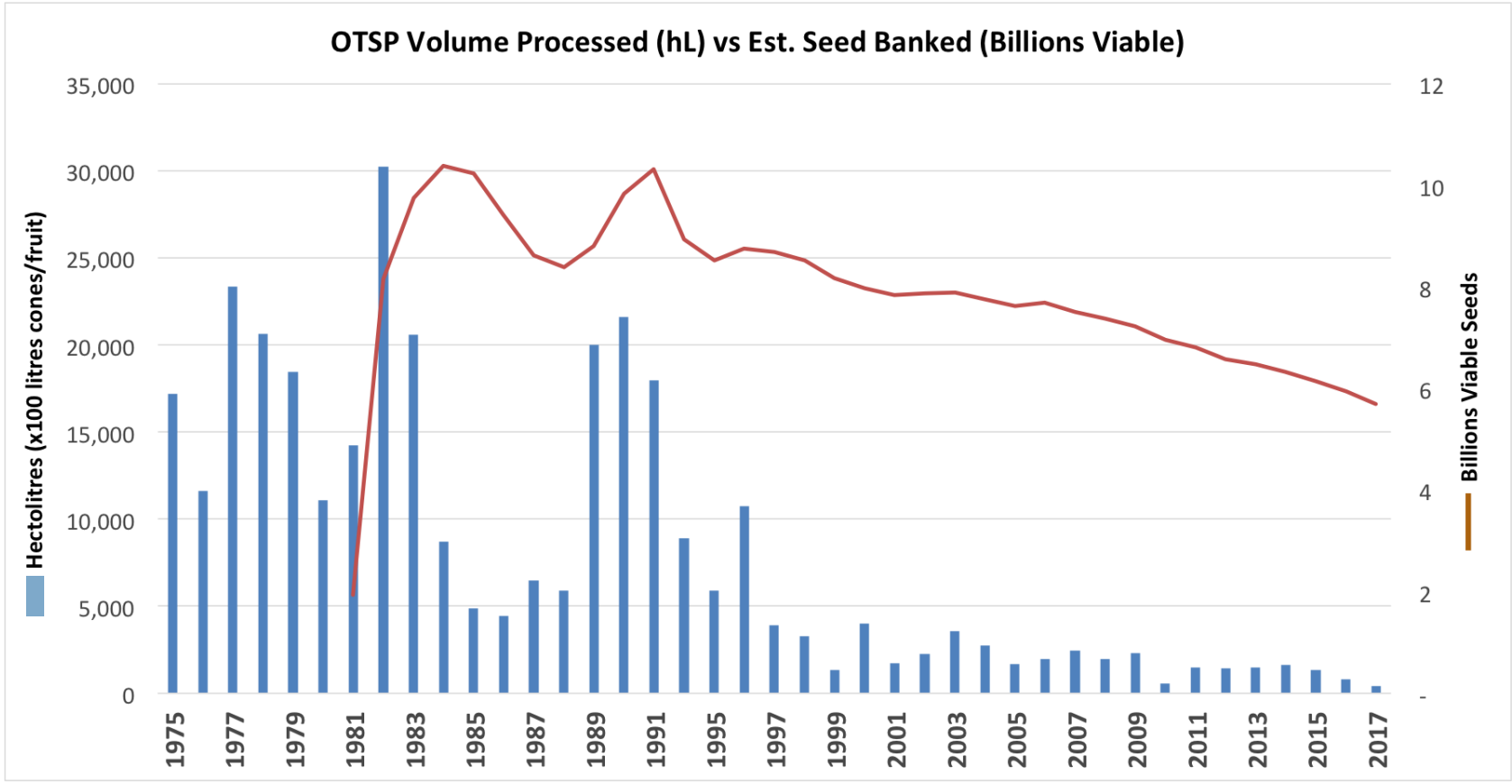
Pictures of BC Tree Seed Centre: 14,192 hL max

Surplus & Downturns

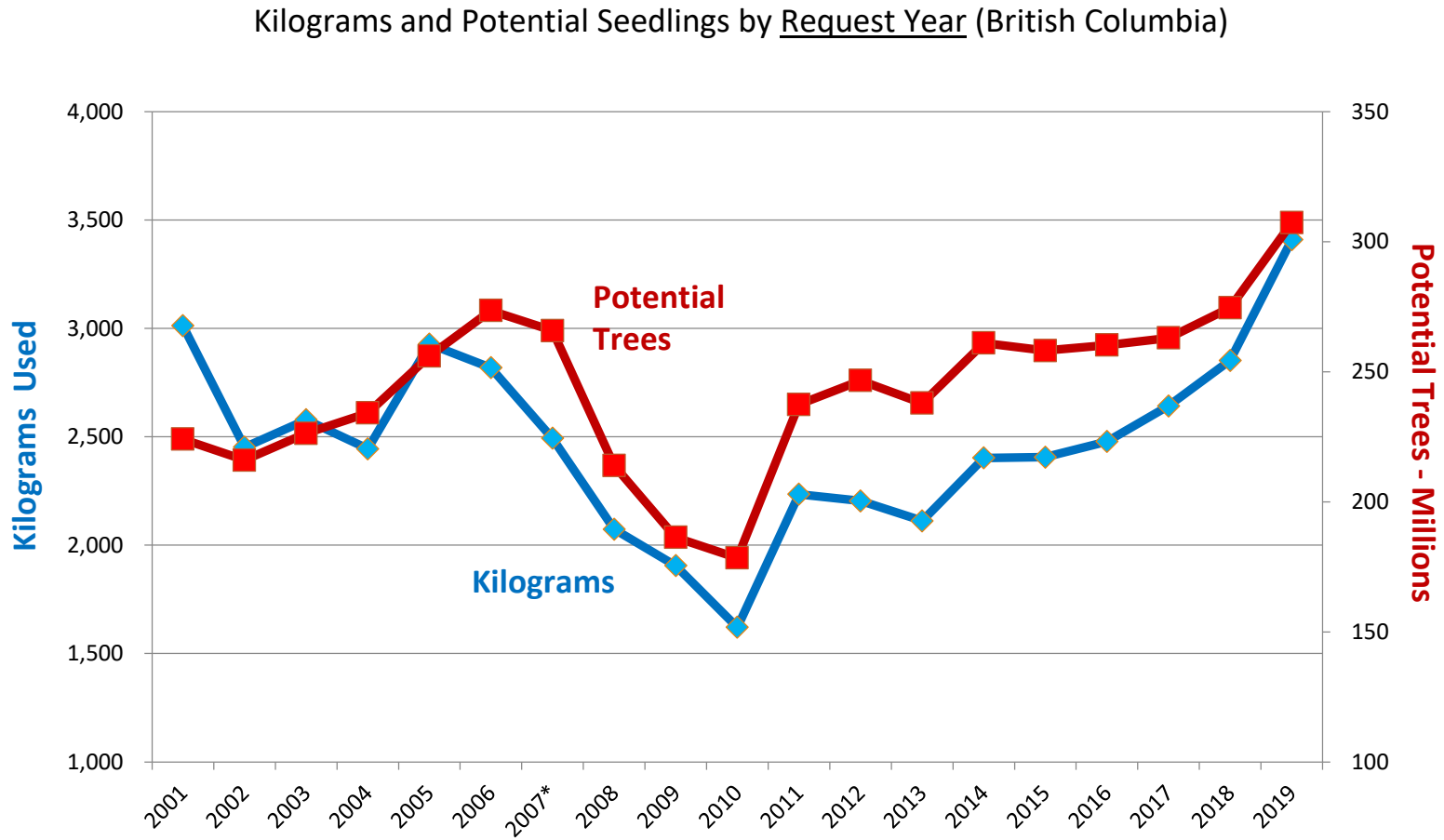
- Forecast and collection contracts in the 80s-90s in Ontario created large public seed bank
- Seed orchard quantities began in 90s
- Improved seed use efficiency 90s-00s
- Reduced planting, more complexity after 1996
- >70% stock grown out of province



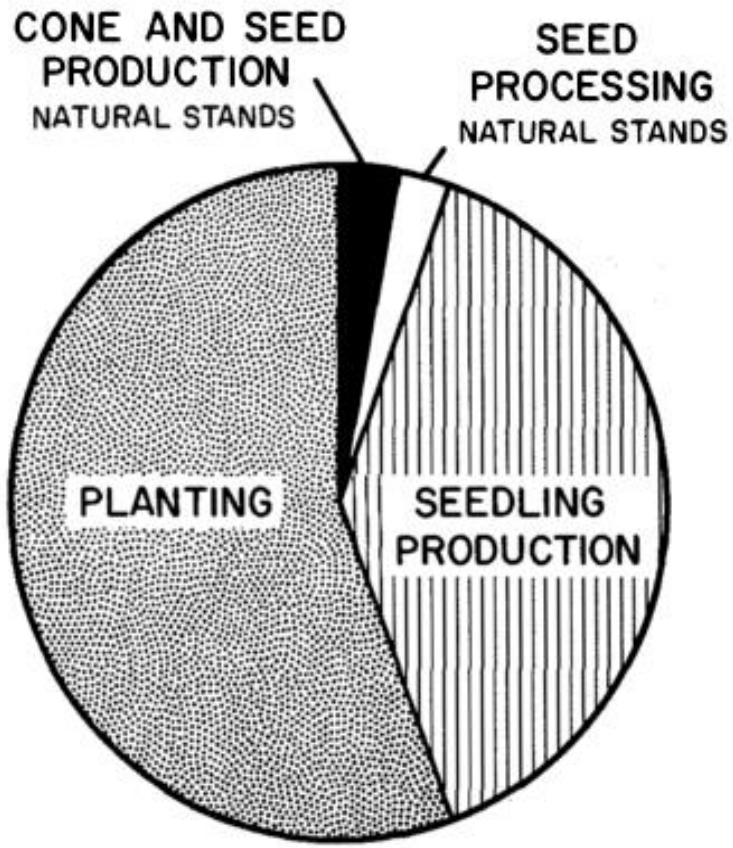
	Average Vol (hL)	Avg Vol (hL) –Pj+Sb	% for Southern ON
1975–1996 (MNR)	14,141	3,163	22% (42 species)
1997–2017 (post-MNR nurseries)	2,011	1,250	62% (140 species+)

Cash-Flow for TSCs – Riding the Waves

- Every downturn or political change can lead to a review of public service value
- Processing income alone cannot always smooth the waves – focus on quality and longevity of product & people
- **Managers must have long-term vision!**



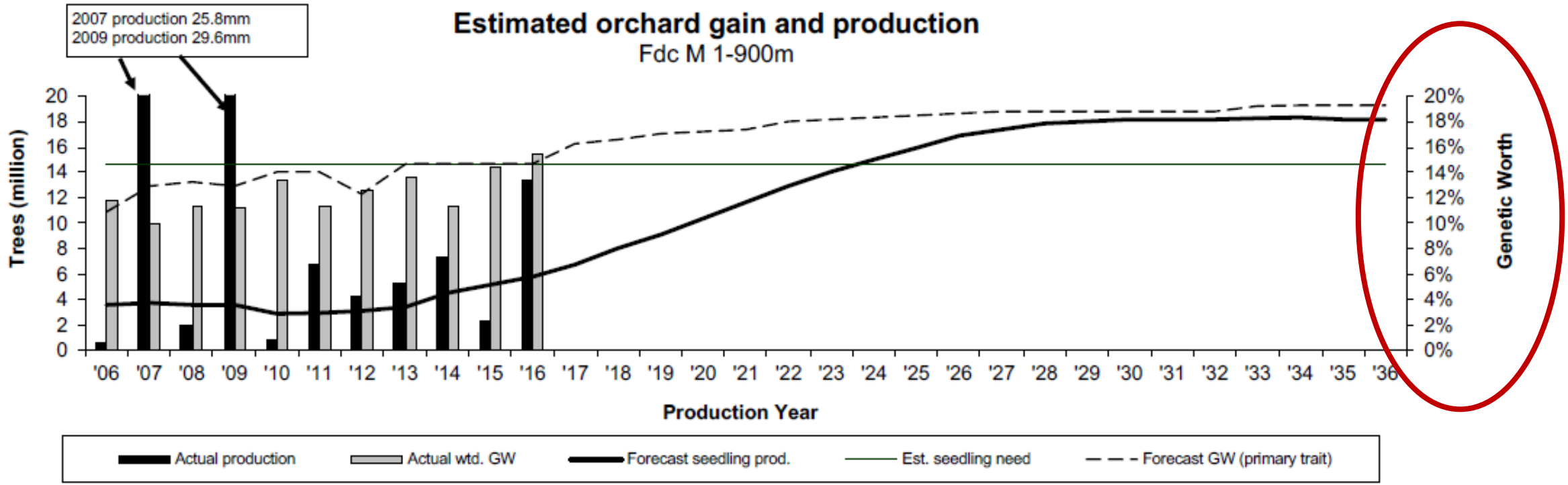
The Cost of Seed



Seed Procurement Activity per hL (Ontario, not including orchard management)	Seed Cost Component (%)	2019+ Trend for Former Clients
Seed Planning & Contract Admin	3.7	↑↑
Collection Contract	52.1	?
Shipping	6.2	↑↑
Seedlot Registration & Data Management	2	??
Processing & Testing	25.1	?
Capital Cost & Storage	10.8	↑↑
Total	100%	

Figure from Huber 1981. % from Seedcost /OFRI Technical Report No. 2 (MNR 1996).

Value vs Cost



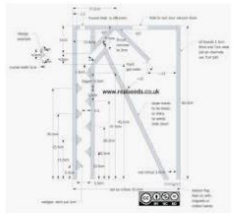
https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/forestry/tree-seed/tree-seed-centre/seed-and-cone-fee-schedule/cone_and_seed_fee_schedule_2019.pdf

Specialized / Low-Tech Processing Capacity

Figure 2. Tray containing catkins that have opened and are ready for processing. Photo by Bernard Daigle

Figure 3. Catkins being processed in a cone tumbler with a screen wrap with air flow provided by a combination of a shop vacuum and hair dryer. Photo by Bernard Daigle

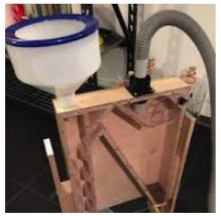
Regardless of availability and cost, these pieces of equipment often require more fine-tuning than large processing machines for low-volume species.



DIY Seed Cleaner Aspirator f...
realseeds.co.uk

DIY Seed Cleaner Aspirator from RealSeeds
realseeds.co.uk

DIY Seed Cleaner Asp...
realseeds.co.uk



DIY Seed Cleaner Aspirato...
realseeds.co.uk

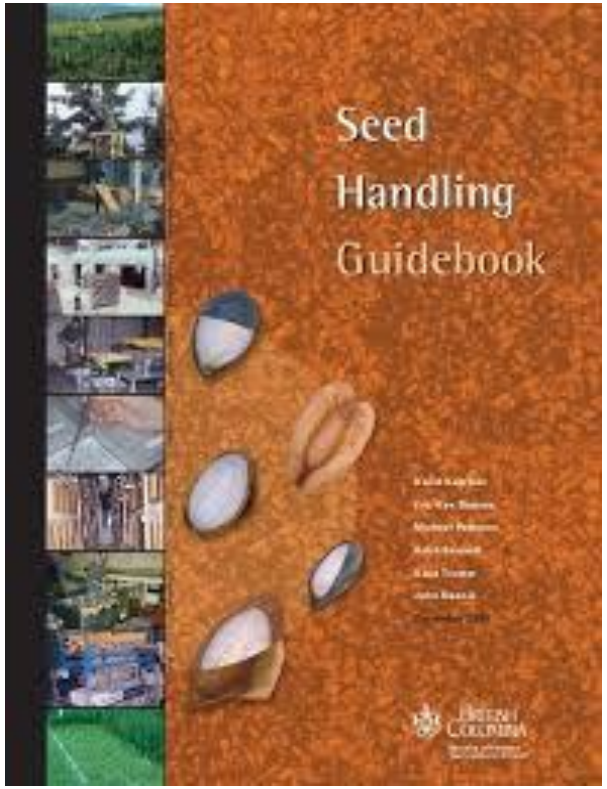
DIY Seed Cleaner Asp...
realseeds.co.uk

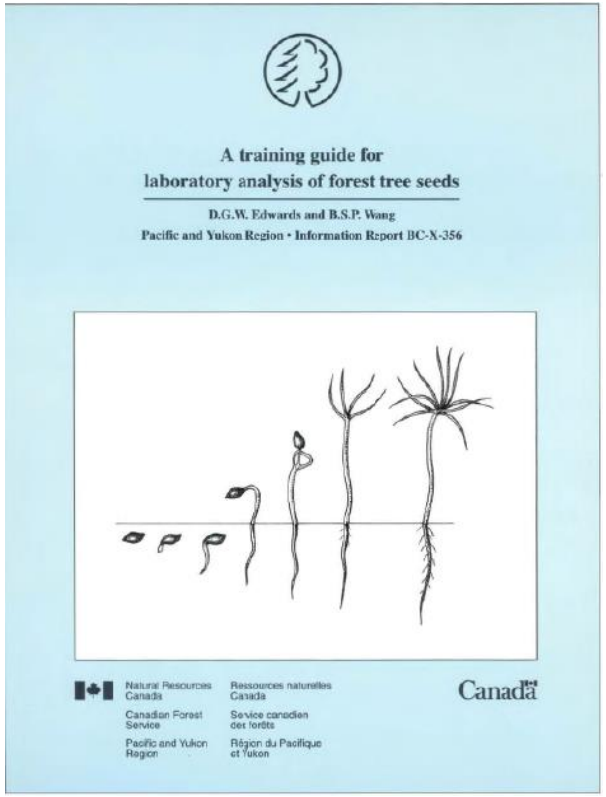
DIY Seed Cleaner Asp...
realseeds.co.uk

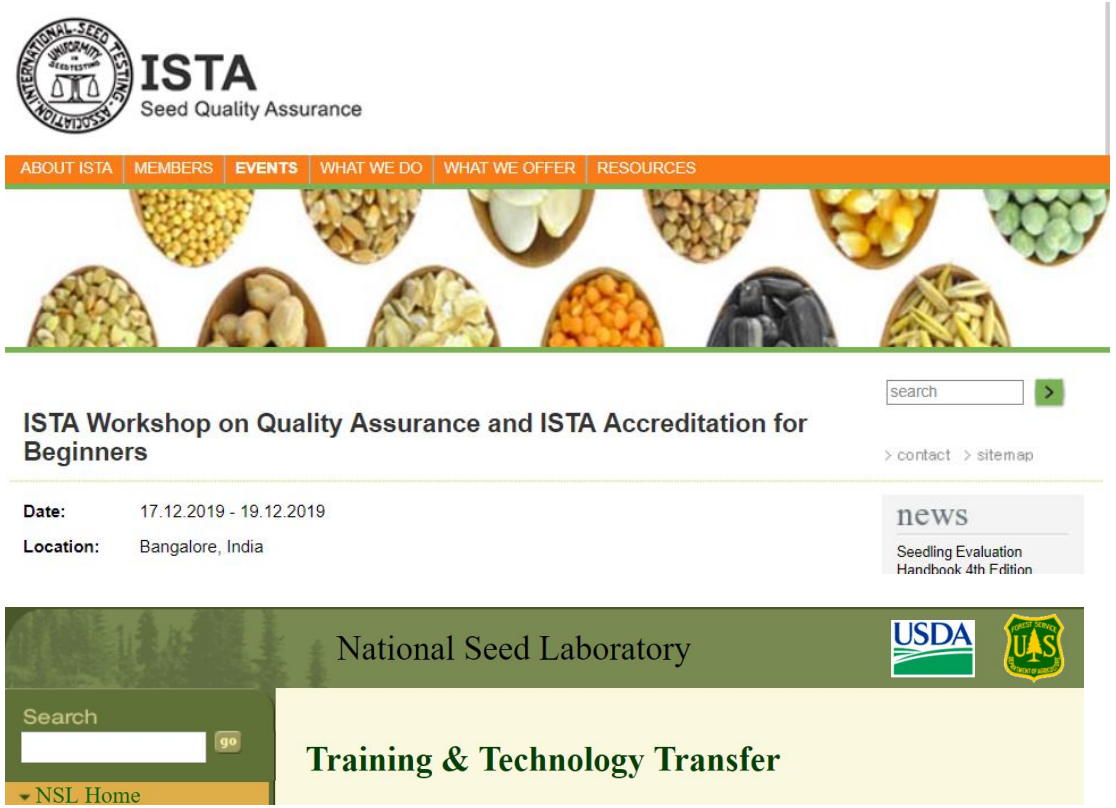
DIY Seed Cleaner Asp...
realseeds.co.uk

Excellence in Seed Centre Expertise

After Collection: Training & Succession of Seed Centre Technicians







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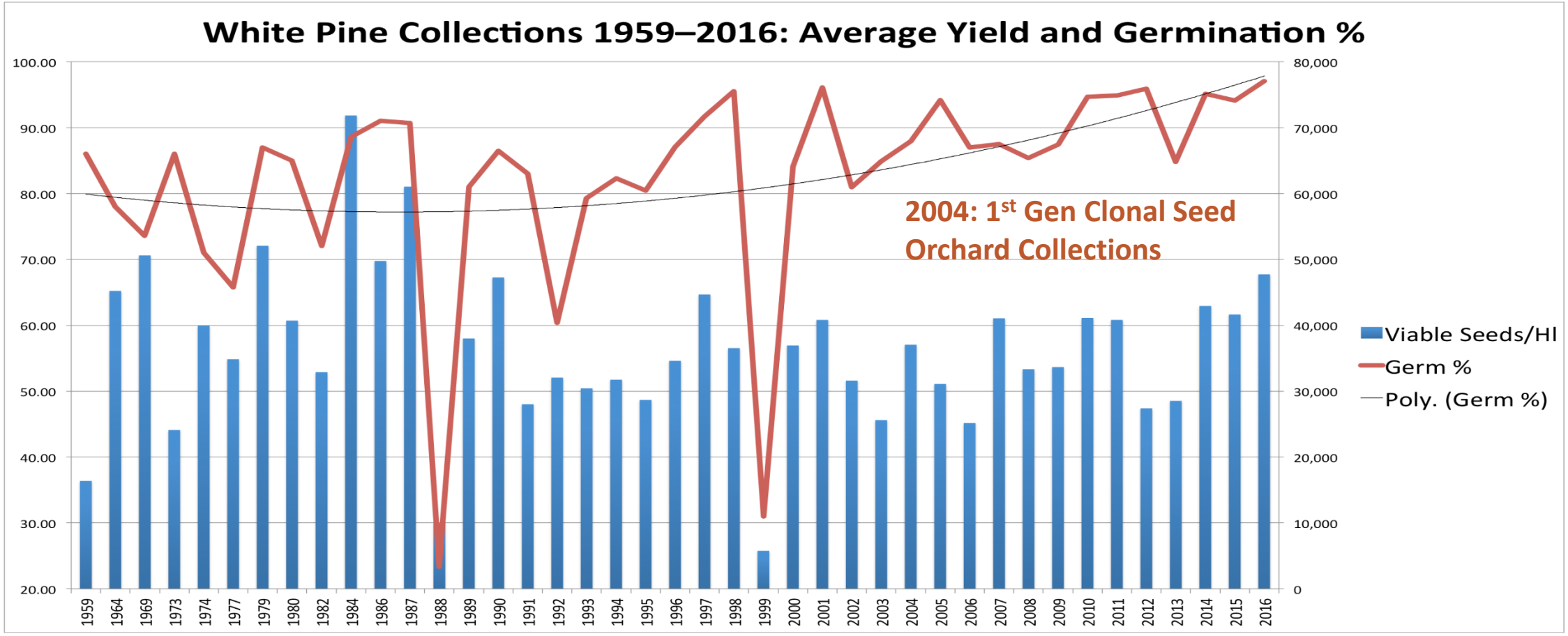
Most happens on the job under supervision/SOPs but training is accessible ($$$). Best candidates come from nursery, agriculture, botany, perishable product processing, chemists. Operational TSCs need staff with production mentality.

Long Data Series in Advance of Climate Change



Ontario example: Average germination percentage (left axis) and viable seeds per hectoliter (right axis) of all Pinus strobus seed collections 1959-2016. Viable seeds per hectolitre are higher during topping operations but overall, germination % has increased. Data supplied by Ontario Tree Seed Plant, chart by Forest Gene Conservation Association.

A Role for Post-Secondary Programs

- Opportunities for industry partnerships to refocus on effective regeneration techniques, introduce students to applied seed research, equipment, and maintain special/low-volume seed orchards.

CENTRE FOR BOREAL RESEARCH

OVERVIEW

NAIT's Centre for Boreal Research is a

FOUR REASONS TO CHOOSE NAIT AS YOUR APPLIED RESEARCH PARTNER:

KPU Seed Program

Supporting a vibrant organic seed sector in British Columbia

School of Environmental & Natural Resource Sciences
Frost Campus | Fleming College

THE ARBORETUM UNIVERSITY OF GUELPH

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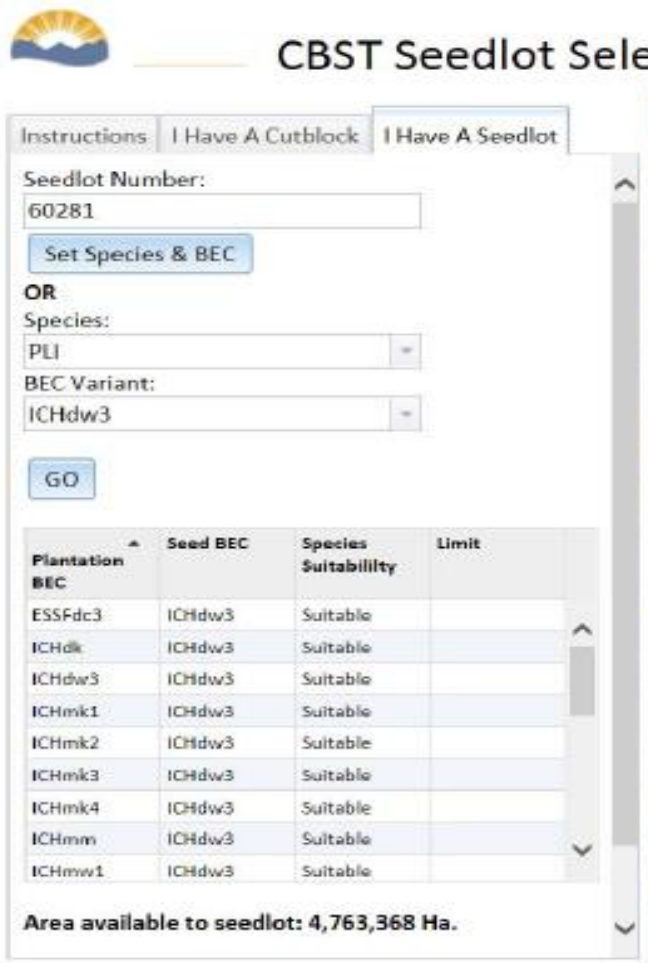
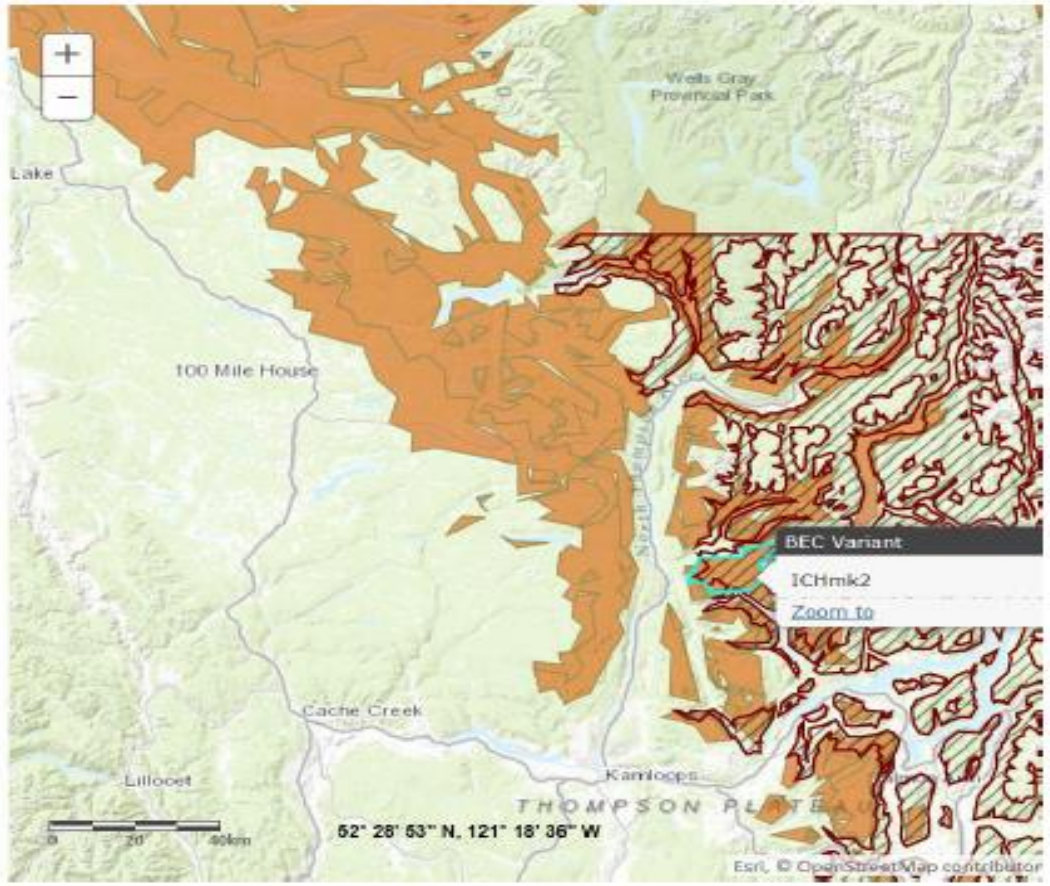
https://www.nait.ca/industry/applied-research/centre-for-boreal-research/programs/plant-seed-technologies
https://www.kpu.ca/seeds

Climate-Based Seed Transfer (CBST)

- BC introduced in 2018 (O'Neill, Spence, Zedel); 212 BEC variants
- AB with controls latitudinal southern movement for 5-needle pines
- Ontario consulted on draft CBST policy 2017-2019 with industry





Assisted migration' to account for past climate change and one quarter of next rotation = dynamic

Climate-Based Seed Transfer (CBST)

Seedlot Selection Tool

About | Tool | Layers | Saved Runs

Planting Healthy Forests

The Seedlot Selection Tool (SST) is a GIS mapping program designed to help forest managers match seedlots with planting sites based on climatic information. The climates of the planting sites can be chosen to represent current climates, or future climates based on selected climate change scenarios.

1. Select Objective

You can find seedlots for your planting site or planting sites for your seedlot

2. Select Location

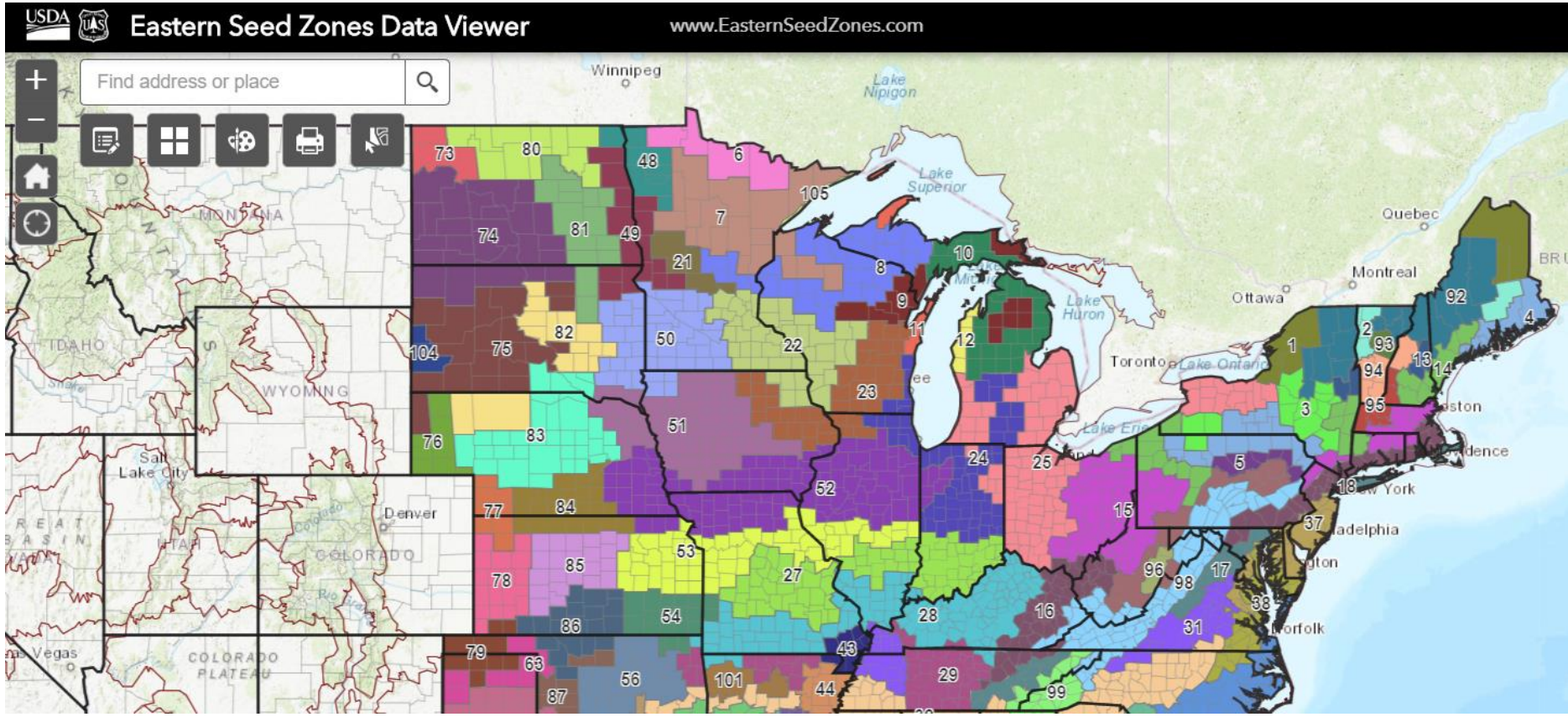
You can click on the map or enter coordinates to locate your seedlot or planting site

3. Select Region

You can select the geographic region closest to your site or choose from a list of available regions

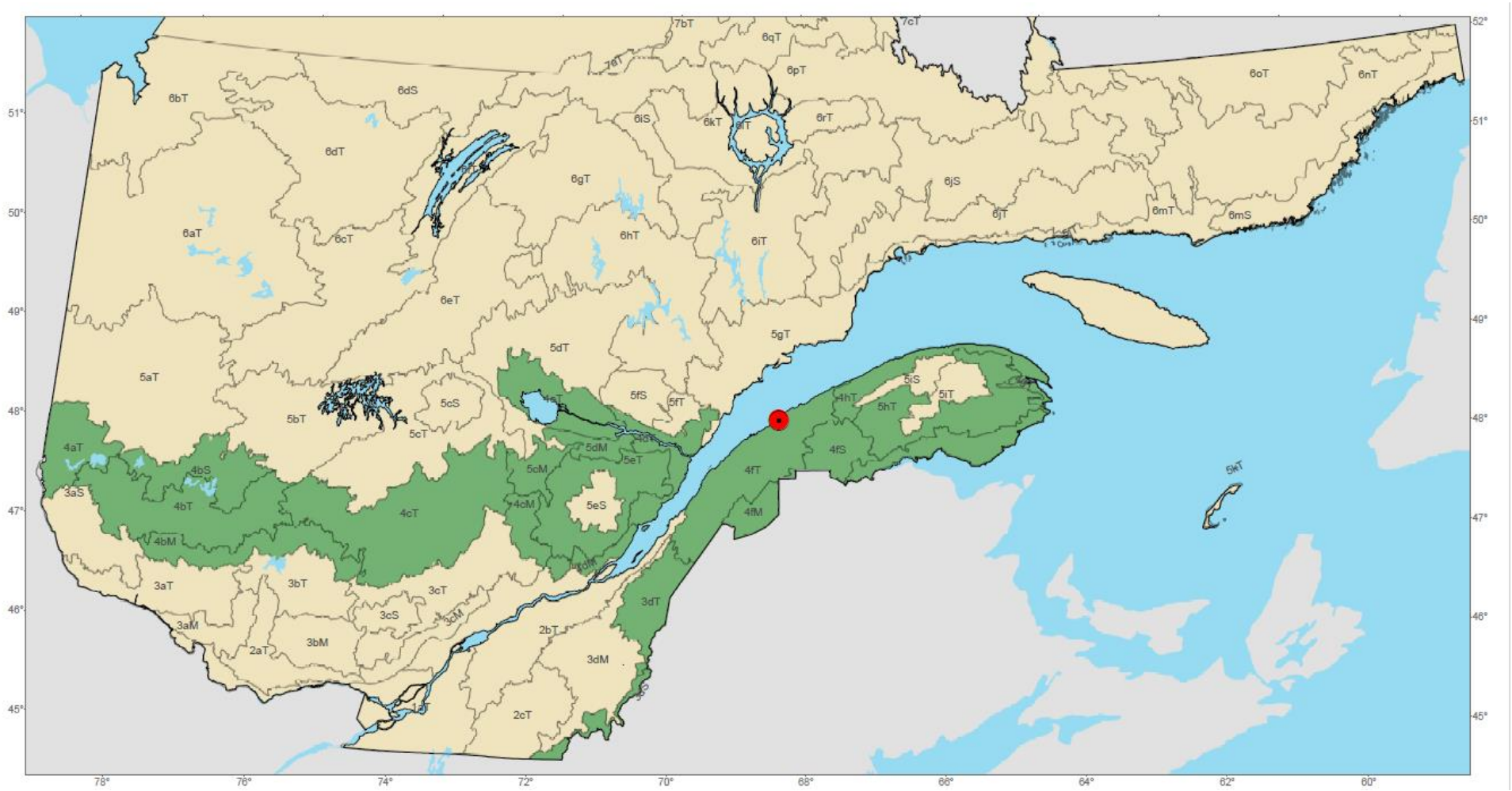
4. Select Climate Scenarios

You can select historical, current, or future climates for your seedlots of planting sites

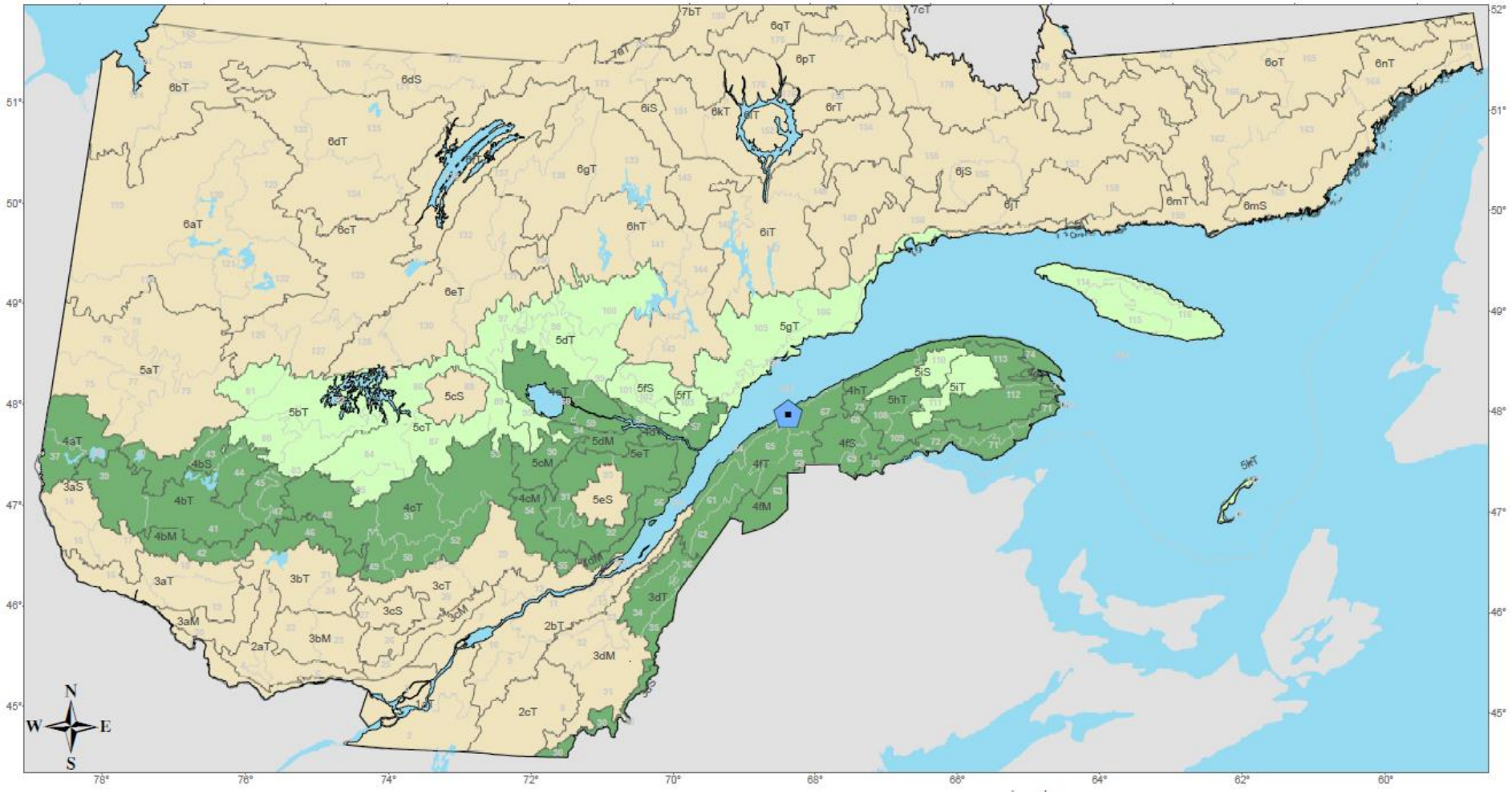


Much effort has gone into developing these tools but they are not tied to inventory, nor seedlot/stock registration standards. US-Canadian border sourcing and contracts will be a complex process for some practitioners.

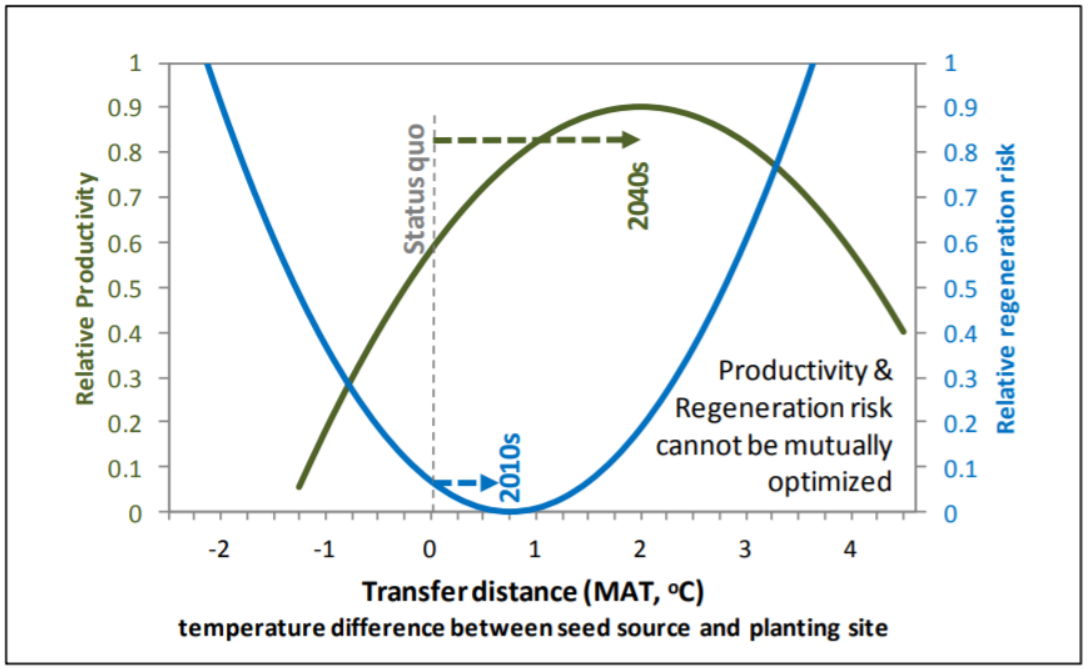
QC: Deployment of White Spruce Orchard Seed



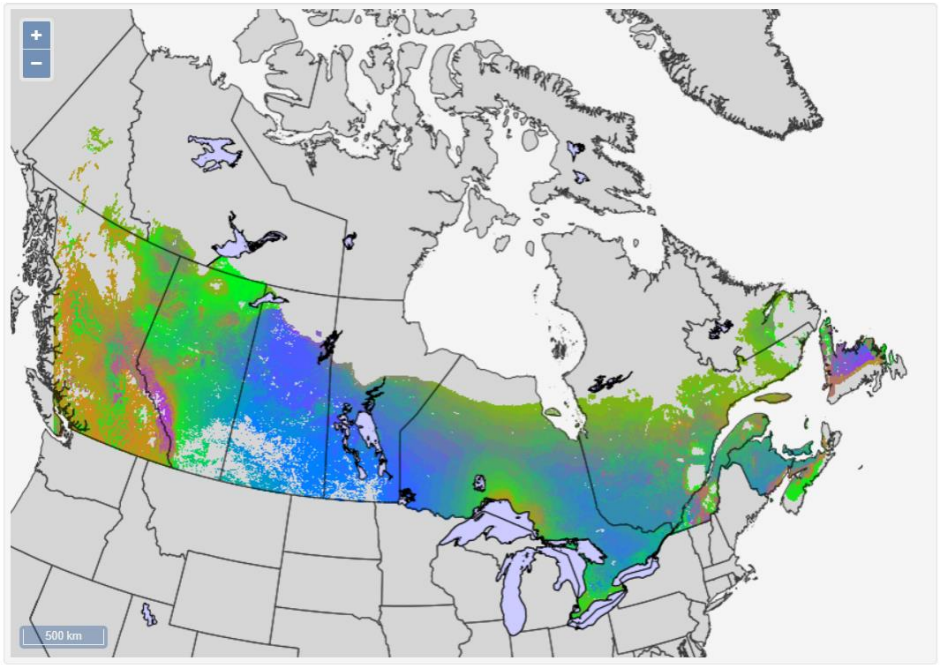
QC: Deployment of White Spruce Orchard Seed



The Cost of Inaction: Productivity, Drought, Natural Regeneration Risks



NRCAN Forest Vulnerability Assessment Tool

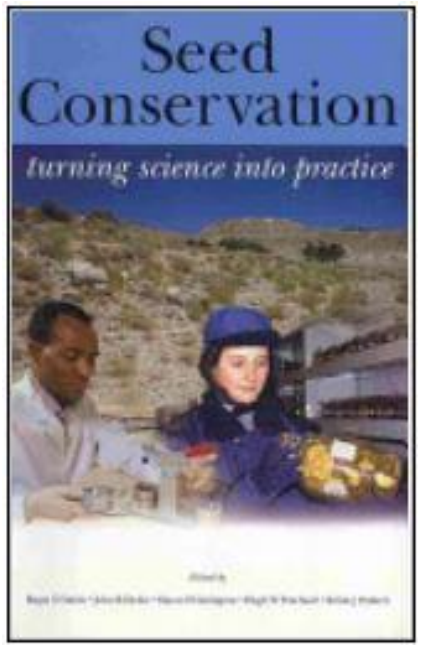


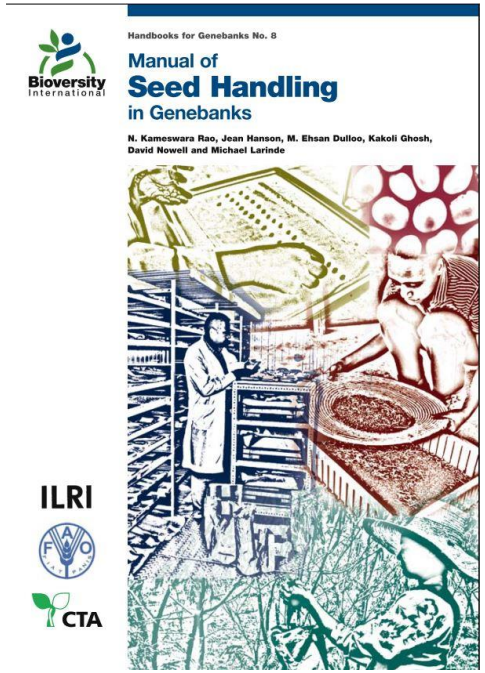
http://www.fgcouncil.bc.ca/CBST-investment-extension-note-FINAL.pdf (Woods and Maloney 2016)

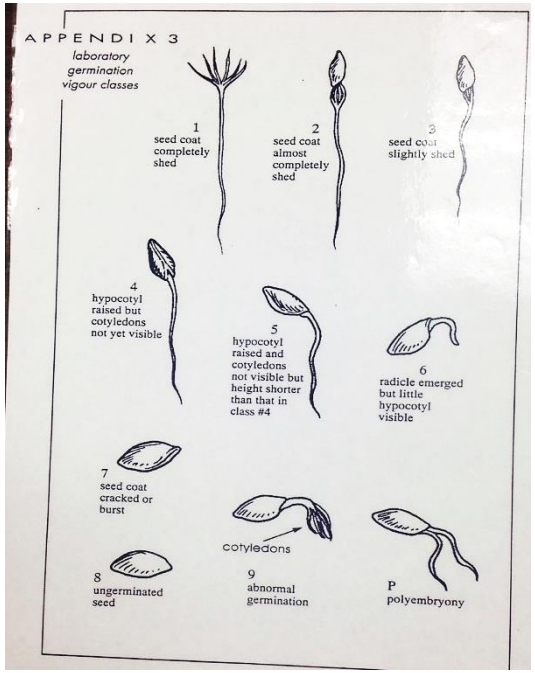
https://glfc.cfsnet.nfis.org/fcvul/?m=migration&lang=e

Storage, Testing, Seed Preparation

- Topics are well known
- Not an issue; many existing protocols and references
- Differences on the germinant state (1X 2X 4X radicle, Wang's Classes)

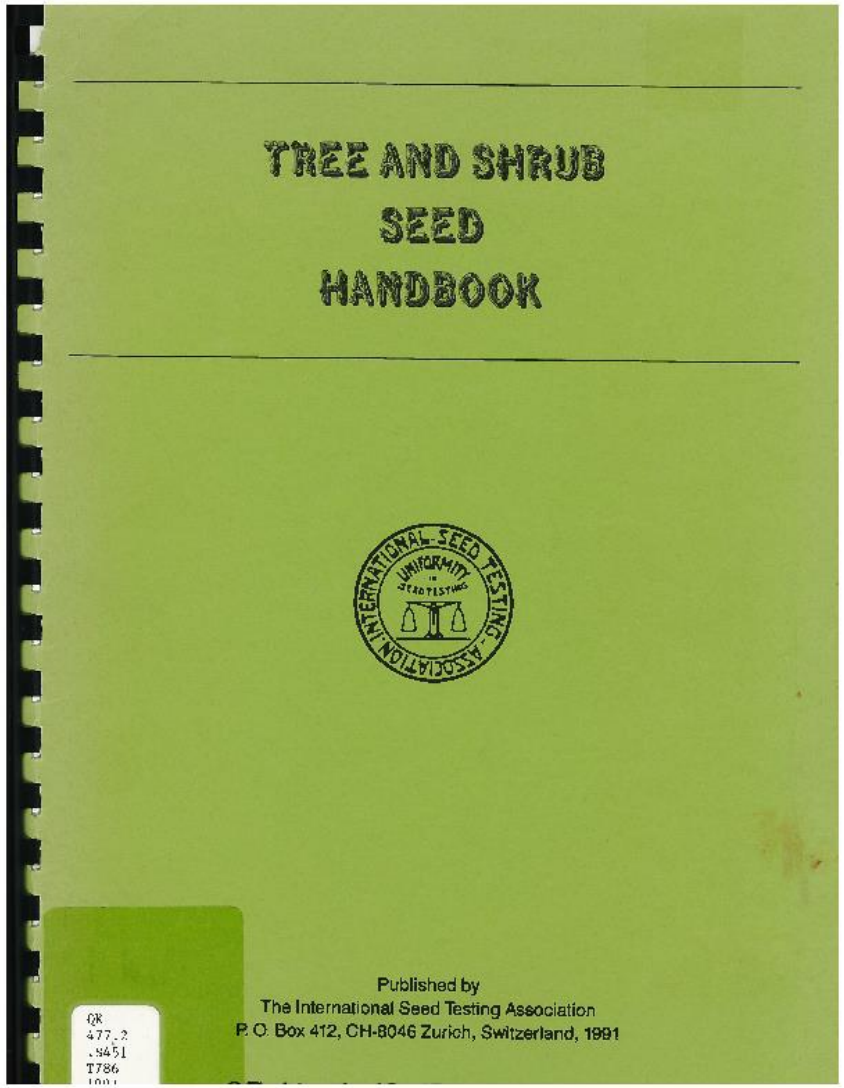




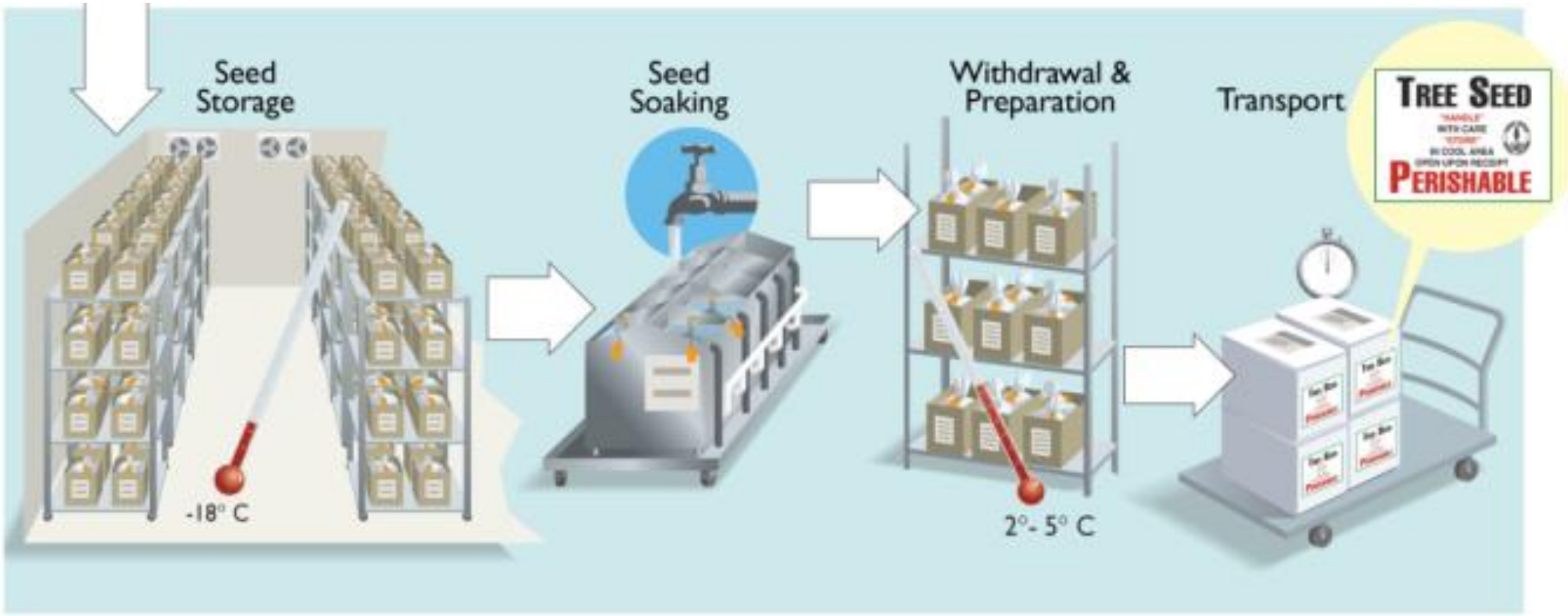


Storage, Testing, Seed Preparation

- First version 1991
- New version announced for 2020-2022
- Main concern =
  few tree seed labs are ISTA accredited



Storage, Testing, Seed Preparation



Operational vs Conservation Storage

Different containers and temperature used for seed conservation

- British Columbia: plastic bags in waxed box, -18°C

Storage

Operational vs Conservation Storage

- Quebec
  - Plastic container (10, 20 l)
  - Different color tag with the species
  - -3°C and +3°C for recalcitrant
  - Tests for a new container with HDPE and Cellulose Nanocrystals

Operational vs Conservation Storage

- National Tree Seed Centre, New Brunswick
  - Mason jars, will be soon replaced by foil sealed bags for the conservation lots
  - -20°C or Cryo

Photos : Donnie McPhee (NTSC)

Operational vs Conservation Storage

- New Brunswick
  - Plastic containers (≈ 12kg of seeds)
  - -8°C

Photos: Michele Fullarton (NB)

Operational vs Conservation Storage

- Alberta Tree Improvement Seed Centre, Conservation Collections
- Similar to BC
- Re-sealable aluminium trifoliate bags for genetic conservation, -18°C
- Eliminates any moisture transfer
- **Minimal benefit in freezer, greater in cooler**

Photos: Dave Kolotelo

Seed Testing

Mainly follow ISTA or AOSA rules established for forest species.

- Germination
- Purity
- Moisture content
- Number of seeds per kg

Seed Testing

Germination box: mainly Petawawa or smaller (BC, AB)

Quebec

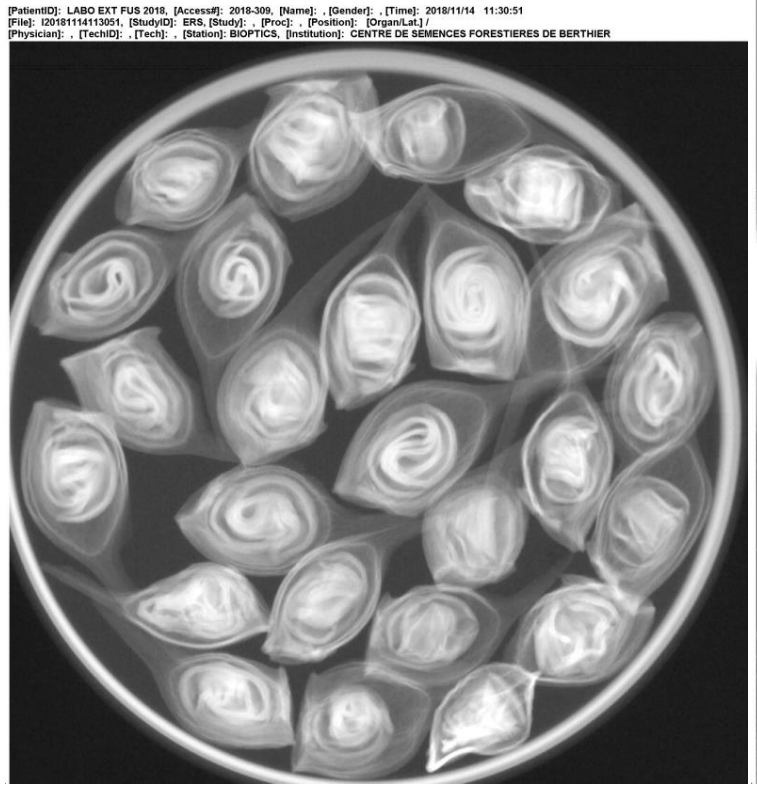
Oak

BC

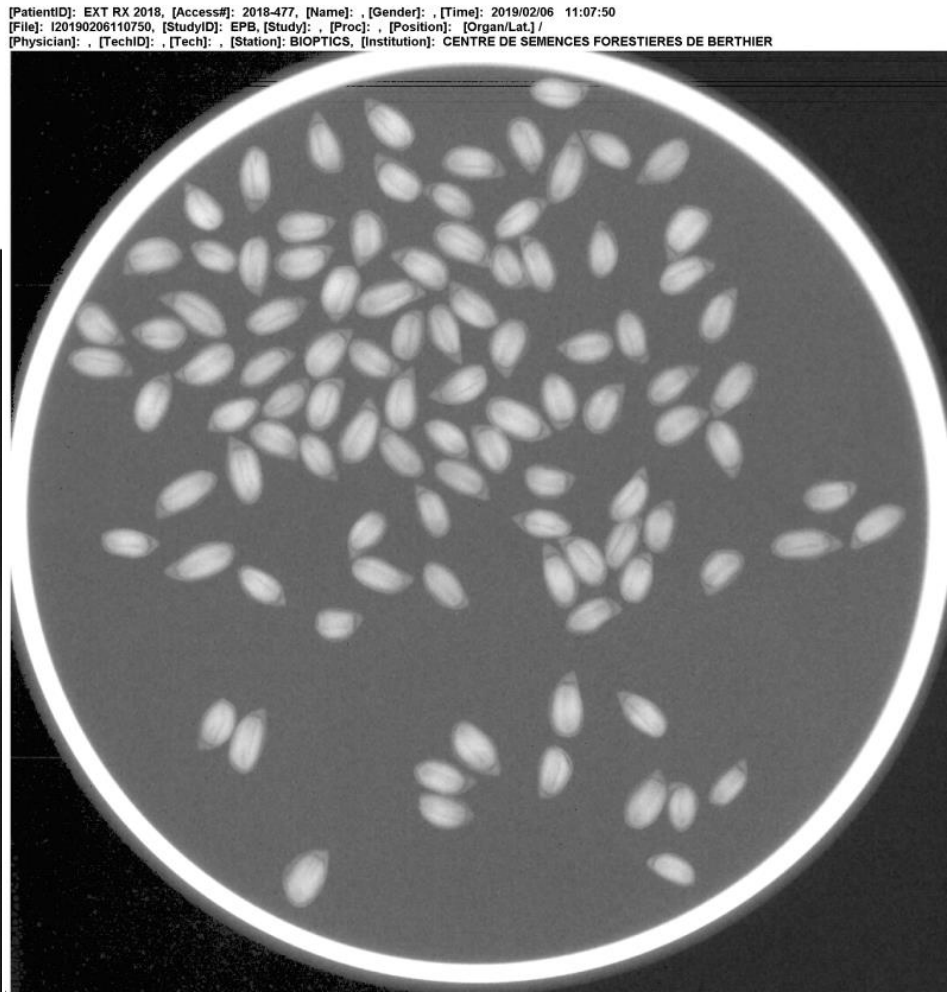
Testing: X Rays

- Non-destructive
- Expensive but reliable tool
- Used to check cleaning and seed quality and viability

Sugar Maple



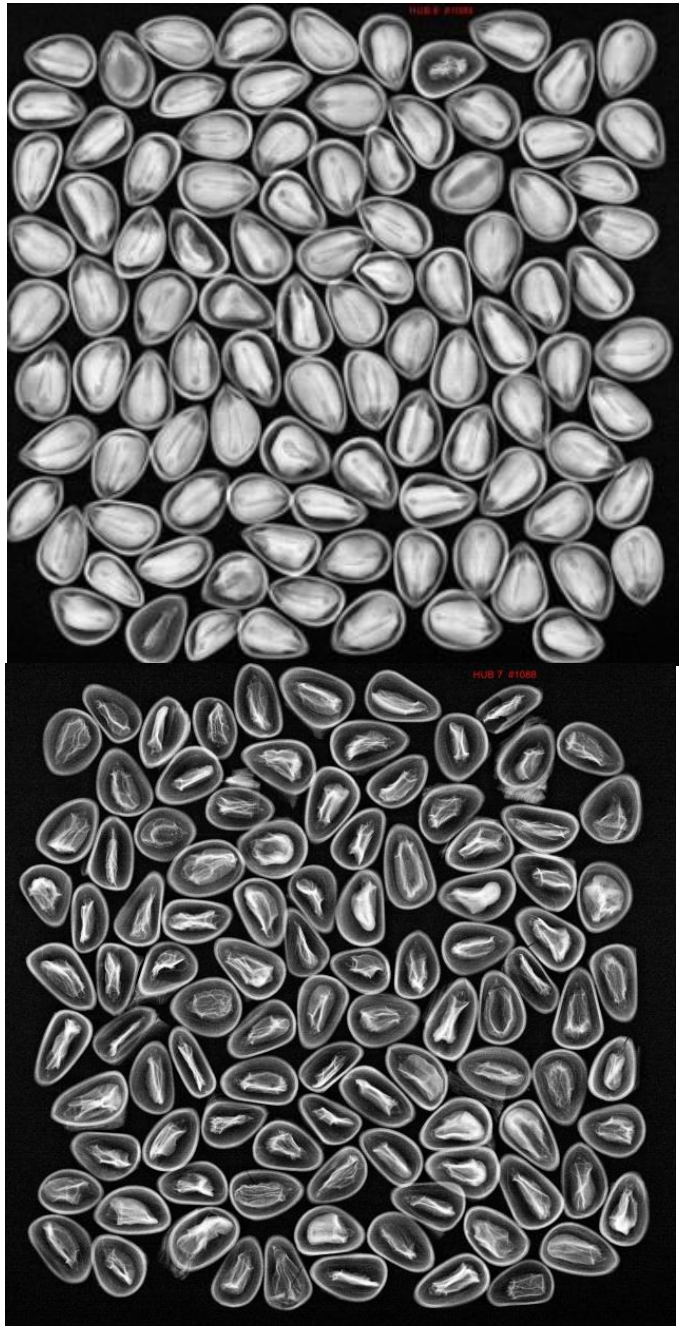
White Spruce



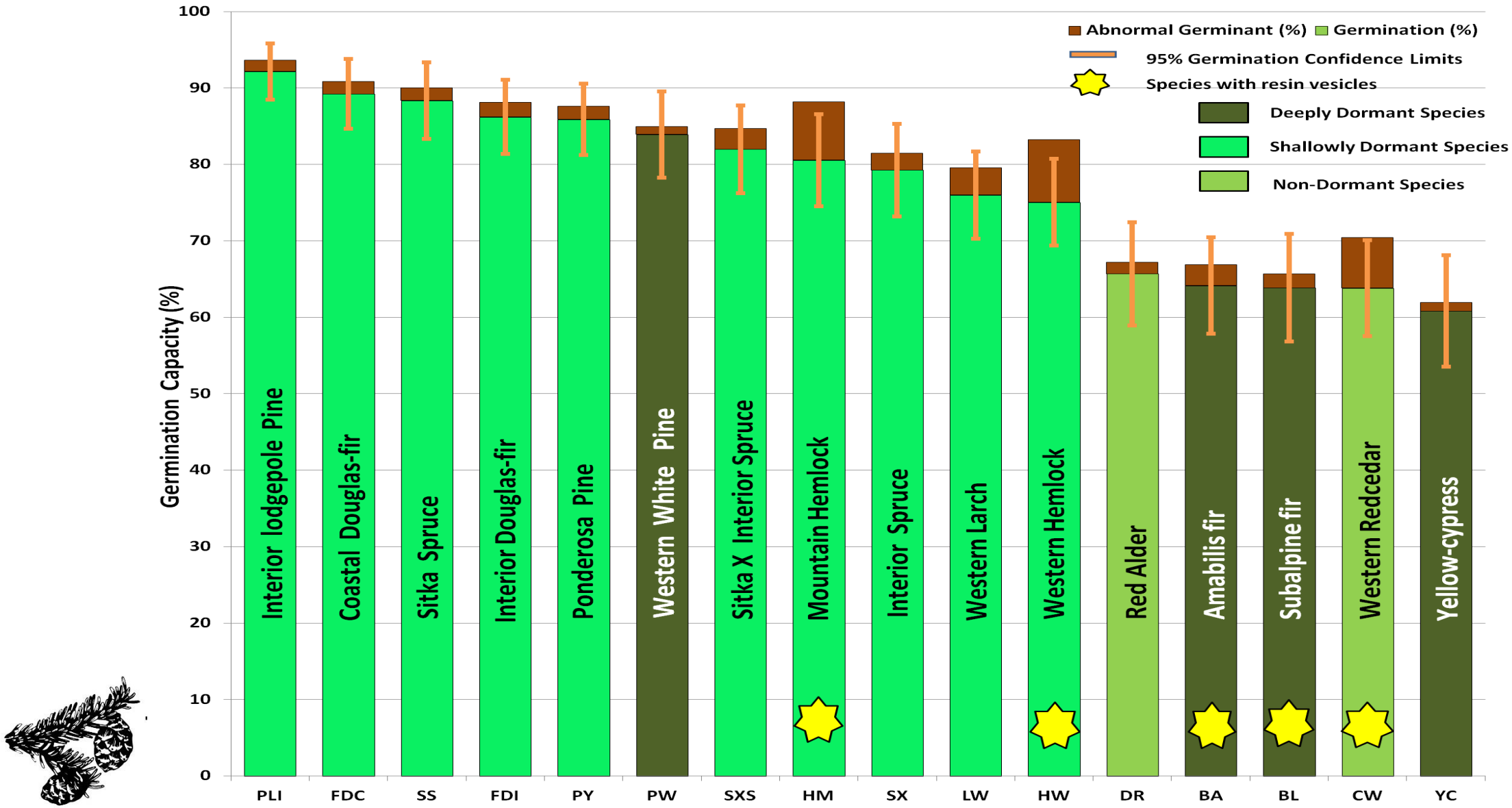
Testing: X Rays

In BC, used to estimate seed viability for whitebark pine operationally

- Embryo development
- Mechanical damage
- Insect damage (*Megastigmus* spp.)



Tree Seed Diversity in Practice



Testing

- Introduction of new species adapted to warmer climate.
- Need to develop new protocols for testing and germination conditions in nursery.
- Knowledge sharing is essential to succeed in this challenge.

Seed Preparation for Sowing

Stratification Steps:

1. Running water for imbibition
2. Surface drying
3. Open bags for stratification duration

Seed Preparation for Sowing

BC 2019

	% Requests	% of Grams	% of Seedlings
Stratified	86 %	95 %	94 %
Pelleted	10 %	1 %	4 %
Dry	4 %	4 %	2 %
TOTALS	2,718 Requests	3,408,547 grams	307,246,500 Seedlings

Quebec 2019

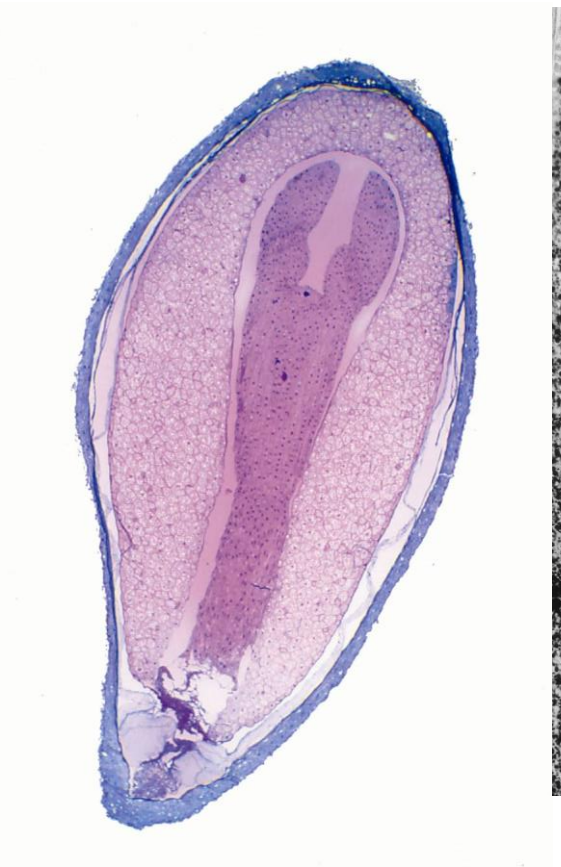
	% Requests	% of Seedlings
Stratified	49 %	29.6 %
Dry	51 %	70.4 %
TOTALS	704 Requests	148,697,050 Seedlings

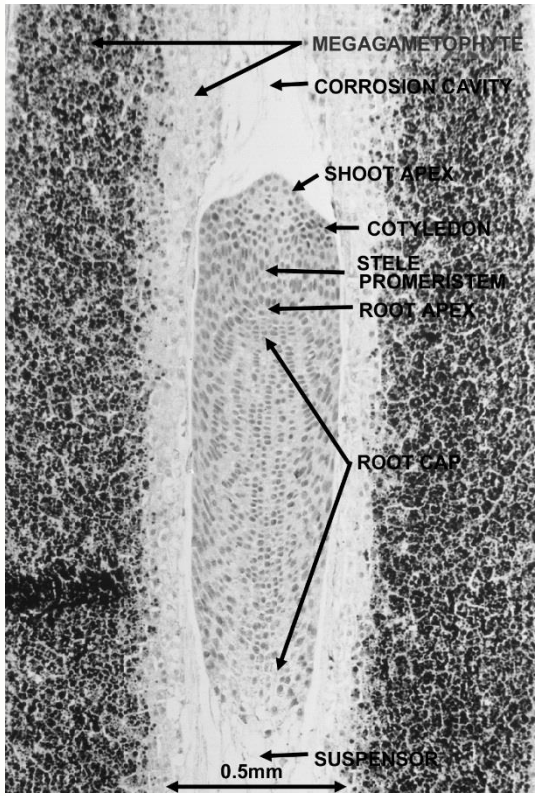
New Tools *(a few skeletons from the closet)*

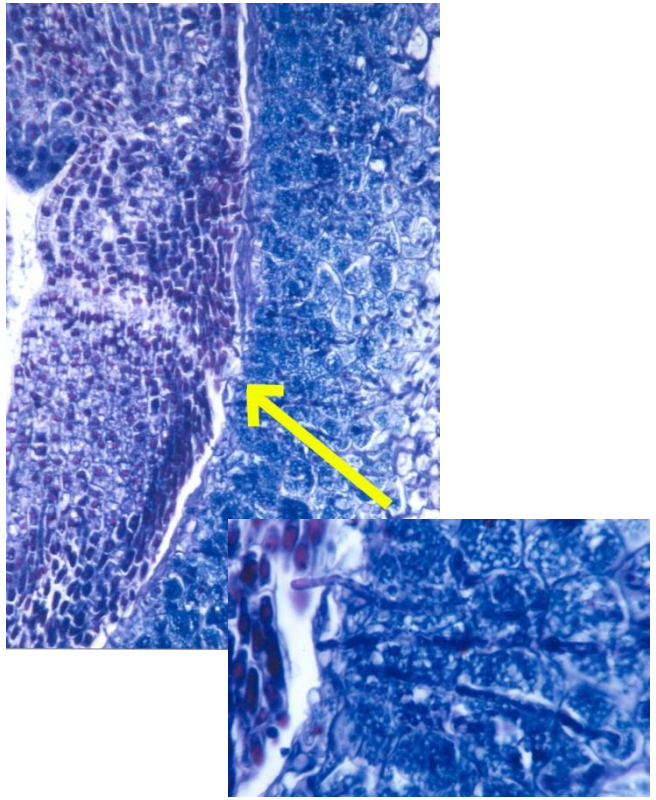
- There is a great deal of development in New Tools for seeds to aid in processing, attribute quantification and/or decision-making:
  - faster results
  - cheaper results
  - more accurate results (reproducible and easy to interpret)

- Much of this is happening with Agricultural seeds:
  - Lower genetic variability (relative ease of 'calibration')
  - Massive amounts of seed , required annually world-wide **(60 Billion US$)**
  - Many technologies are expensive and only available to large organizations
- Using the right tool for the problem at hand
  - You don't need a micropipette to measure litres of water (efficiency) *high-tech illusion*
  - Prioritizing problems and selecting the best tool vs. Finding problems for tools
  - Loss of expertise and experience (wisdom) also causes people to point to technology

Microtome Sections -Scanning Electron Microscopy





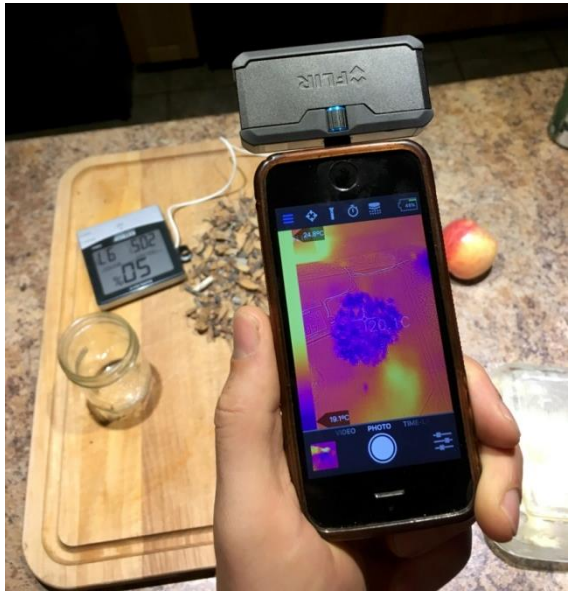


Phenotyping Methods

P = G + E + G*E

NMR/ MRI / Multispectral imaging / Electrophotography

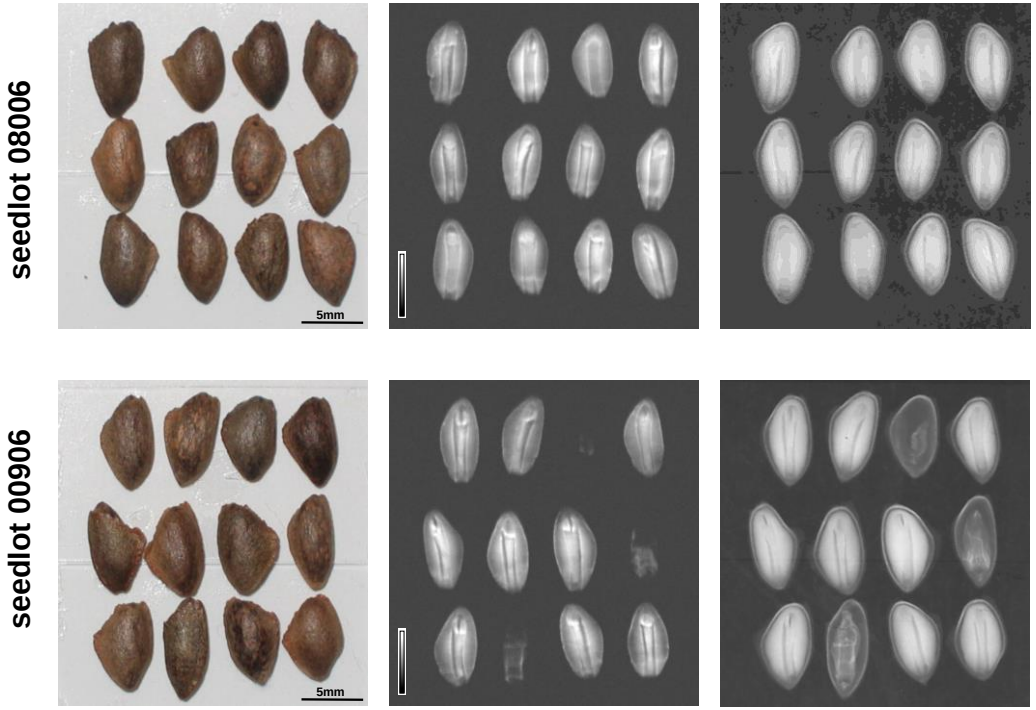
- Amazing technologies – mainly borrowed from the medical field
- Very high cost – not practical for operations, but useful research tools



Thermal camera for android phone $ 520 CDN

Tree Seed Working Group Workshop

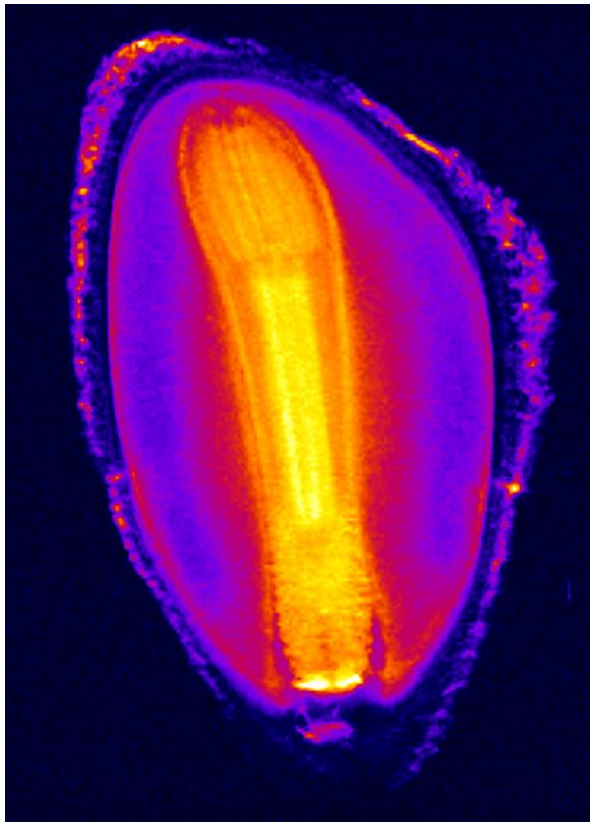
2019 Canadian Forest Genetics Association Conference
Conference de l'Association canadienne de génétique forestière 2019



Western white pine
***Pinus monticola* Dougl. ex D. Don**

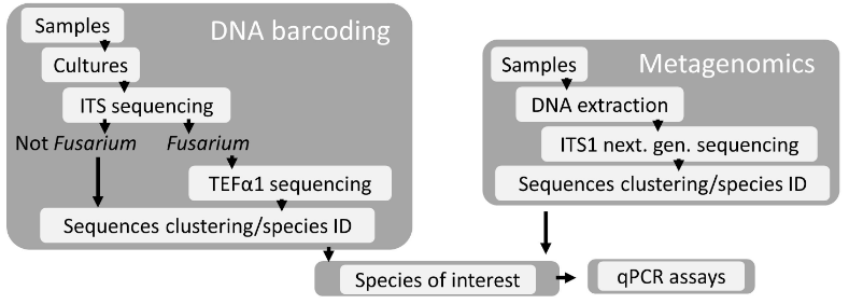
^{1}H MRI

X-ray



Molecular Tools – not just for early selection

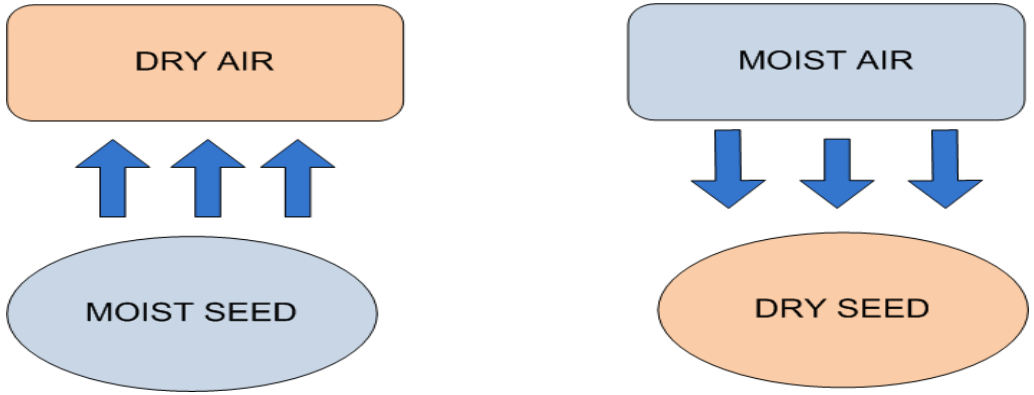
- Quantifying genetic diversity in reforestation materials – *How much is enough?*
- Quantifying inbreeding "success" (western red cedar) *How to minimize?*
- Dissecting genetic architecture (especially in non-TI program species)
- Identifying *Fusarium* to the species level – q PCR methodology in development
  - Rapid, efficient results vs. traditional plating methods
  - Genus taxonomy/ life stage is very complicated
  - Is identification enough?
    - Yes, for introduced species, rare and highly pathogenic species
    - No, for ubiquitous, fairly common species – need quantification and risk assessment

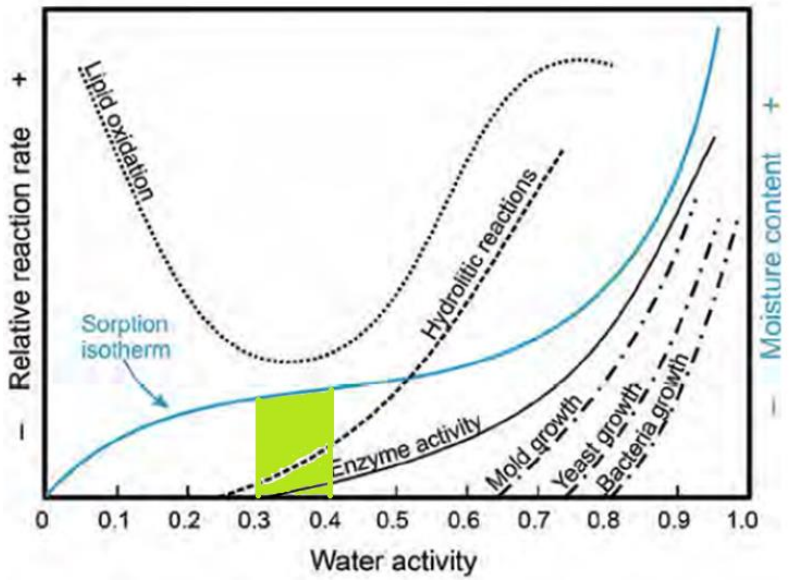


- Be clear on what the end product is – does it really meet your needs

If you can't explain it simply you don't understand it well enough
Albert Einstein

THE BASIC Water Activity CONCEPT



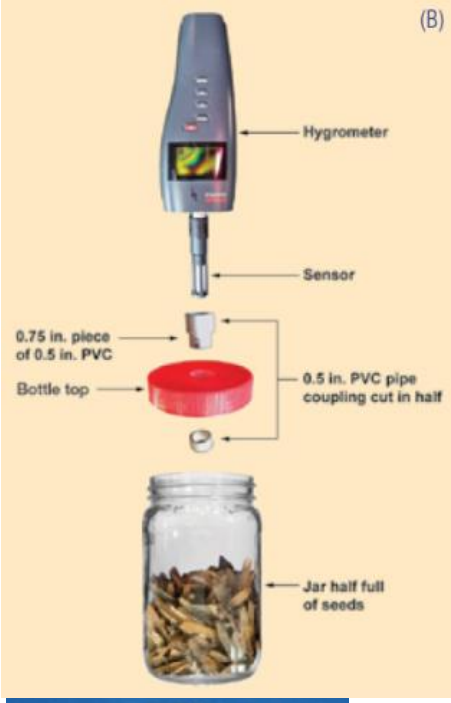


- Cones and Seeds are hygroscopic
- Seeds will lose or gain moisture to the environment until an equilibrium condition is reached
- Equilibrium (ERH) will also be influenced by fat content ↓
- Non-destructive, quick (5-10 min), and simple
- Better indicator of the rate of microbiological, chemical, & enzymatic activity

CTIA 2008 QC– Patrick Baldet – 'from frozen pizza to seeds and pollen'

Water Activity Measurement

- Used in many seed banks world wide
- Integration into ISTA … soon
- Already in Alberta seed testing standards
- Used for GC collection in BC
- A tool to guide drying and retesting in Quebec. Also used for pollen (controlled crosses).



Water Activity Applications

Water activity integrated into BCC drying line at the Berthier Tree Seed Centre

Drying with humidity and not heat

Convert a cabinet to a Aw-based drying cabinet using humidity not heat!
Two –pressure principle to produce a standard relative humidity generator
(Baldet & Colas 2013)

Simplified and cheaper design without the need for a saturation tank.
See TSWG News Bulletin # 68
(Colas & Desrosiers 2019)

Tetrazolium – chemical indicators

- Long established means of determining seed viability based on reaction of respiring seed parts with a stain (tetrazolium chloride) **ISTA**
- Very quick results, labour intensive, but very useful if you really need to know if a practice or event has killed seed (e.g.. cooler turned into a freezer with stratified seed)
- Hesitant to introduce as a standard test (tool in the tool box)

- Other chemical indicators have been used:
  - Fumarase as an indicator of seed vigour (Scots pine)
  - Fluorescein diacete as a seed viability test – Ontario (jack pine, black and white spruce)

Quick Test Overview (low tech, except for X-rays)

	Results in	Equipment Costs	Tech. Time Required	Predictive Ability	Expertise Required
H_2O_2	7 days	¢	**	**	*
Tetrazolium	1-2 days	$	***	***	***
Cutting	Instant or overnight	¢	**	**	***
Incubation	7 days	¢	*	*	**
X-Ray	Instant if digital	$$$	*	***	**

- For instant decision-making it's hard to compete with the combination of cutting tests and digital x-rays = bread and butter at BC Tree Seed Centre
- Incubation tests may be useful for confirming viability among certain questionable categories
- Tetrazolium should be something we look at for "problem" seedlots or live/dead decisions (e.g. several times stratiication coolers became freezers – tree seed is robust)

Electrical or Leachate Conductivity

- A raid, objective and quantitative method to predict seed viability / collection timing
- Simply the measurement of leachates from seeds soaked in water
- ‘leaky’ seeds due to incomplete development or cellular damage
- Results available within 24 hours
- Some experience comparing EC to germination capacity (r-values)
- It’s a validated ISTA vigour test
- Not useful for Quercus (**FC**)

Coastal Douglas-fir	**-0.84**
Western redcedar	**-0.80**
Interior spruce	**-0.56**
Interior Douglas-fir	**-0.48**
Interior lodgepole pine	**-0.38**
Western hemlock	**0.03**

Pelleting

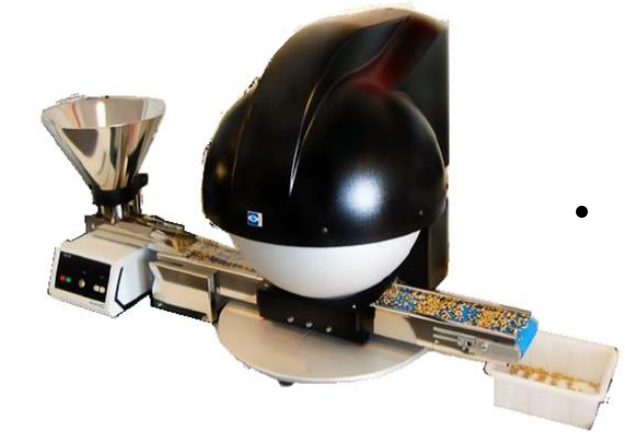
- Used operationally in BC for western redcedar and red alder
- Used in NB for black spruce
- See talk by Jean- Marie Sobze on Thursday

- Can simply be to increase mass, sowing precision
- potential to be much more
  - Introduction of fertilizers
  - Introductions of pesticides/ herbivory deterrents
  - Introduction of mycorrhizae
- Coating → Encrusting → Pelleting

Computer Chip Technology

- Large advancements in monitoring tools
  - Ability to monitor temperature and humidity
  - Seed orchards, cone sheds, processing facilities – kilns
  - Shipping materials !
- Data, Data, Data – not just for collecting!
- **Precision Farming** – driven by technology
- Initial explorations in BC seed orchards
  - Soil mapping
  - Nutrient foliage monitoring – fertilization regimes
  - Water deficits
-

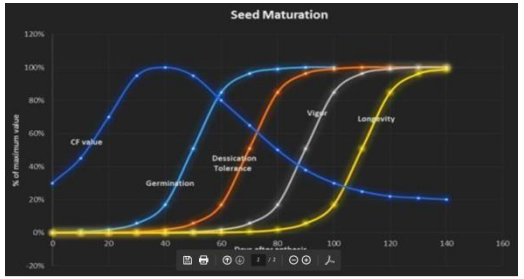
Multispectral Analysis



- Fast and accurate determination of surface colour and chemical composition
- Automated, “unmanned” operation

Chlorophyll Fluorescence

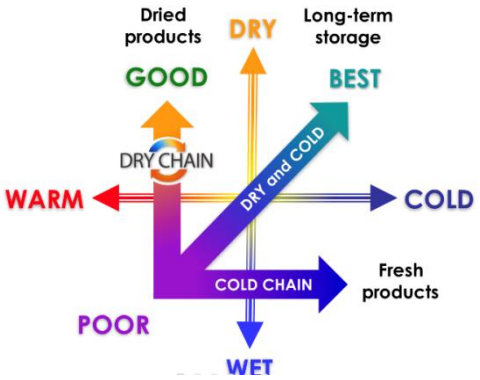
- Inverse relationship between chlorophyll content and seed maturity in many species



Oxygen Consumption

- Oxygen consumption a quick method of measuring respiration and metabolism
- Quicker than a germination test **(24-120 hrs)**
- Also an indication of seed vigour under field conditions

Food Security
Tools for Rural Farmers

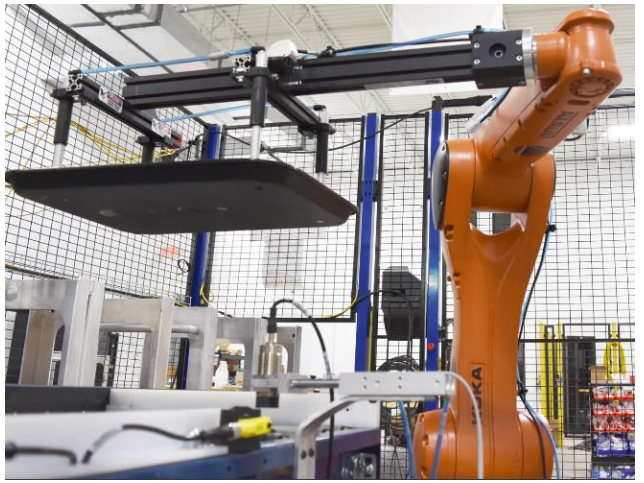


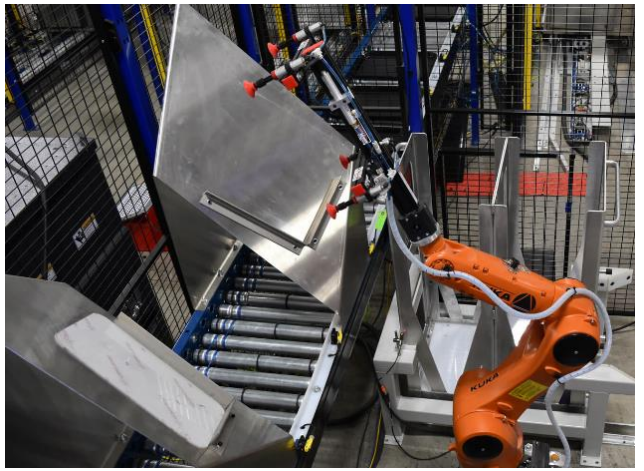
- Practical tools like drying beads / RH indicators for the rural farmer

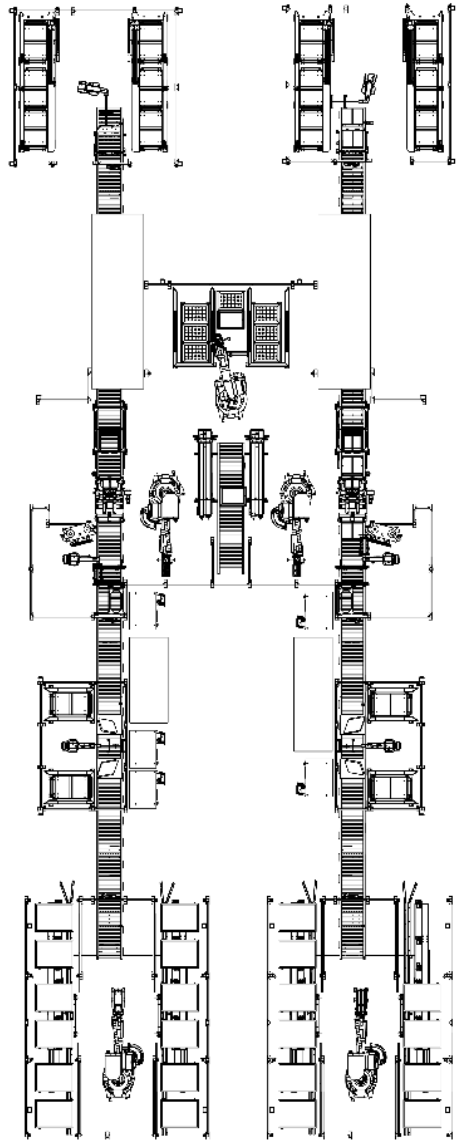
Robotics – Fully automated Lab Prototype

https://www.visualcomponents.com/insights/case-studies/ias-project-case-study/

- Robotics replaced a crew of 100 people –
- prepping seed & equipment, counting, data entry
- Inspired by labour and quality issues







Summary of Risks to Cone & Seed Services

- Cone and Seed services taken for granted, lack of reinvestment
- High capital costs for a TSC, highly variable crops not a great business case – the public sector should be involved
- Surplus seed and economic downturns result in pressures on seed centres; it's a long-term commitment that needs to be maintained
- Research becomes "proprietary information" – need publicly-funded, practical and available-to-all research *(knowledge portfolio diversity)*
- HUGE risks associated with failure
  - BC seed inventory worth $85M at current seed prices
  - Drought, natural migration failure, plantation establishment are looming; climate-based seed transfer one tool but complex process versus local-is-best
  - Increased pressures with climate change – pests, fires, drought, extreme weather

Summary of Future Opportunities

- 50+ years investment by Canadian forest industry and government in R&D but operational needs to actualize the gains are not well-supported = smart reinvestment and recruitment.
- Priorities of TSWG members are for the first steps of the seed sector (seed collection labour, seed storage protocols).
- Training and resources are available, but field experience is better learned … in the field.
- Collaboration between provincial experts more important than ever.
- Large divide between high tech methods and practical field activities – lots of opportunities here.

Thank You!

2nd generation Eastern White Pine (Berthier, QC)