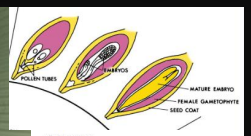
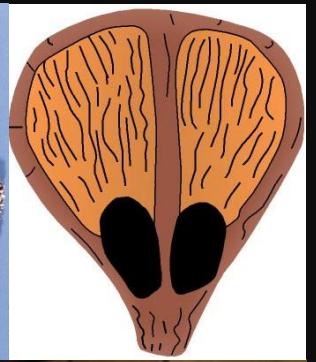
Cone Maturation, Collection, Storage and Handling



Dave Kolotelo



Cones are the Vehicles to our Seed

- **Cone Maturation** – continuous process primarily heat unit driven
  - *Talk will focus on post-fertilization events until collection*
  - *Pli specific falldowns not covered in this talk*

- **Cone Collection** – a point in time designed to maximize seed yield and quality *(decision is influenced by other crops)*
  - *What are our indicators (review – emphasis on practicality and facility development of localized tools – no silver bullet)*

- **Cone Storage** – continuation of 'maturation', can impact seed quality, and yield
  - *What is after-ripening? What conditions are required?*

- **Cone Handling** – activities used to inform, maintain, or enhance cone condition, seed quality and yield
  - *Everyone has a role in exercising due diligence*

- **Tree Seed Centre - Upcoming Work**
  - *kilning trials, efficiency quantification, water activity*

Cone and Seed Truisms

- Seed Quality (germination%) is thought to be maximal at time of natural dispersal - we want to collect at dispersal = **IMPRACTICAL**
  Labour and Time Issues
- Patterns of seed quality (germination) during development may be obscured by embryo dormancy which develops during maturation
- Goal is seeds mature enough to be extracted, and to germinate under optimal & suboptimal conditions, and which can be freezer stored for prolonged periods ☺
- Moisture content is directly related to damage potential
  - (moisture content ⇧ then risk of damage ⇧)
- **The earlier the collection (relative to seed shedding)the more attention needs to be paid to post-collection handling!**

- Germination is not solely a population characteristic !
- Germination = function of
  - Cone Collection timing
  - Cone Handling, Storage and Transport
  - Cone and Seed Processing
  - Seed Pretreatment

- Seed Yield is influenced by the above factors and the Pollination and fertilization success for each crop

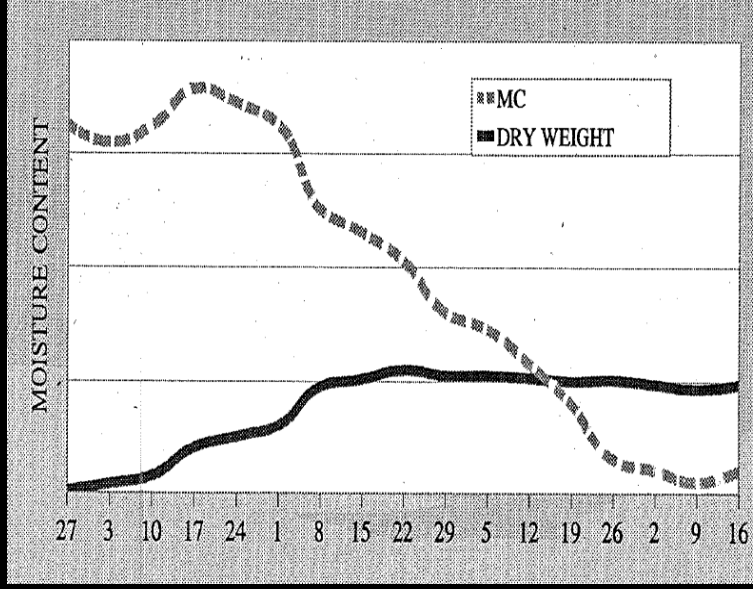
- Most cone ‘maturation’ work (1950’s, 1980’s) aimed at wild stand seedlots – even there they found differences in seed maturity between
  - Years (on any given day)
  - Stands ~ differences between orchard clones
  - Trees within stands
  - Cones within a tree (location / aspect)
  - Seeds within a cone

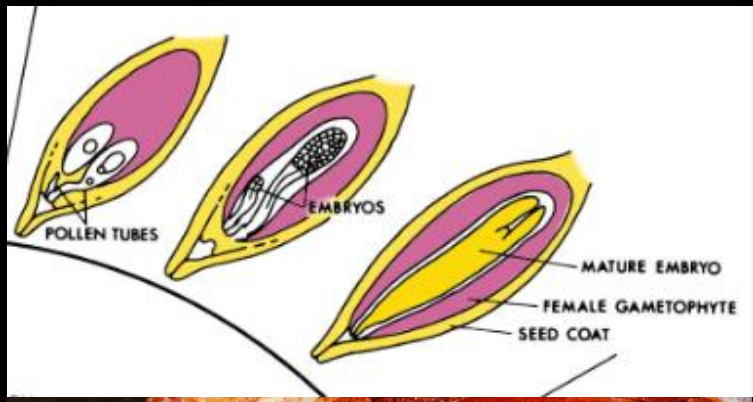
Cone Maturation

- Maximum cone dry weight achieved prior to full maturation
- Very high initial moisture content (60%+)
- Cone dehydration is accompanied by build-up of storage components in megagametophyte and embryo
  - Simple sugars ➔ complex sugars, fats, proteins
- Megagametophyte changes from jelly-like to firm and white

- Conifer seeds are not vascularized
- Cones have one vascular strand into bract and two traces into the scale which branch
- Embryo nourishment is supplied primarily from embryonic fluid in the corrosion cavity secreted from the megagametophyte
- Mature Embryos have a well developed vascular system

- Female cones photosynthesize





Seed Maturity

- We are almost always dealing with needing to "after-ripen" crops (*i.e.* some degree of immaturity = collecting before seed shedding)
- ***What is Possible*** – 3 month early harvest in NZ with Radiata pine – Shaf (ProSeed) - feeding the genetic gain program immediate need
  - Limiting factor was not seed maturity, but seed extractability from cones!
  - No obvious anatomical changes occurred during this after-ripening period
  - Feasible for other species or lucky combination of an exotic and a new environment?

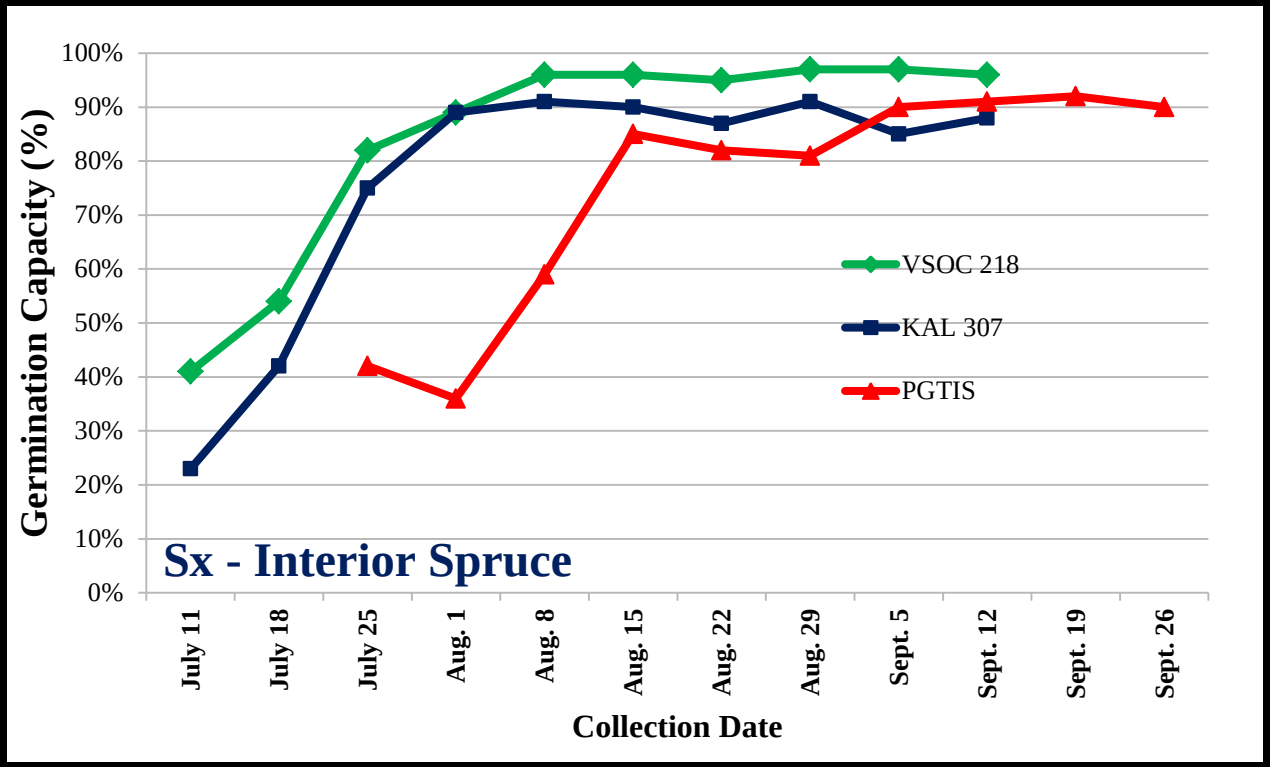
The more pre-mature the collection, the more exacting the cone storage conditions need to be to get continued development -

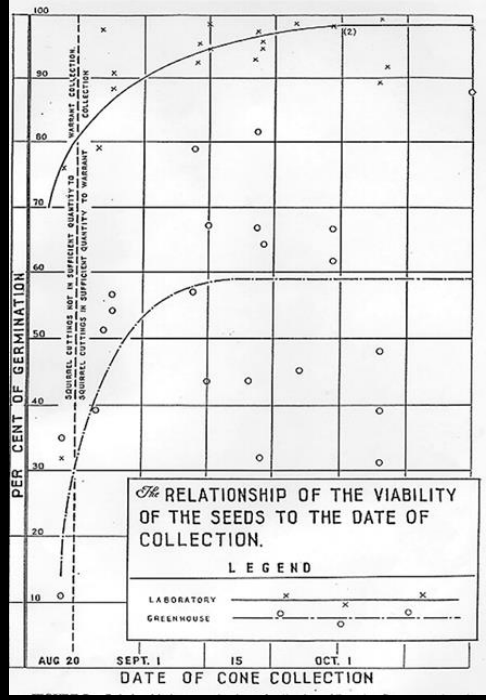
- Temperature
- Humidity levels

both of which could be interior orchard challenges

- **What works one year shouldn't become Standard Operating Procedures**

Collection Timing
Impact on Germination





- Collections from early, mid and late clones bulked together
- Poor germination from earliest collections
  - Bias from bulk collections (late clones very bad in early picks)
  - How early can early clones be picked? Window-widening

Seeds must reach a stage at which they are independent of the tree for nutrition

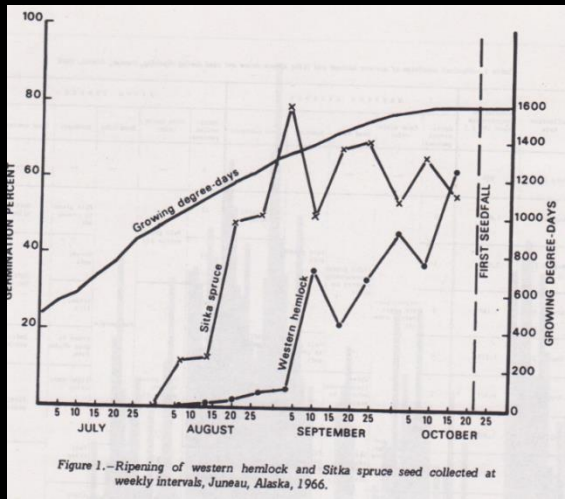
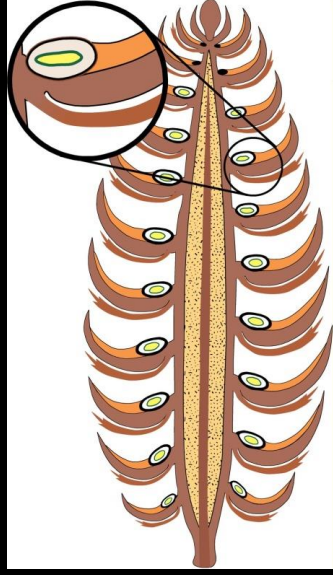


Figure 1.—Ripening of western hemlock and Sitka spruce seed collected at weekly intervals, Juneau, Alaska, 1966.

Cone Crop Monitoring



- Monitoring the condition of a crop prior to harvest is important to:
  - Determine size of crop
    - Seed planning (budgeting / present + future needs)
    - Plan resource requirements (pick, interim storage, transport)
  - Determine maturity level
    - More frequent monitoring closer to collection
    - Proper sampling of stand/orchard variability
  - Determine pest problems
    - Pro-active or active control in orchard

Sampling

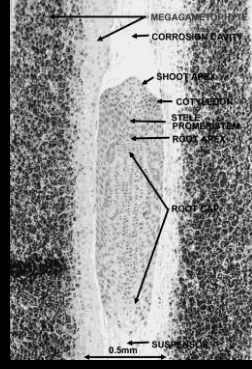
- Any result (*i.e.* fspc) is only as good as the sample taken !
- Randomly drawn from the population
- Representative of proportions in the population (i.e. clones)

- Seed orchard seed represent much more variation than natural stands
  - Removal of inbreeding depression
  - Recombination of genotypes previously not in contact (although climatically similar)

- Sample size determination has three components
  1) Accuracy required (*i.e.* 1 fspc)
  2) Variation present in trait of interest
  3) Risk tolerance (*often 95% confidence used*)

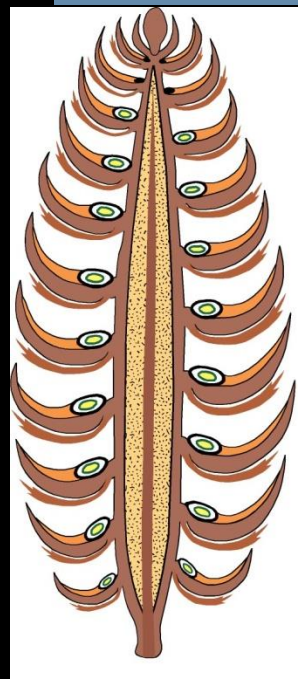
- **We looked at seeds per half cone for wild interior spruce seedlots**
  - **provides indication of accuracy and risk = information (averages aren't all created equal)**
- **Accuracy not linearly related to sample size**

Accuracy Level (#seeds/half cone)	*Estimated sample size*
1	*32.3*
2	*8.0*
3	*3.6*



Cone Maturation Indicators

Emphasis on site-specific method development - What works for your site, species and employees



Cone Morphological Observations

- Cone maturity is tied to a reduction in moisture and lignification of tissues (woody structure)
- Extremes in appearance are obvious –the earliest we can pick cones is not so obvious from cone morphology
- cone colour, bract colour, firmness - degree of scale flexing (1953)
- Seed or seed wing colour are not great indicators, especially with seed orchard crops – large variability between clones
- Seed wing release from cone scale is HIGHLY RECOMMENDED
  - Separation of seed from ovuliferous scale





Half-Cone Cuts

(not recommended for lodgepole pine)

- Originally designed to help determine whether to collect a natural stand crop (Y / N) – *megagametophyte presence*
- Seed orchard crops are almost always collected
  - Pest observations / axis test
- FRDA 55 -correlations between filled seeds in ½ cone and whole cones:
  - Douglas-fir : r^2 =0.71
  - Interior Spruce : r^2 =0.81
  - Subalpine fir : r^2=0.77

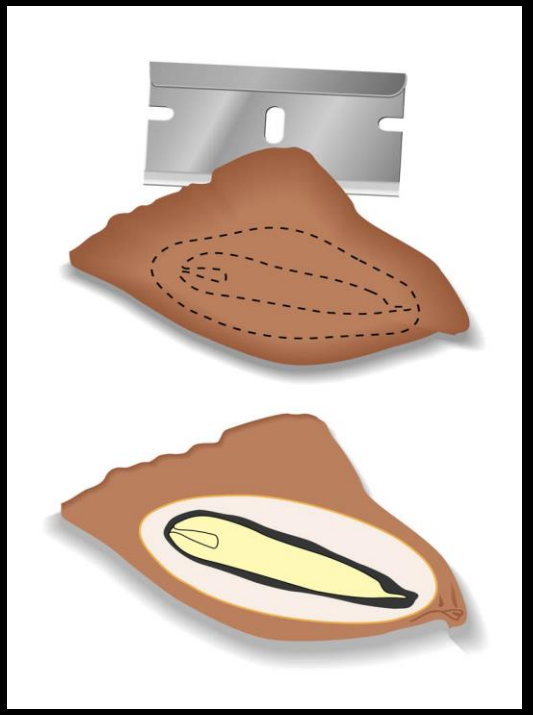
FRDA 055 minimum collection standard for lodgepole pine is **20** filled seeds per cone!

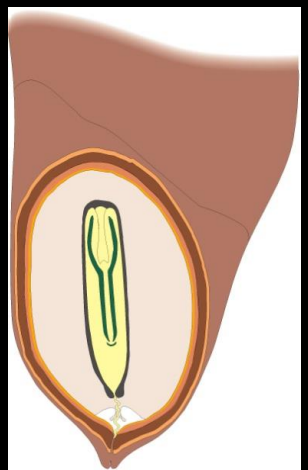
Cone "Axis Test"

- KAL credit Kudo's (Chris and Gary)
- Assessment of moisture level / cone independence
- Quick and easy to perform in the field!
- Useful for western larch, interior spruce and Douglas-fir
- Cut cone longitudinally – does axis appear brown and dry? Indicating link with tree has been severed
- Or does it still contain moisture (Gary suggest running knife blade on axis – look for water droplets)

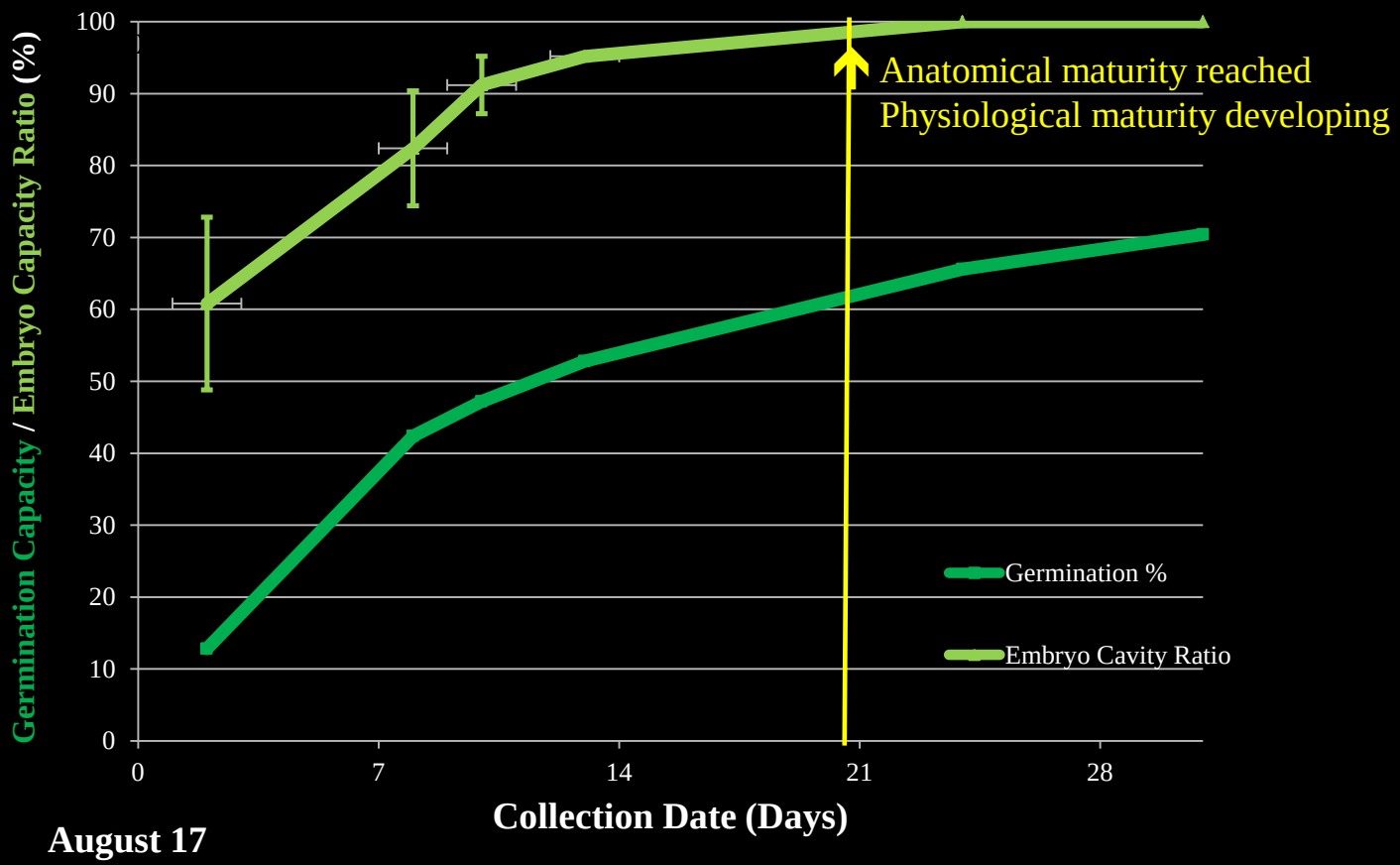
Cutting Tests

- **'seed anatomy tests'**
- Seed cut longitudinally
- **embryo length in relation to corrosion cavity (> 90%)** ***(1982 still using 75%)***
- Megagametophyte = white with a firm, solid consistency
- Used extensively in cone and seed processing – viable / non-viable seed estimation
- Lack of overnight megagametophyte shrinkage used by some to indicate maturity
- Green embryos are a 'warning' ➔ germination



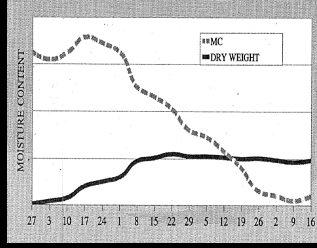


Embryo Cavity Ratio



- Embryo cavity ratio has been a good maturation indicator
- Physiological maturity continues after this stage
- Reason for proper post-collection handling procedures =After-ripening)

Other Methods Used



- Liquid Floatation - cones will dry and will reach a certain specific gravity at maturation – consistent measurement – clonal variation?
  - Direct specific gravity assessment cumbersome
  - Liquids (kersosene, various oils) have been used to assess maturity (1950's)
  - When some % (80-90) of cones float then ,cones are considered mature
  - Isthere something we can use to make water less dense?

- Degree Days – maturation is primarily degree day driven
  - Lower and upper threshold temperatures? 5 and 35° C used at KAL
    - At high temperatures, 'reactions' may cease or slow-down
  - Can provide a good guide to crop progression vs. other years

- Indicator plants – integrates other environmental variables (light, precipitation …)
  - For white spruce , fireweed capsule bursting was found to be superior to degree-days

- Biochemical indicators – generally not field methods
  - Amount of reducing sugars -shown to be an accurate method
  - Leachate conductivity – decreases during maturation

ONE TIME ACTIVITIES

- Collection, post-collection handling & transport
- Care, organization and $ invested at these stages will be ‘captured’ for the entire life of a seedlot
- Do you only quality assure your cones until they are in the sacks? Investments in QA
- Do you know what conditions your harvested cones experienced
  - **Yesterday at noon**
  - **Last night**
  - **Do you open your cones sacks during storage**

“Risk Management” requires a real appreciation of when risks are greatest

And what the costs of failure are

Cone Collection Due Diligence

- Use new sacks or properly sterilized sacks (steam/hot water)
- Limit amount of debris included (mc / fungi / abrasive)
- Move sacks daily from collection site to interim storage
- Correct Identification (Outside and inside sacks)
- Fill sacks ½ to ⅓ full to minimize heat build-up / cone expansion
- Keep sacks off ground / on sides to reduce weight
- Place sacks in shady, cool environment protected from the elements and pests with good air circulation (fans help!)
- Turn sacks to encourage uniformity, discourage clumping
  - Frequency depends on cone moisture content
- Examine cones during cone storage –
  - Know how your cones look at shipping, not just at picking

Cone Storage

- Goal is to slowly dry the cones and complete maturation process maximizing seed extractability and germination
- Physiological changes continue after anatomical maturity has been reached
  - Protection / Aeration / humidity levels ?
  - Weight distribution / restricting opening

Serotinous Pli can be stacked

Coneworms (*Dioryctria* spp.)

- Insect continues feeding after cone harvest ! Distinctive dark head
- Complicated life cycle = overlapping generations makes control difficult
- Identification during seedlot evaluation crucial – prioritize extraction // cooling slows feeding
- COMMUNICATION

Fungal Problems

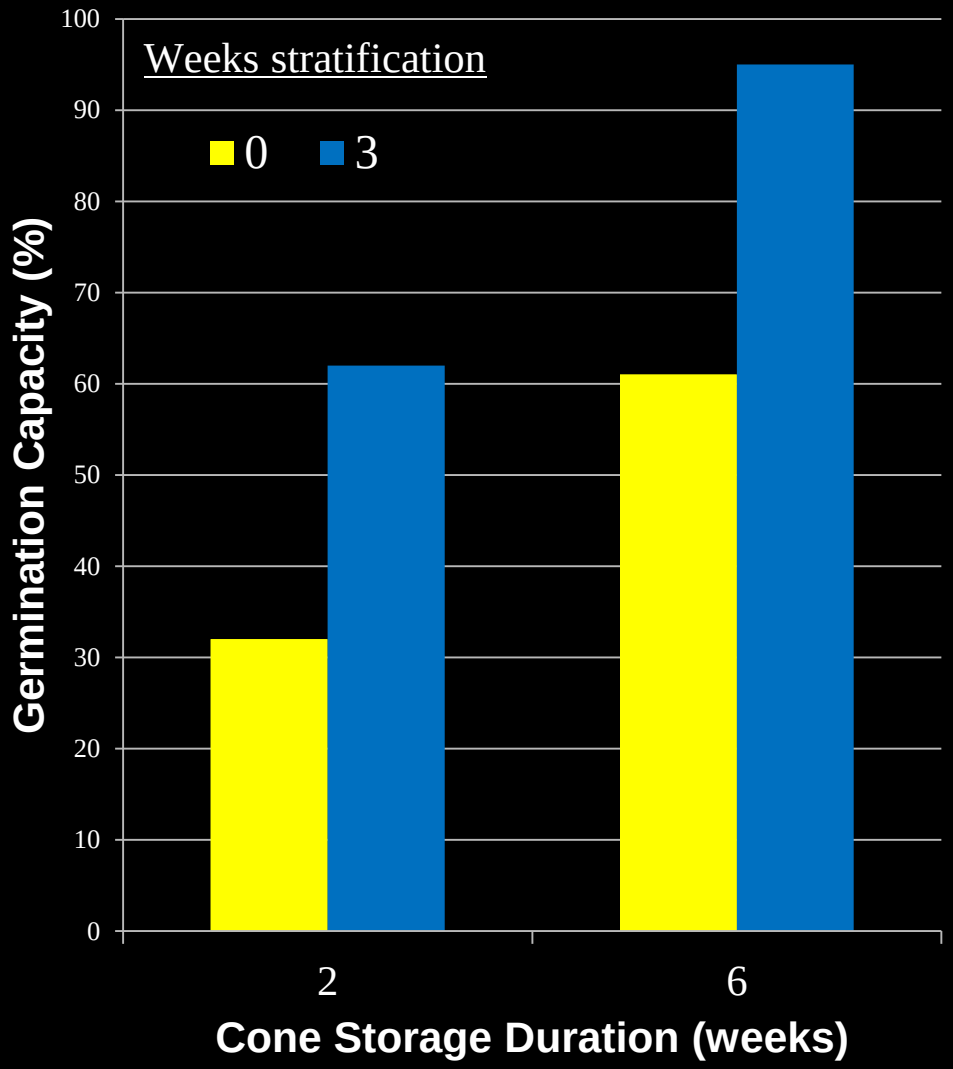
- Uncommon, but do occur
- Easy to correct if identified early
  - change environment
- Lack of due diligence with post-collection handling

- Communication!

Cone Storage
Impact on Germination

- Caron *et al* 1990
- 18 Op white spruce trees
- Collected at time of seed shedding

Impact of prolonged cone storage as important as stratification!!!

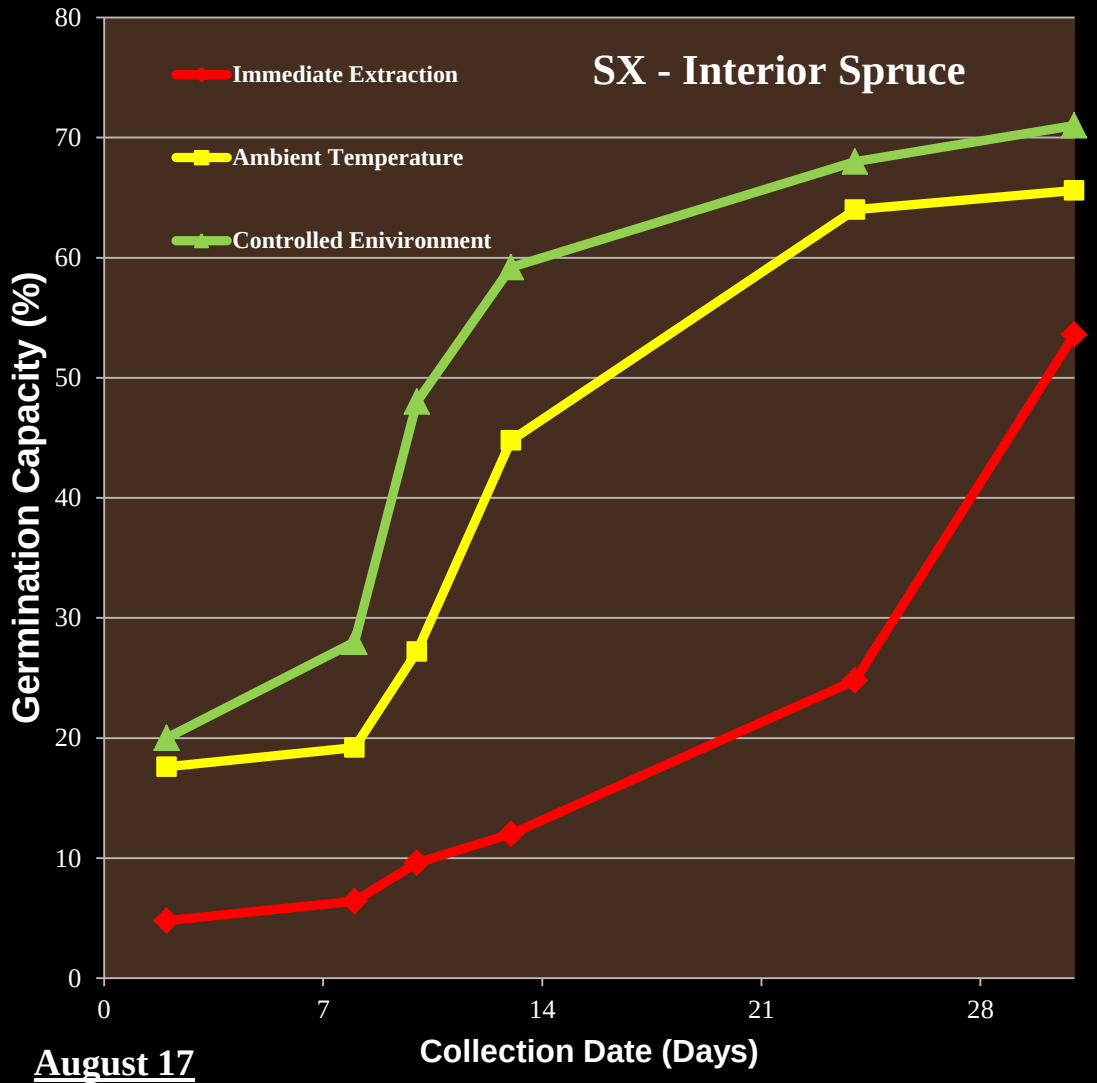


Cone Storage

Internet story

- Cones collected over several dates were subjected to three treatments
  - Immediate extraction
  - Ambient Temperature
  - (4 weeks)
  - Controlled Environment
  - (4 weeks 5°C – 75-100% RH)

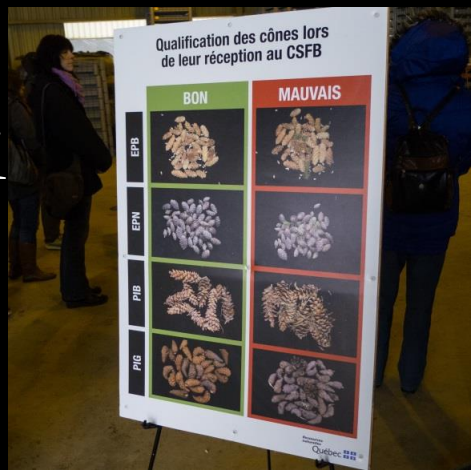
- At all collection dates the controlled environment treatment maximized germination



August 17

Cone Transport

- Communication, communication, communication
- Palleted shipments please!
  - Aeration
  - Cone tags facing out
  - Seedlot / family separation clarity important
- Keep Shipment cool
  - Shipping distance
  - Moisture content of cones
- Later collected (close to shipping) material i
  - higher MC / expedited racking / extra ventilation



TSC Perspectives/ Activities

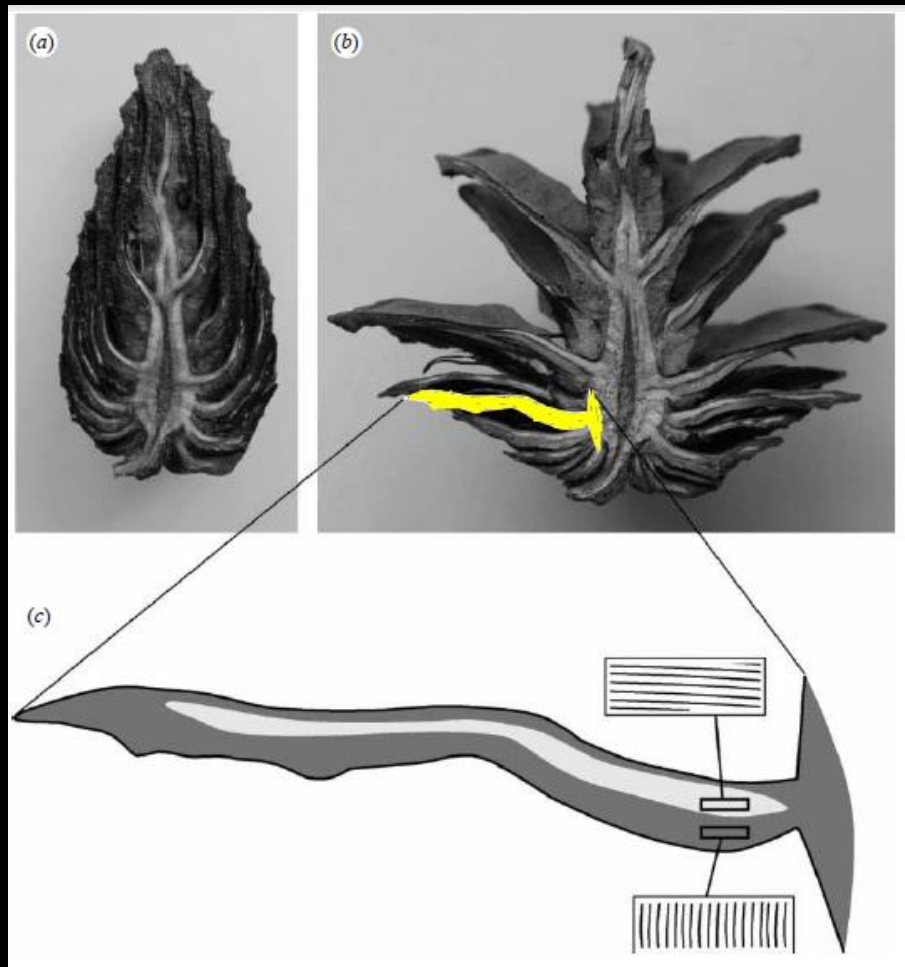
- General sense that many conelots arrive at TSC with moisture contents below the optimum seed extraction = cones too dry
  - Earlier shipping
  - Multiple shipments?

- Conducting trials this fall looking at various kilning regimes to improve efficiency (mini-kiln on site= controlled temperature*humidity chamber)
  - Lab scale ➔ inform large scale needs
  - Increased extraction efficiency / decreased energy + time required

- Call for Cones !
  - We don't just sample your cones
  - Anyone interested in participating, please contact me
  - Rough estimate would be 100 cones (Pli probably more)
- Call for fspc information
  - Most orchard crops are open on arrival and we can't get an accurate estimate
  - Is information available ???

Cone Opening

•Cones react to RH% similar to the way a bimetallic strip responds to temperature
• Difference are due to orientation of cell wall microfibrils
•Upper Scale – low angle microfibrils resist elongation
•Lower Scale – high microfibril angle allows elongation when damp closing cone

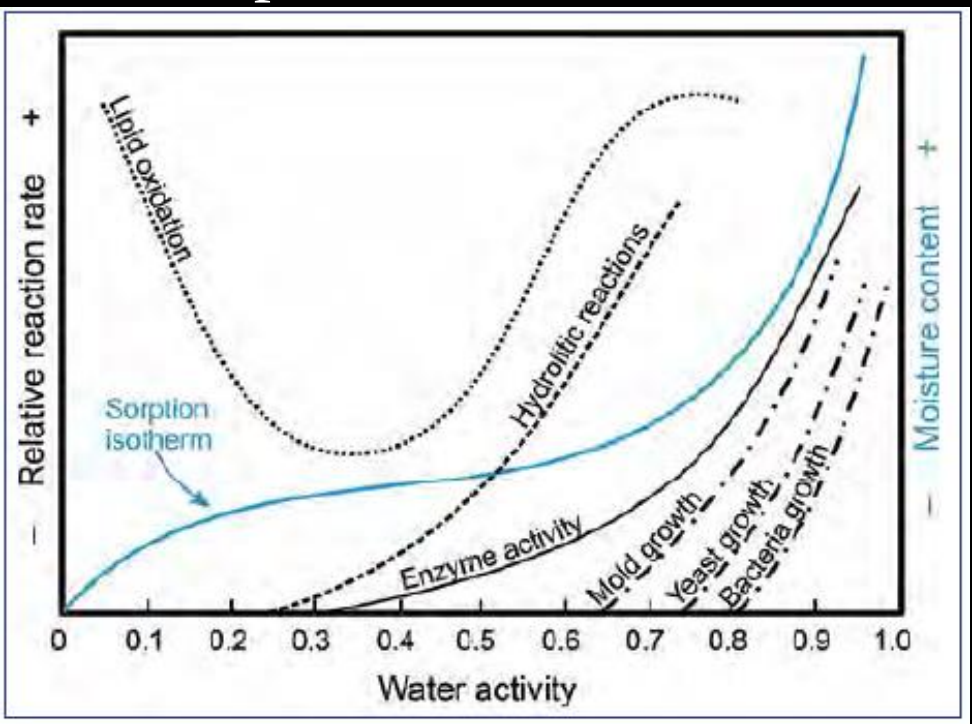


•Cones can be calibrated to be a hygrometer HYGROMORPHS

•For serotinous species the resin bond must be first broken before RH plays a role in cone opening

Water Activity

- Different method for looking at water status of seeds / cones
  - Used extensively in food industry
- Provides a more accurate assessment of deterioration risks
- Relates to moisture availability for biotic and abiotic factors
- Potential use for determining when physiological maturity is complete



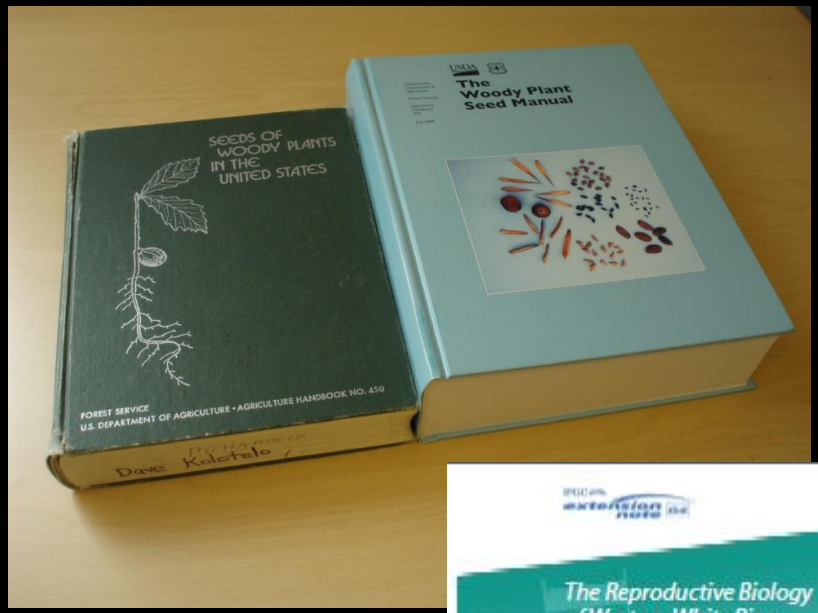
- Technology is also used for constructing seed and pollen driers
  - Drying without heat
  - No chance of overdrying
- Not efficient for large-scale driers (kilns) – cabinet style

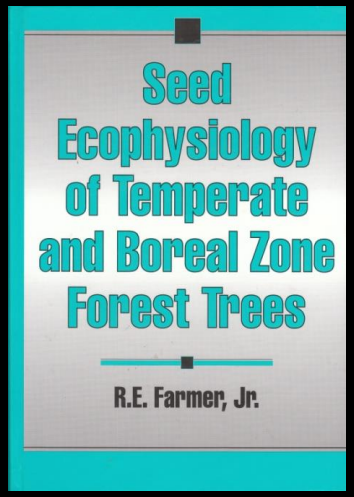
- Baldet + Colas article in Tree Planters Notes

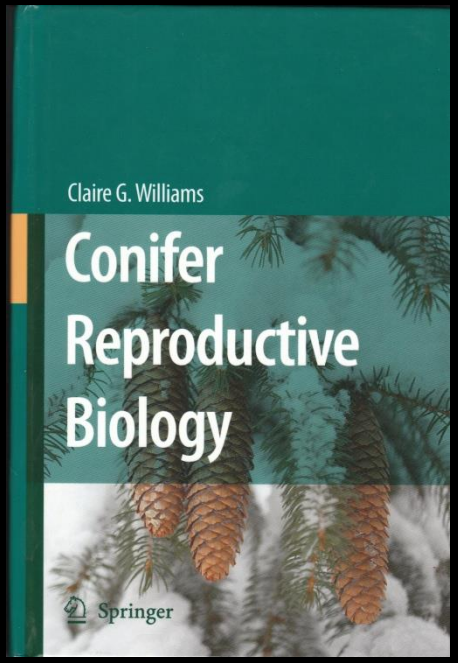

DRIERITE
2
DRIERITE
3
SONDE

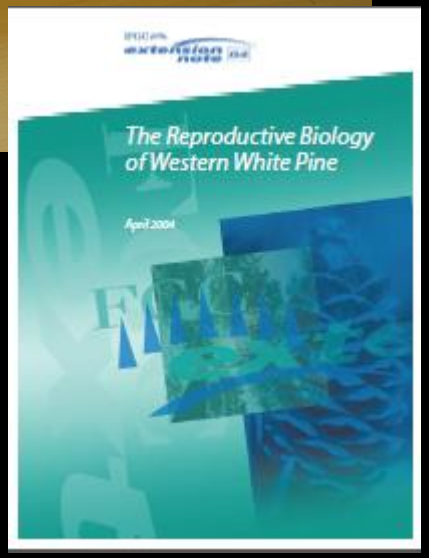
EXTENSION

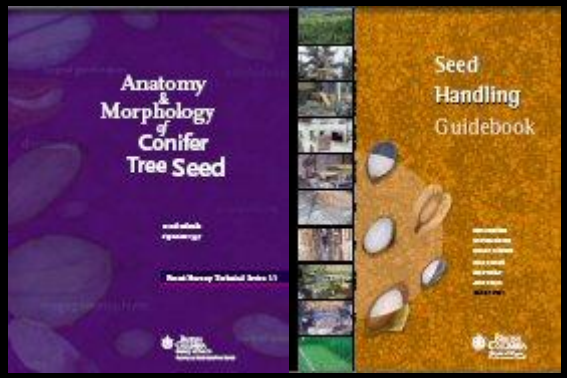
Tree Seed Working Group Newsbulletin

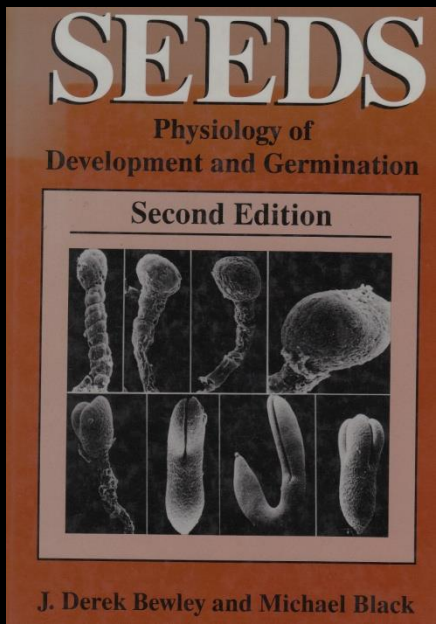












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TREE SEED

"HANDLE"
WITH CARE
"STORE"
IN COOL AREA
OPEN UPON RECEIPT

PERISHABLE