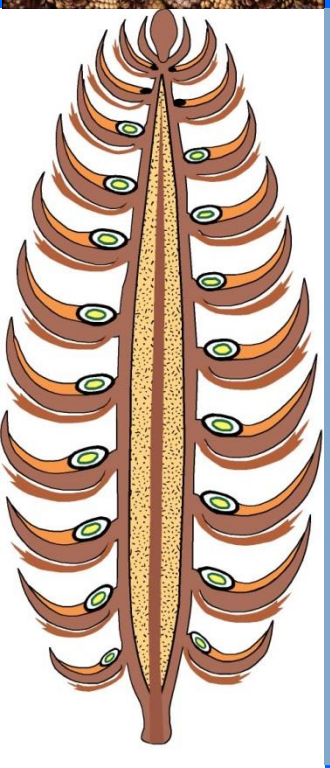
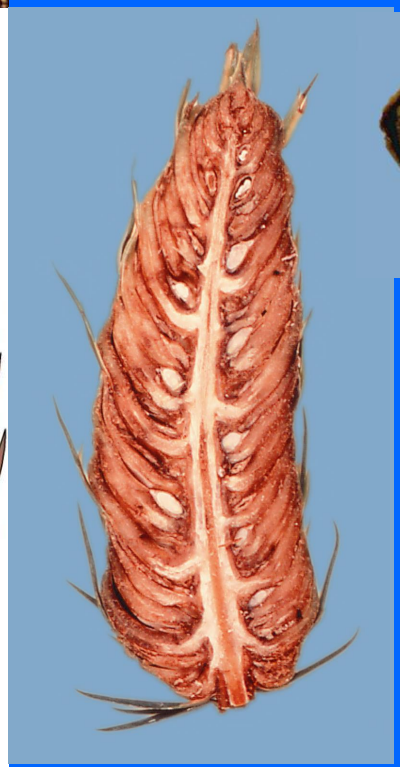
Cone and Seed Biology
Tree Seed Centre Services

Wild Stand Cone Collection Workshops
June 2018





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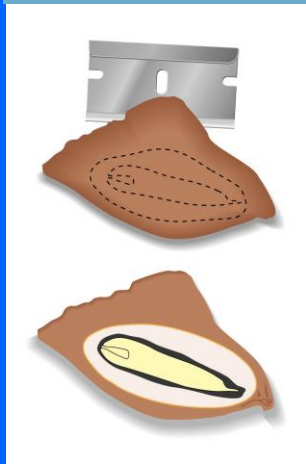
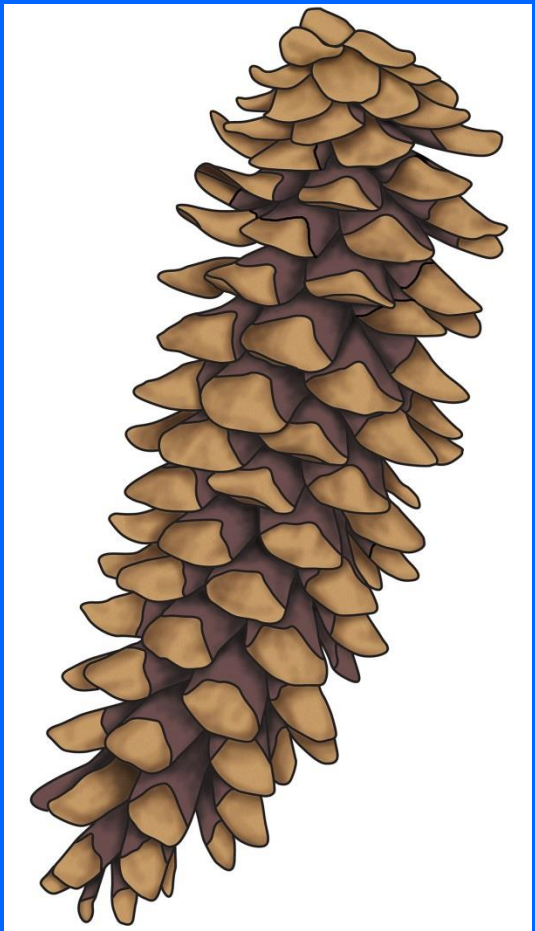


Overview

- Basic Concepts
- Seed Biology
- Reproductive Biology
- Crop Evaluation and Risks
- Tree Seed Centre Services

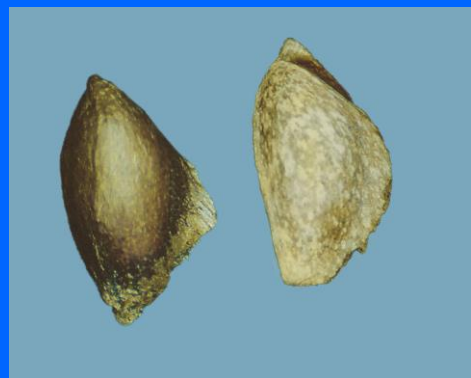


Other Workshop presentations available

https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/tree-seed/tree-seed-centre/cone-seed-improvement-program/workshops-presentations

Basic Concepts

- **Seed is a <u>living</u> biological end-product of genetic and environmental interaction and its behaviour cannot be predicted with certainty**
- Forest tree seeds (+shrubs, ground vegetation) are in a relatively wild state compared to agricultural crops = **genetic diversity ⇑**
- 'Complicates' direct adoption of agricultural techniques and practices



- Seed quality (Germination and seed longevity) is maximal at time of natural dispersal
- Cone and seed moisture content relates directly to risk of damage **(MC↑ - Risk of damage↑)**
- Dehydration of cones and seeds accompanies maturation
- Evaluate seed Morphology and Anatomy

Morphology - Anatomy

Dewinging Morphology Differences

Wet *vs.* Dry

Resin Vesicles

Damage to resin vesicles will reduce germination

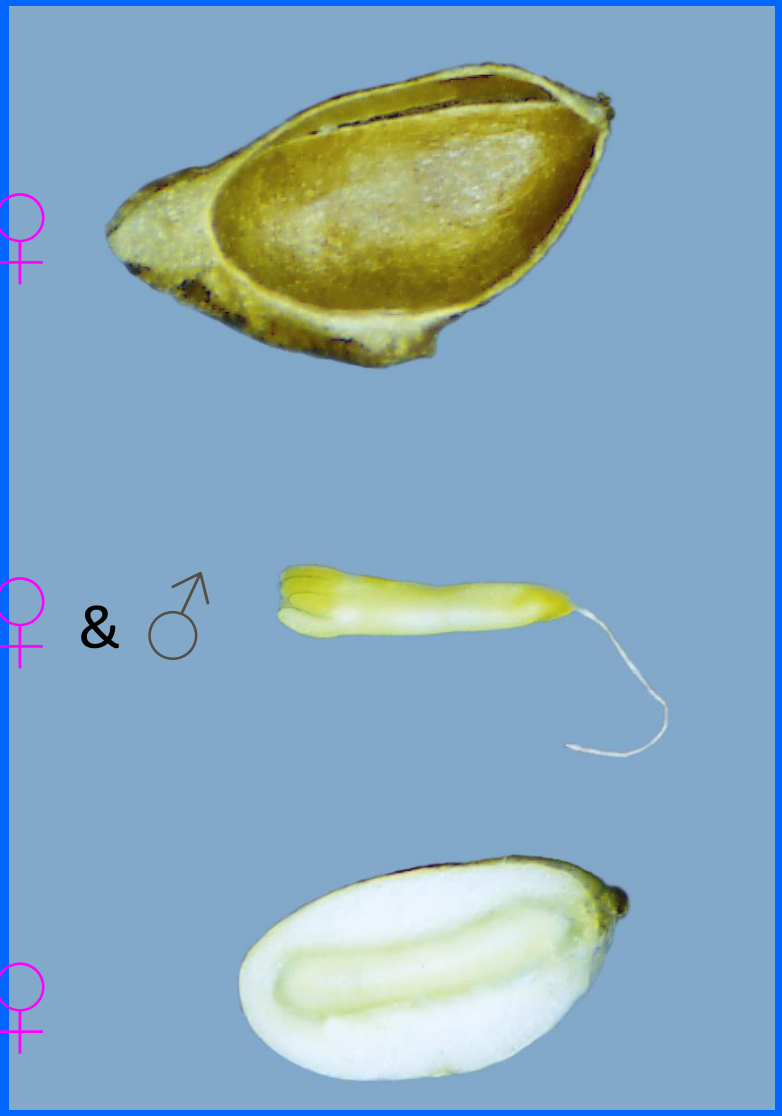
What are seeds made of ?

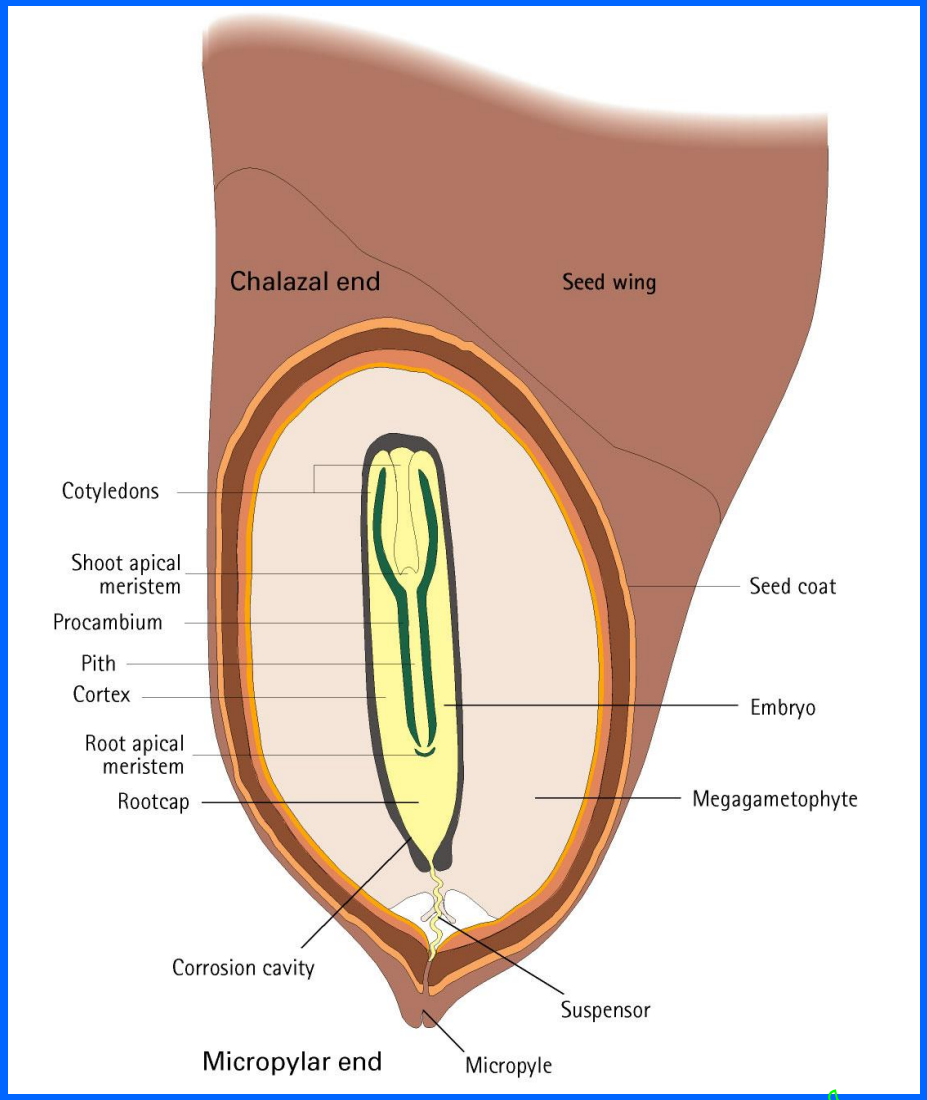
- **Douglas-fir** seed
  - 35% lipids [60% in megagametophyte]
  - 32% protein [16% in megagametophyte]
  - 29% fibres (seed coat)
  - 4% minerals, starch, sugars other minor components

Seeds Are a Great Food Source for many organisms!

- Interior spruce - 8 to 10% of seed is protein
- Variability between and within species

Seed Anatomy





Seed Moisture Content

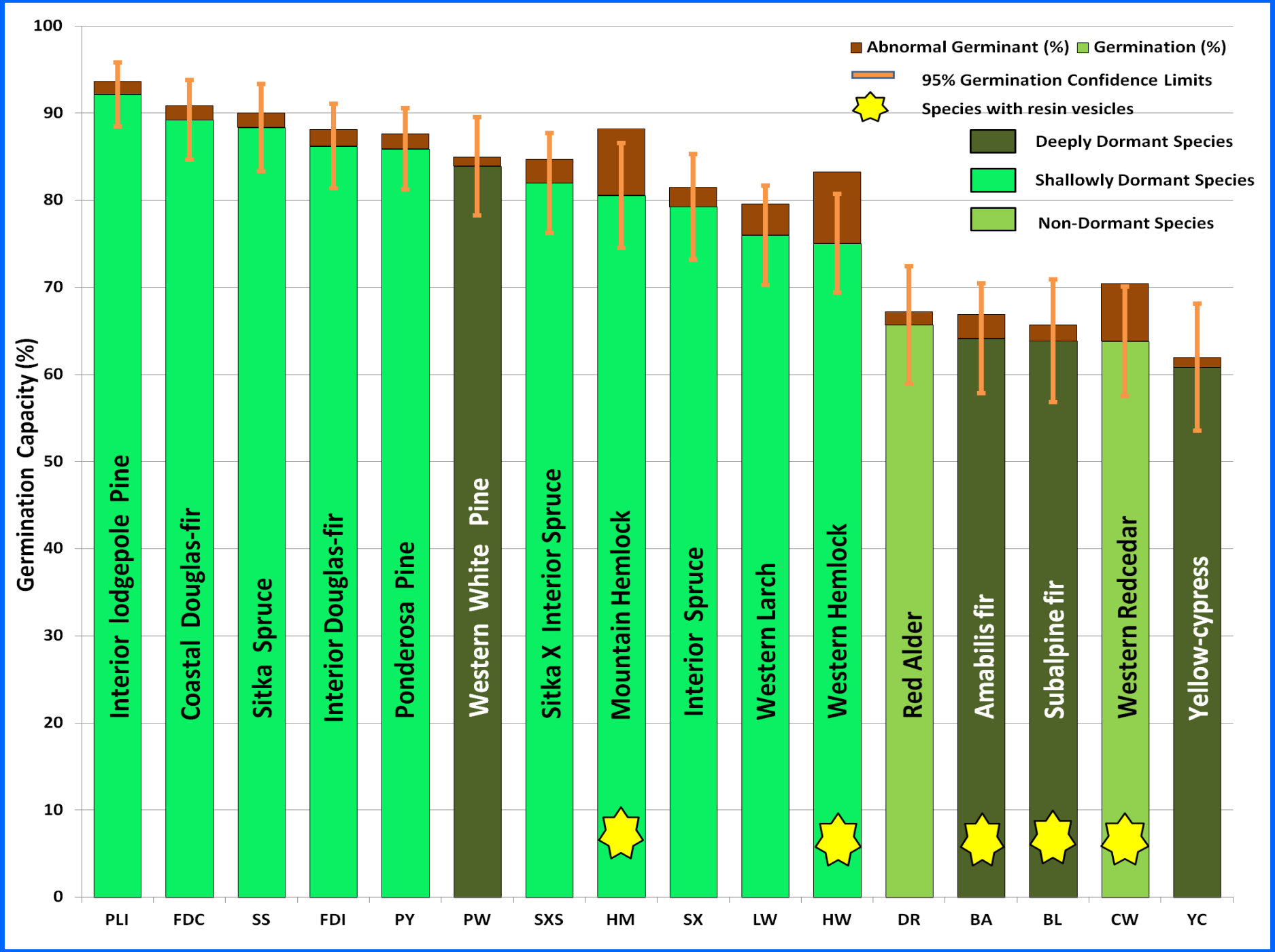
- Cone and seeds at elevated moisture contents are more susceptible to injury
- Appearance changes with moisture content
- Dehydration is part of seed maturation

What does a seed need to germinate?

- **Moisture**
- **Overcome Dormancy**
- **Temperature Sums**

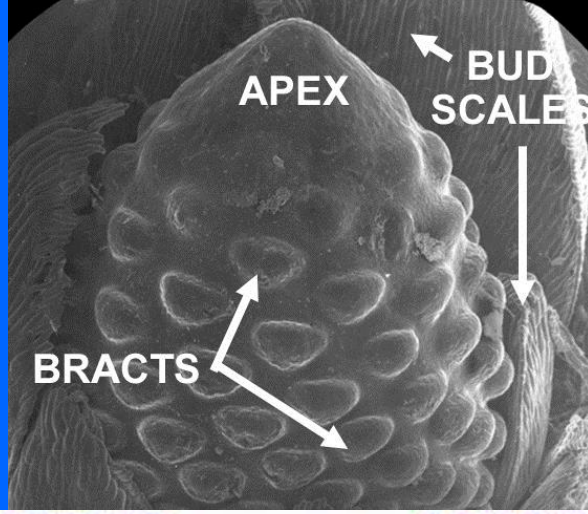
properly stratified conifer seed does not have a light requirement

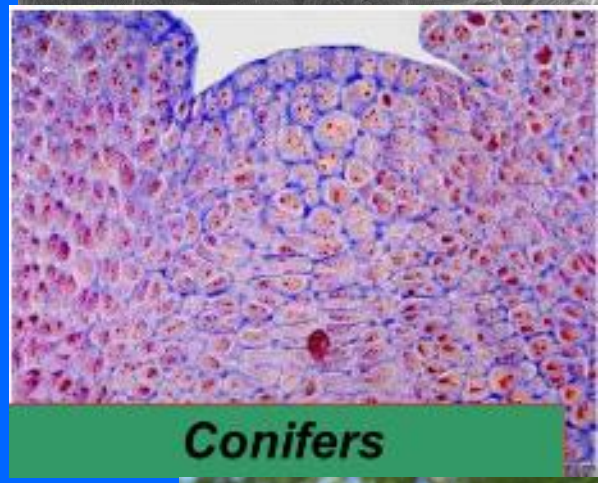
- some angiosperms have more specific requirements - light, alternating temperature and/or moisture, gases, nutrients, smoke

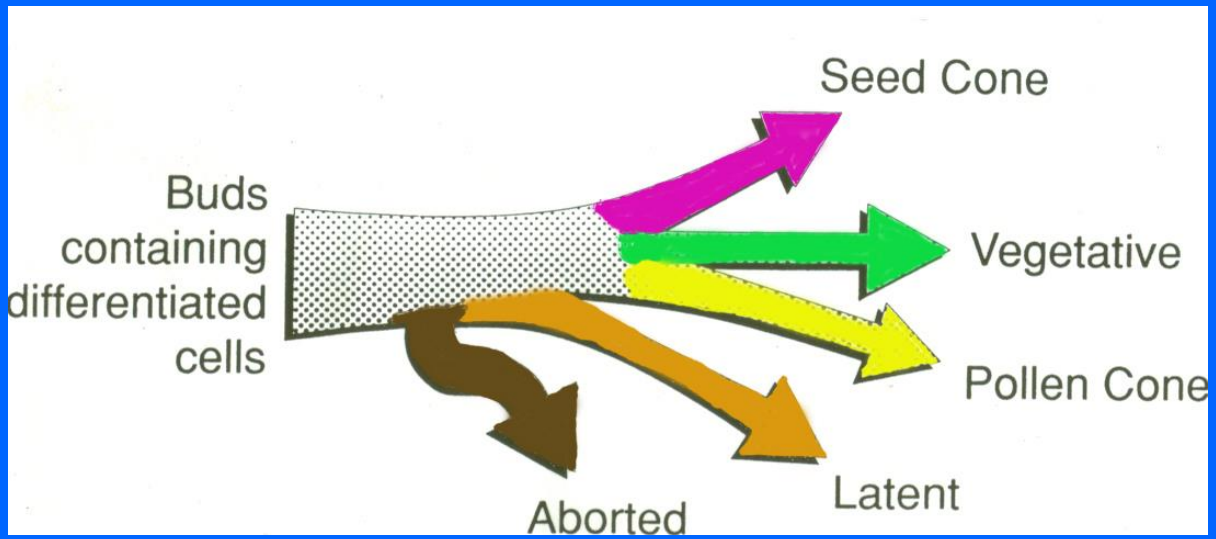

Abnormal Germinant (%)
Germination (%)
95% Germination Confidence Limits
Species with resin vesicles
Deeply Dormant Species
Shallowly Dormant Species
Non-Dormant Species
Germination Capacity (%)
100
90
80
70
60
50
40
30
20
10
0
Interior lodgepole Pine
Coastal Douglas-fir
Sitka Spruce
Interior Douglas-fir
Ponderosa Pine
Western White Pine
Sitka X Interior Spruce
Mountain Hemlock
Interior Spruce
Western Larch
Western Hemlock
Red Alder
Amabilis fir
Subalpine fir
Western Redcedar
Yellow-cypress
PLI
FDC
SS
FDI
PY
PW
SXS
HM
SX
LW
HW
DR
BA
BL
CW
YC

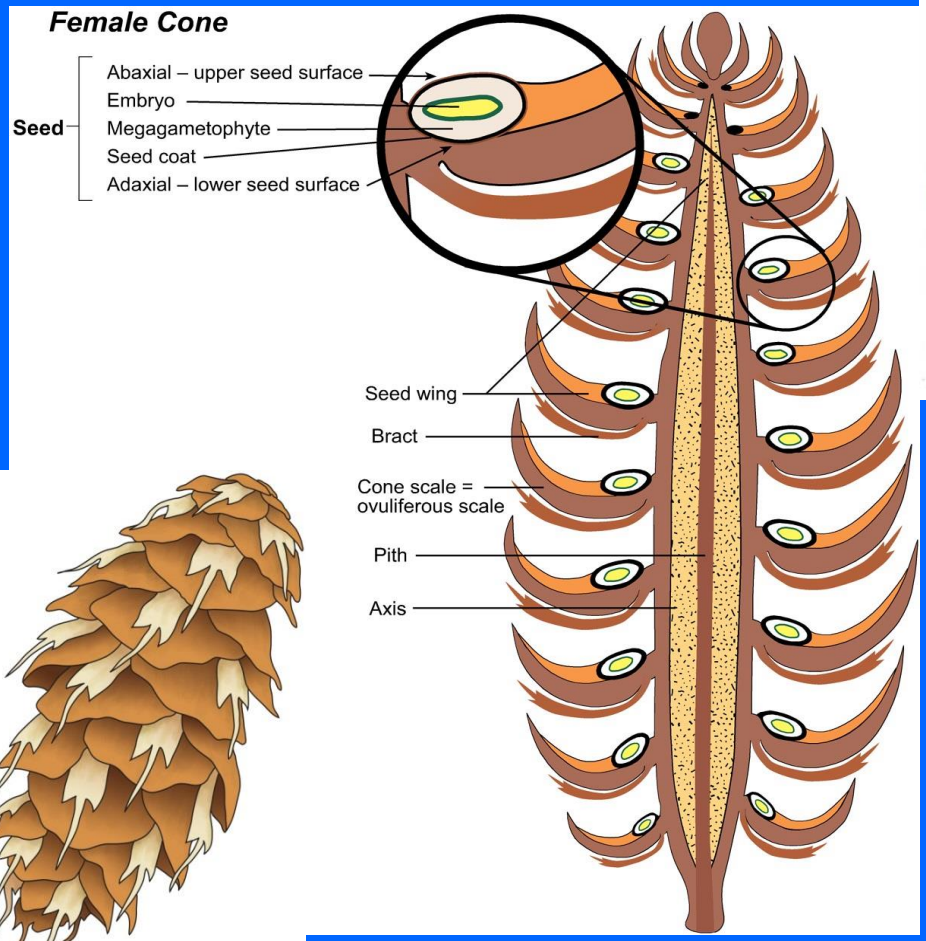
Reproductive Biology

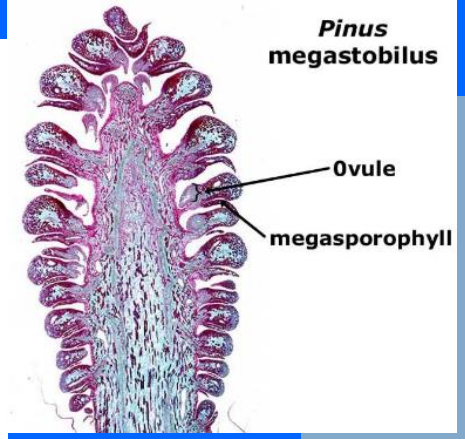
- **It all starts in the Apices**
- Meristems found in shoot-tips; buds, roots, under bark, within Pine needle fascicles
- Meristems are the site of cell division – producing tissues "in their wake"
- Primordia for next years structures are 'differentiating' within developing buds
- Shoot position & vigour, tree vigour, and climate will impact primordia fate

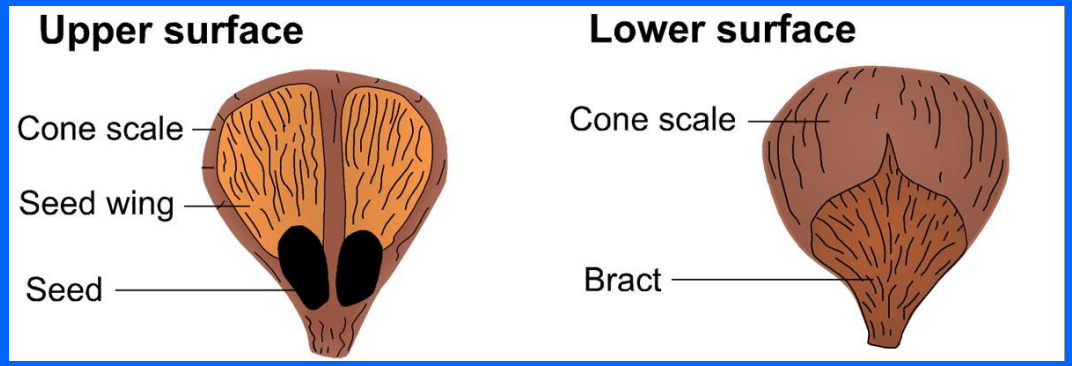




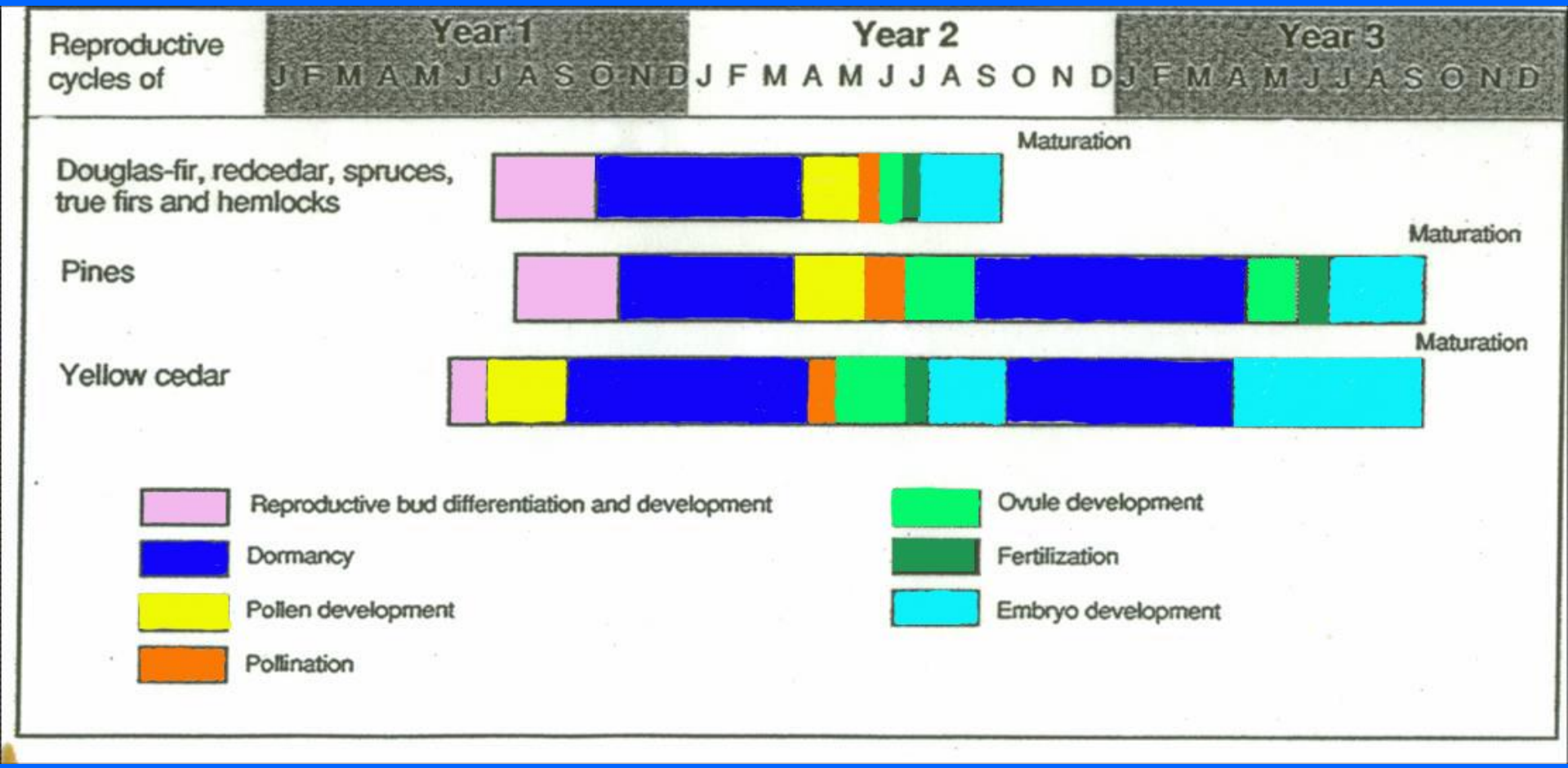



Female Cone
Seed
Abaxial – upper seed surface
Embryo
Megagametophyte
Seed coat
Adaxial – lower seed surface
Seed wing
Bract
Cone scale =
ovuliferous scale
Pith
Axis


Pinus
megastobilus
Ovule
megasporophyll

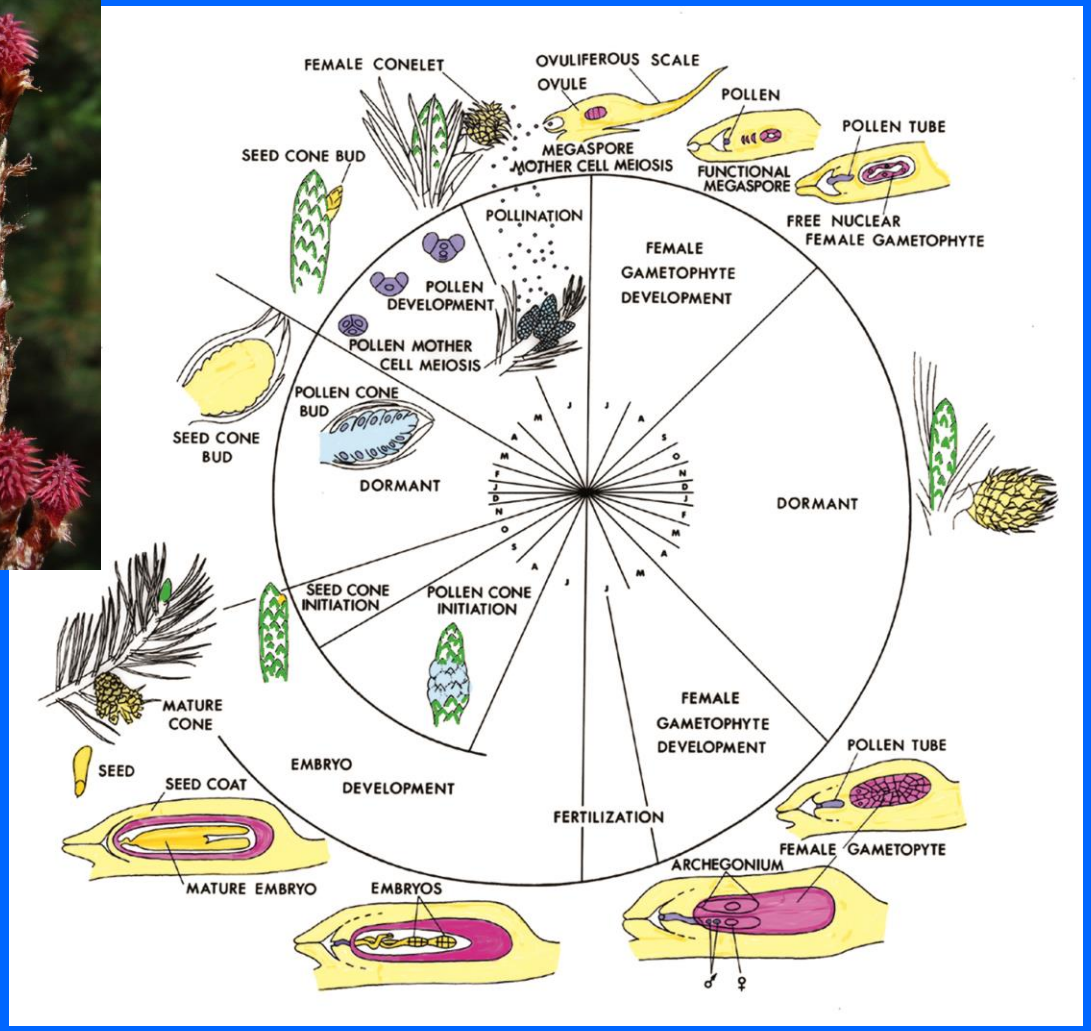

Upper surface
Cone scale
Seed wing
Seed
Lower surface
Cone scale
Bract

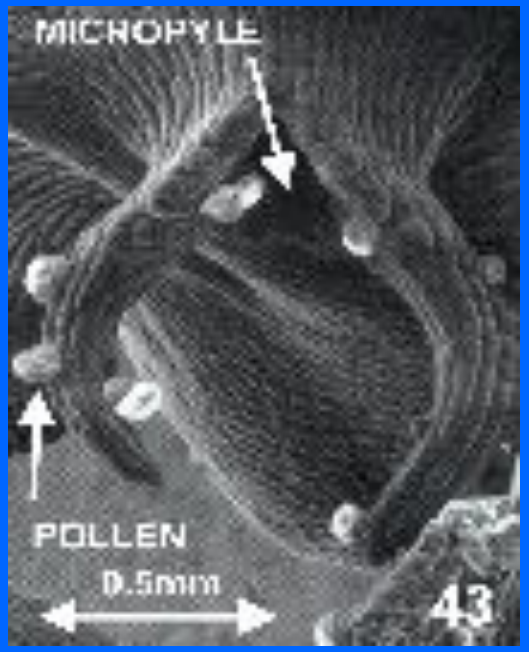
Three BC conifer Reproductive Cycles



Pine fertilization time one year after pollination

Lodgepole Pine Reproductive Cycle



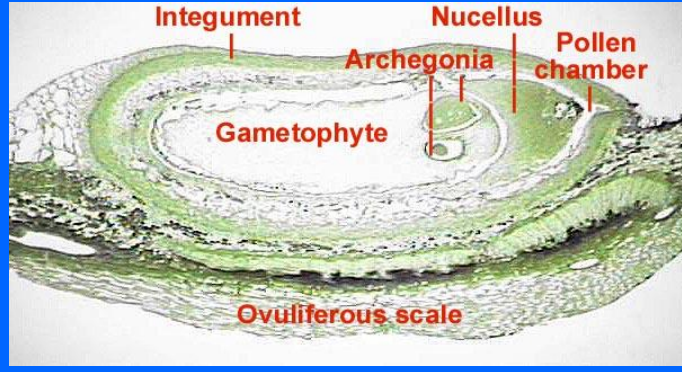


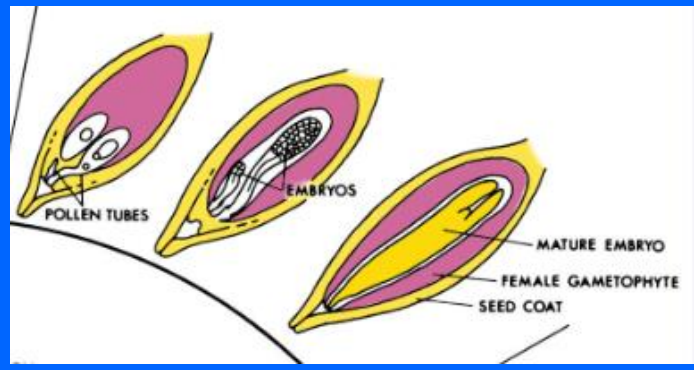
Species can have different Pollination mechanisms

- All Reproductive cycles can be found at: **http://www.fgcouncil.bc.ca/doc-14-brochuresposters.html**

Seed Maturation

- Seed coat formation occurs very early in development (before fertilization!)
- Actual embryo growth is rapid – MC is high
- Dehydration with abuild-up of storage components in megagametophyte and embryo
  - Simple sugars ➔ complex sugars, fats, proteins





- Megagametophyte changes from jelly-like to firm and white
- Mature Embryos have a well developed vascular system, prominent cotyledons
- At maturation the seedwing easily detaches from the ovuliferous scale

- **Most Conifer Species will form seeds even if no fertilization occurs**

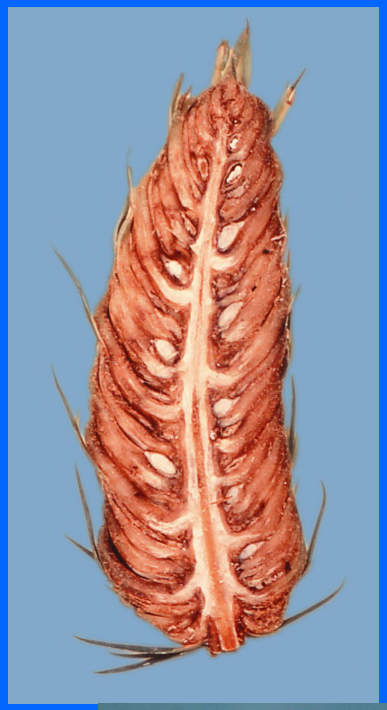
Cone Morphological Observations

- 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





Cone Maturation in Douglas-fir



Cone worm (*Dioryctria* sp.) damage →

Pli Cone Classes

Class 1

Class 2

Illustrating cone aspect variation
protection from wearing against stem

Class 3

Class 4

Pli Cones To Avoid

Opened cones

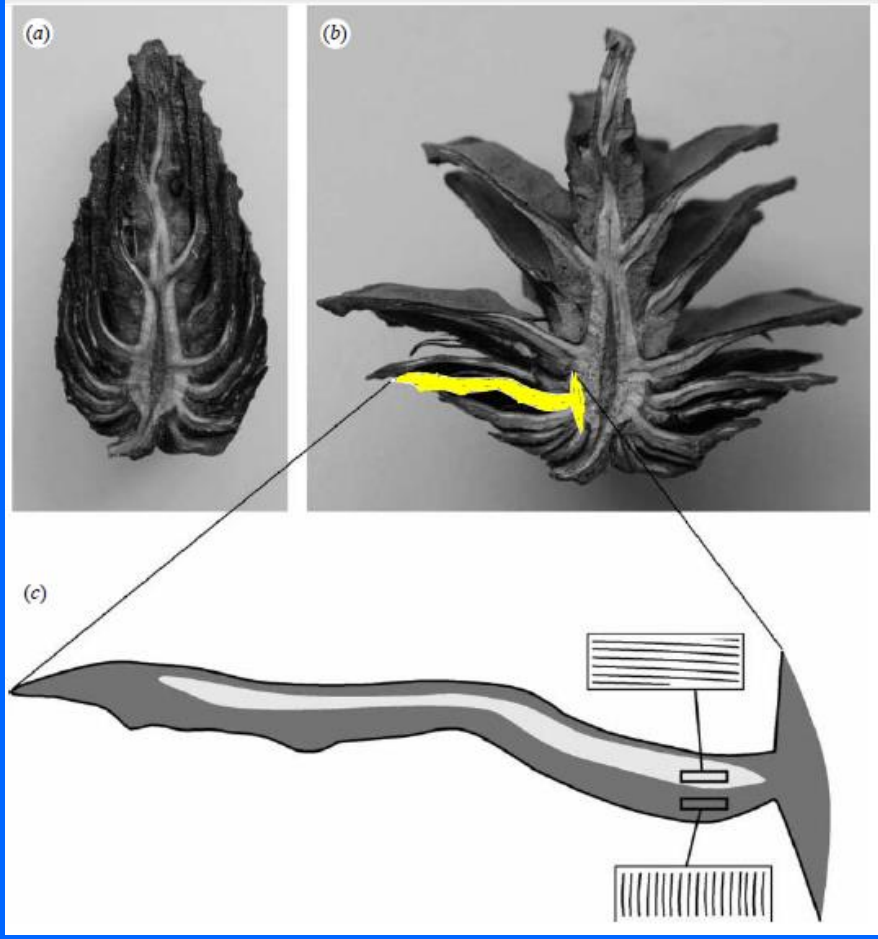
Insect damaged cones

Very small cones
(2 - 2.5 cm)
one normal cone
for reference

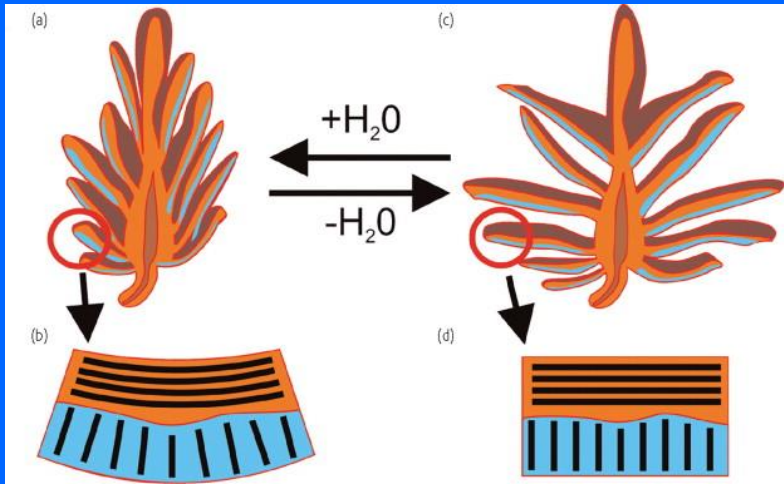
Resin covered
cones
rocks

Cone Opening

- Cones are hygroscopic – respond to RH
- Cones react to RH% similar to the way a bimetallic strip responds to temperature
- Difference is 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



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



Crop Risks

- Environmental
  - Spring frost – hardiness veg > ♂ > ♀
  - Excess moisture – delayed pollination
- Physical
  - Pollen viability – pollen may not germinate
  - Prefertilization incompatibility – no pollen tube growth, incomplete tube growth
  - Postfertilization inviability – incompatibility / selfing
  - Cone abortion – if insufficient pollination occurs
- Pests

Most Conifer Species will form seeds even if no fertilization occurs

Cone Sampling

Any evaluation or test is only as good as the sample taken

- Is it representative?
- Was it randomly sampled?
- *Don't just sample by the road!*

- With a highly variable crop it is important that decisions are based on a good representative sample (30-50 cones is reasonable)
- Sample cones from many trees NOT many cones from a few trees

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 interior spruce, Douglas-fir and western larch
- 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)

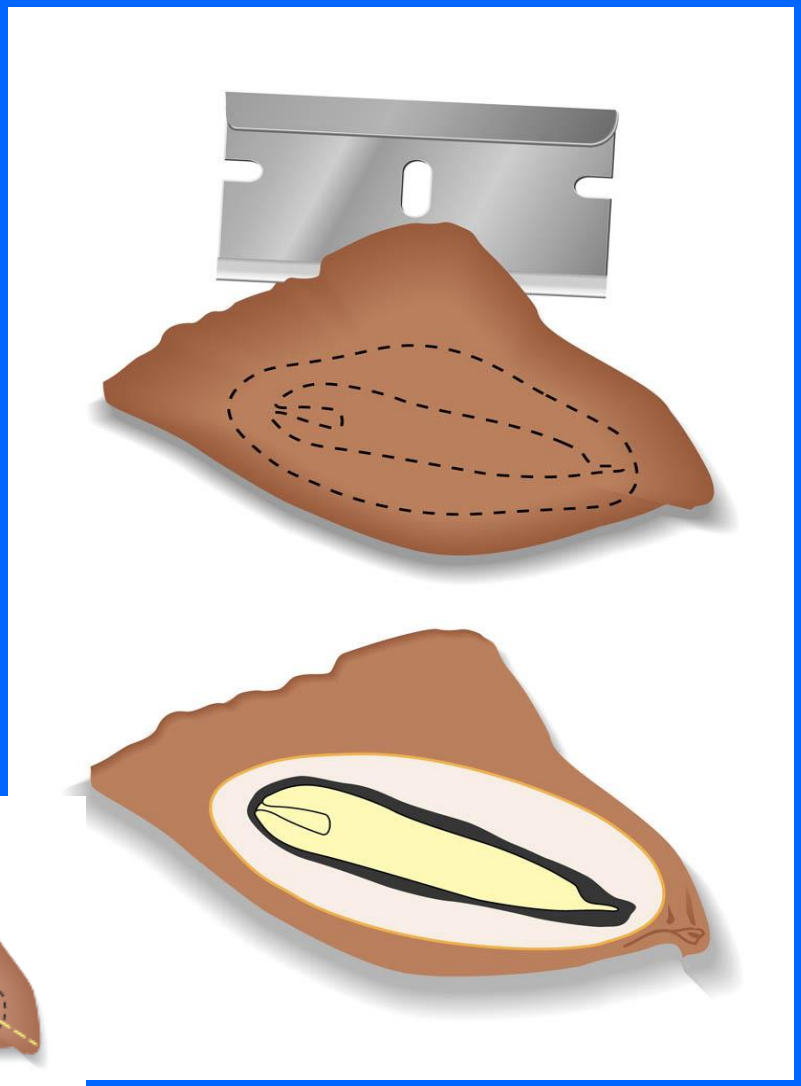
Cone and Seed Evaluation

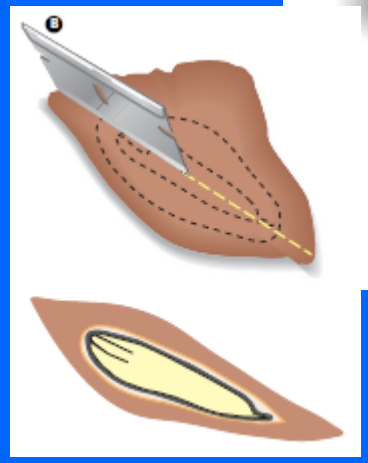
- Embryo Maturity (90+% corrosion cavity)
- Ease of seed wing release
- KAL cone axis test
- Assess insect/fungal activity
- Estimate seed yield (per cone)
  - Dissecting cones - time consuming
  - predictions based on correlations with half-cone counts are common
  - Pli – whole cone assesments
- Seed - embryo and megagametophyte condition **(cutting tests)**

Cutting Tests (Quick Test)

- ‘seed anatomy tests’
- to characterize seed in a sample
- Longitudinal cut preferred
- *classify to needs*
- **% viable**

  % immature
  % empty
  % damaged and discoloured
  % rotten
  % resin filled





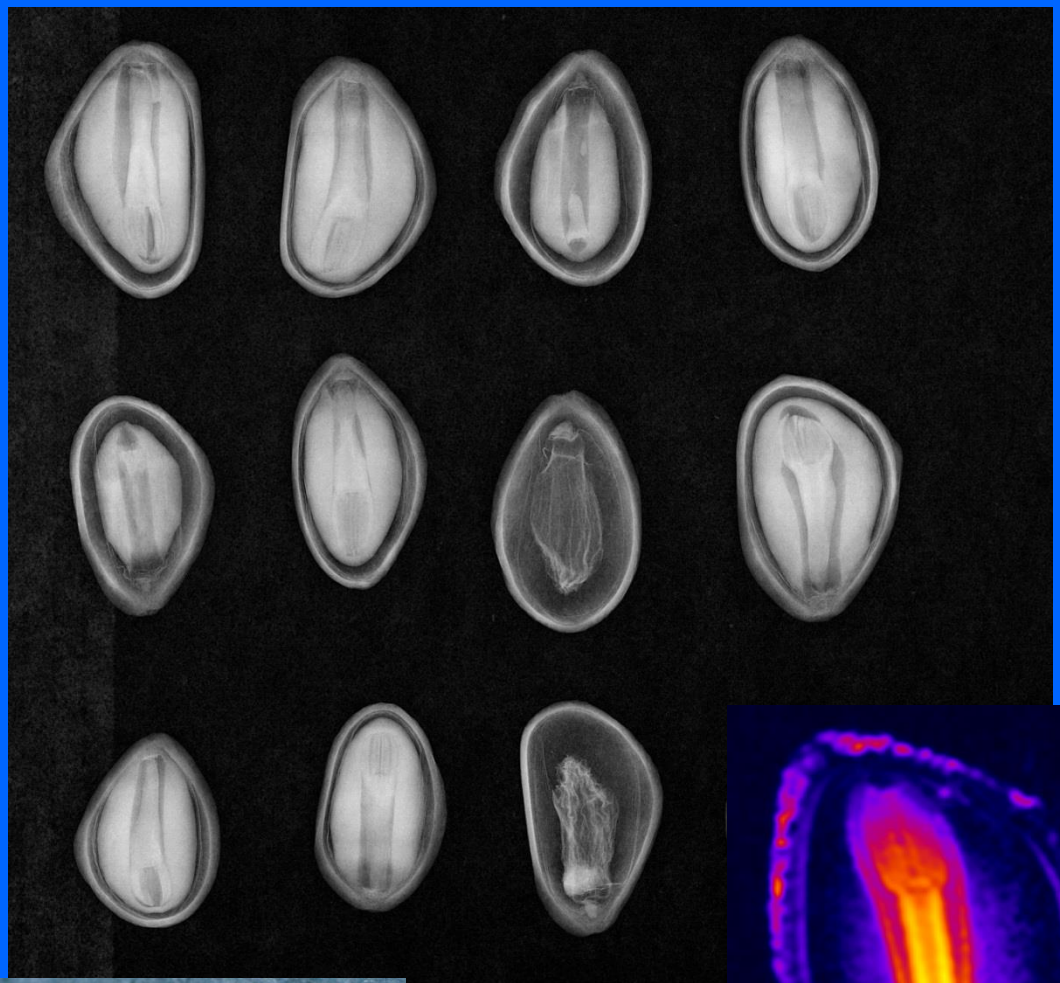
Seed Immaturity

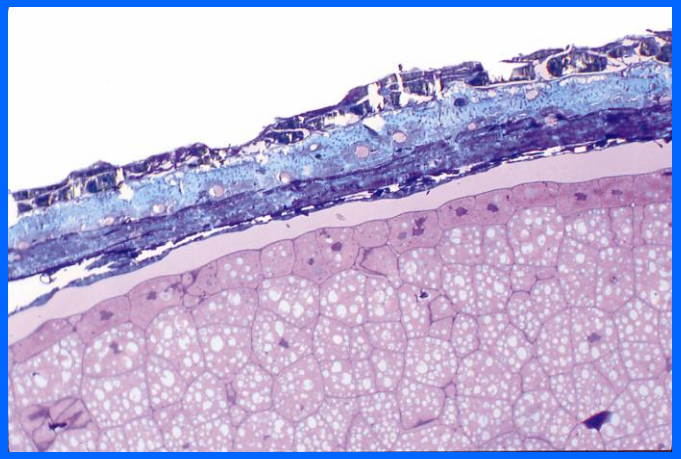
- A basic measure of maturity is the embryo length relative to the corrosion cavity (i.e. 33% in this photo)
- Collect at 90%+
- This is not the only maturity criteria
  - cone/seedwing separation
  - megagametophyte texture
- Below a certain point (?50-60%?) seed will not germinate
- Immaturity introduces variability and complicates seed processing
- Even after anatomical maturity, physiological changes will still occur internally

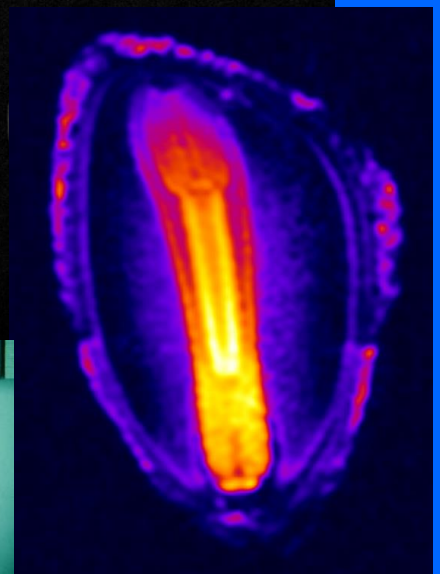
The Good, the Bad, the Uncertain

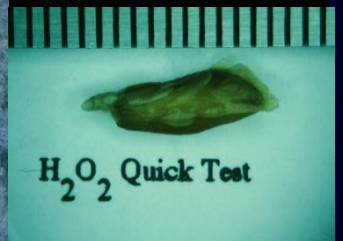
Seeds can be classified based on anatomy (viable / non-viable), but it is not always possible to determine what happened to the seed

Other Visualizations









Collection Due Diligence

- Use new sacks or properly sterilized sacks (steam/hot water)
- Fill sacks ½ to ⅓ full to minimize heat build-up
- Keep sacks off ground / on sides (vs. upright) to reduce weight
- Place sacks in shady , covered environment with good air circulation
- Turn sacks to maintain uniform aeration
  - Frequency depends on moisture content
- Move sacks daily from collection site to interim storage
- Limit amount of debris (mc / fungi / abrasive)

- ***Squirrel caches***
  - Can produce good quality collections – cheaply
  - RISK – especially in wet, cool weather
  - Handle with extra care (maturity, heat build-up??)

Post-Collection Handling

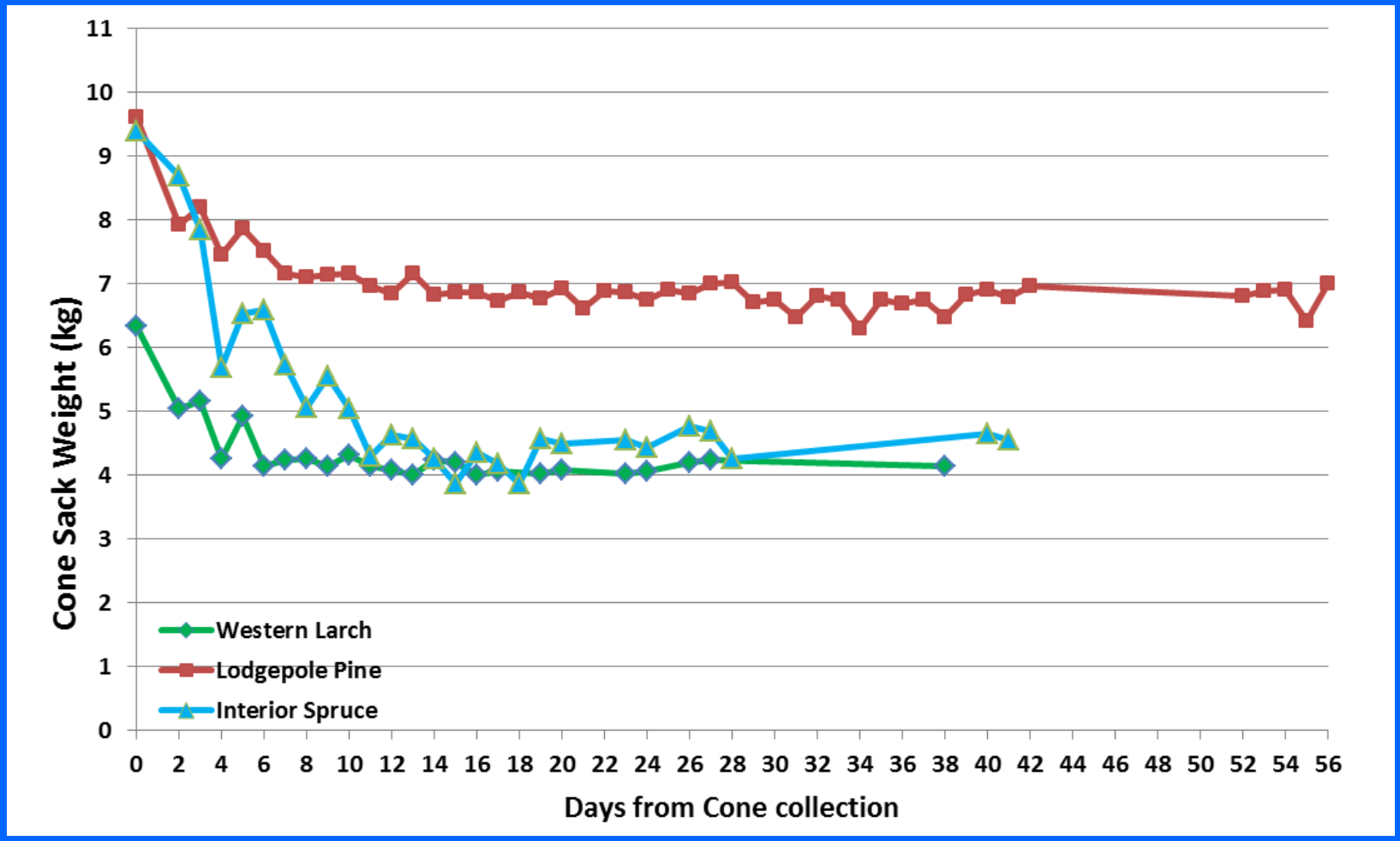
- **"Field"** MC ⇑, Risk ⇑
- 'generally' 4-6 weeks interim storage recommended
- Hw and Cw ship immediately!

- Goal is to slowly dry the cones (after-ripening)
- turn sacks (**uniformity**)
- Protect from sun, rain, animals
- Allow for good air-flow (1 sack depth*)

***Serotinous Pli sacks can be stacked**

NOT so fun 2009 collections

Cone Drying Patterns (Vernon, BC)



- Cone sacks were weighed 3-4 times/week
- We also went to lot of work getting cone moisture contents (*not shown*)
- The important fact is **when do the cones stabilize in moisture content** and that appears to occur within 2 weeks in the North Okanagan (slower elsewhere)

BC Tree Seed Centre

Excellence in Cone and Seed Services

- 13 regular staff
- 4-6 auxiliary/seasonal staff

- **Cone and Seed Processing**
- **Inventory Management**
  - **Seedlot Registration**
  - **Seed Storage**
  - **Seed Preparation** (stratification / pelleting)
- **Testing**

- Finance & Administration
- Facility Management

- Mission Critical facility

- **60th Anniversary in 2018**

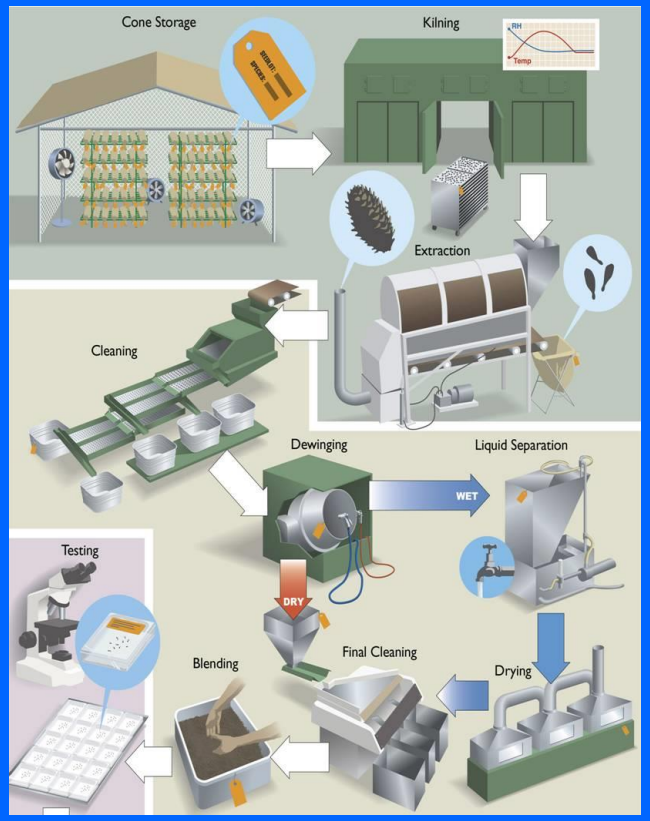
Seed Handling System

Information

Management

Cone Collection
↓
Post-Collection Handling
↓
Cone Processing
↓
Seed Processing
↓
Testing
↓
Registration
↓
Storage
↓
Pretreatment
↓
Sowing

- Examines all steps of seed handling from collection to use
- Any previous "link" can impact your product
- Ensure seedlot:
  - **Identity**
  - **Integrity**
  - **Information**



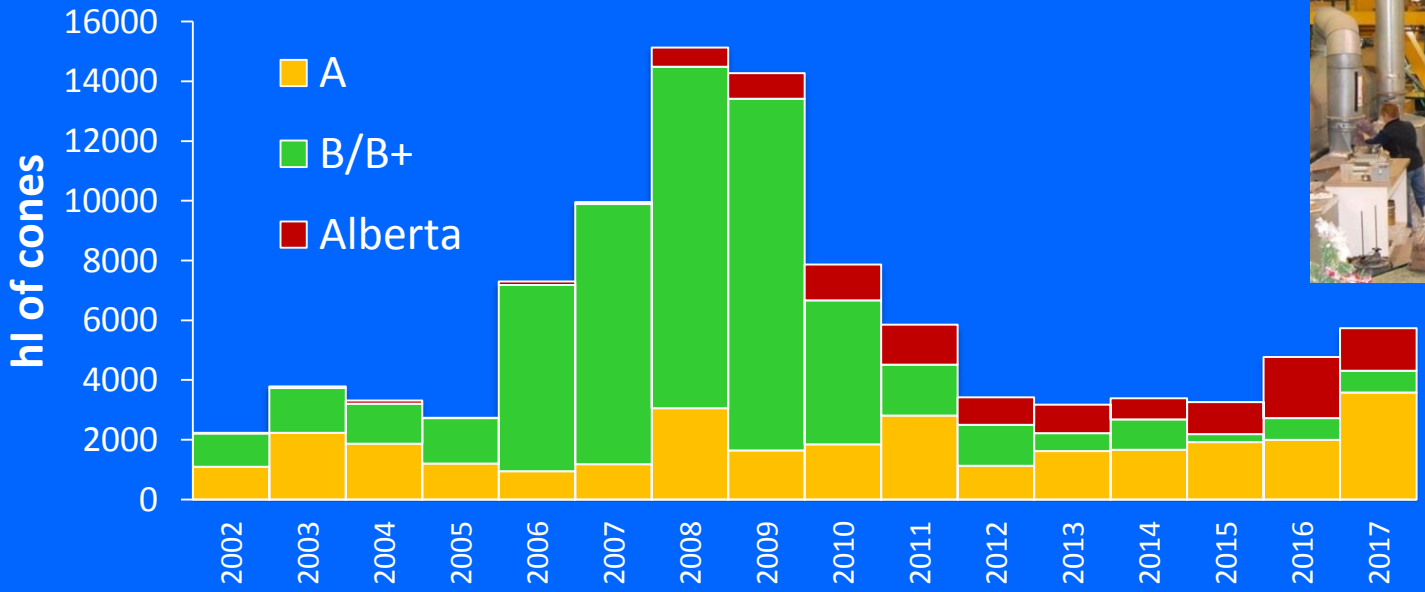
TSC Interface

- Request cone tags
- Request cone and seed evaluation
  - Maturation level/ Pest issues / filled seed estimate
- Request Priority Processing
- Sowing Request updates/ timing shipments
- Action seed sales and transfers
- “clients” responsibility to enter seedlot information on SPAR; shipment responsibility until cones received

Cone and Seed Processing

Debbie Picard

- **Cost Recovery** business area
  - Cone receipt, storage and handling
  - Cone processing (=seed removal)
  - Seed processing (=purification/drying)
- Highly specialized equipment and technical expertise



Priority Processing Background

- Priority requests refer to prioritization of cone processing, seed processing, testing and registration
- Initial goal was to identify seedlots that would be used that year for sowing requests
  (getting improved seed on the ground faster)
- Current request emphasis seems to be on seed sales as many "entities" depend on this income – ***pinch point***
  (may result in getting improved seed on the ground faster)
- There is also a perceived increase in competition for seed sales among some of these 'entities' – ***pinch point***
- In 2011 a priority processing fee of $150 per seedlot was included in the fee schedule to deal with increases in priority processing requests

Priority Processing Principles

1. Available for all seedlots used on BC crown land
2. Seedlots with risk of seed quality or quantity (pests, condition, low dormancy) have an elevated priority
3. TSC will follow these principles
4. Seedlots in an SPU/SPZ with insufficient surplus seed (< 1 year supply @ GW>5) are prioritized
5. Early sow species (Fd, Sx, Hw, Pw, Cw) are a higher priority than late sown species (Pli, Lw, Py)
6. Sowing request id not required – summer plant ↑
7. No deadline
8. Cones must be at the TSC and ready for processing

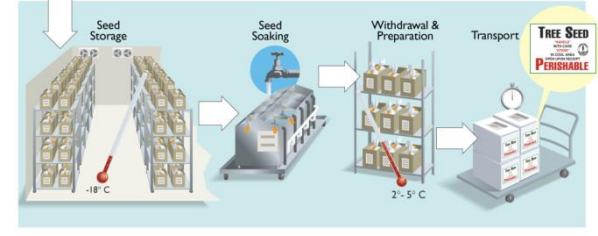
Priority Processing Process

- TSC estimates year's supply of surplus seed by SPU
  - Seedlots (ings) registered on SPAR with GW>5 on August 1
  - FGC seedling demand by SPU
- The seedlots on which priority processing is requested are then placed into categories

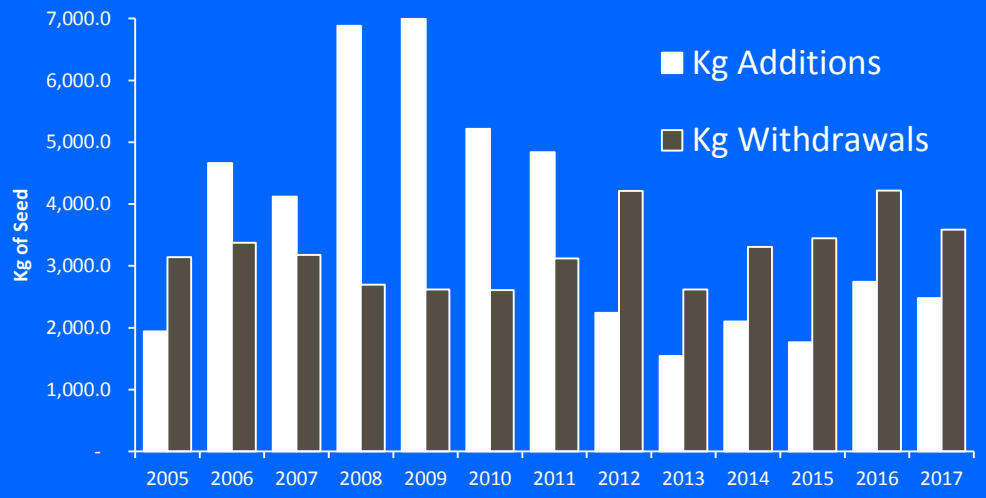
1. Early sow species < 1 years supply
2. Late sow species < 1 years supply
3. More than 1 years supply
4. Family lots and trials

Inventory Management

Spencer Reitenbach

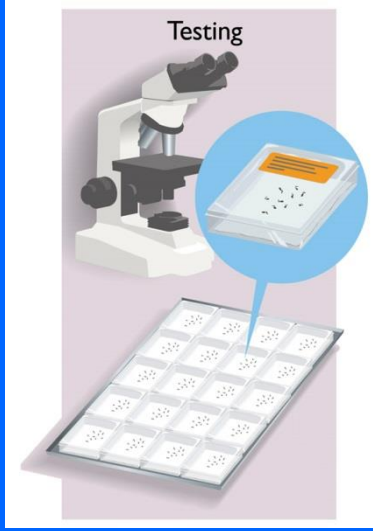


- Seed Storage, seedlot registration, registry management, seed sales and transfers, and shipping (**Stewardship**)
- Stratification and pelleting (**Cost Recovery**)
- Seed Storage is primary reason for Mission Critical status
  - 6 440 seedlots / 8.3 Billion trees / 86 Million $ value

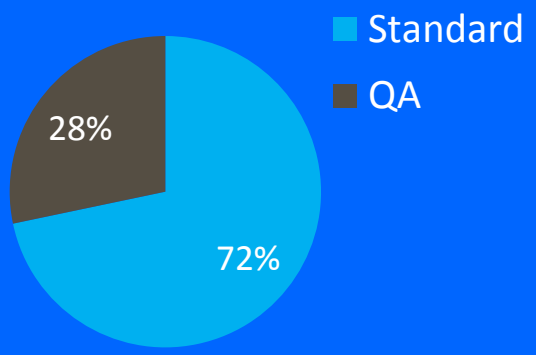


Testing (Stewardship)

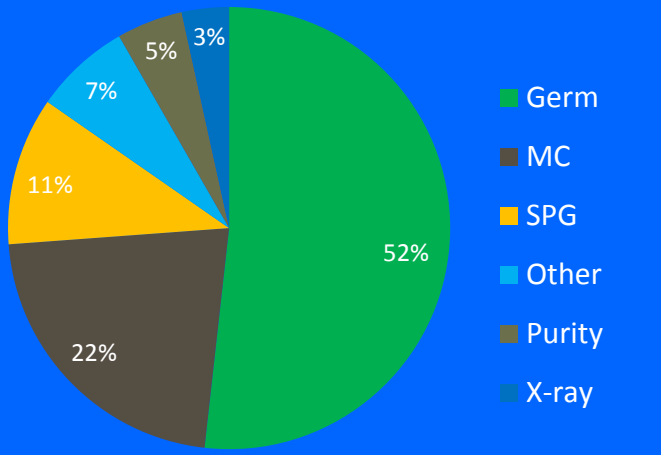
Laura Klade



- Meet CFS for Seed Use requirements and assist reforestation program
- Lead Quality Assurance testing program
- Sophisticated tools to manage scheduling, transaction volume & complexity



- **Test Types**
  - Moisture content
  - Purity
  - Average seed weight (Seeds Per Gram)
  - Germination Capacity (one or more types)
  - X-ray
  - Fungal Assays (MOU – Min. Agriculture 2018)



Finance and Administration

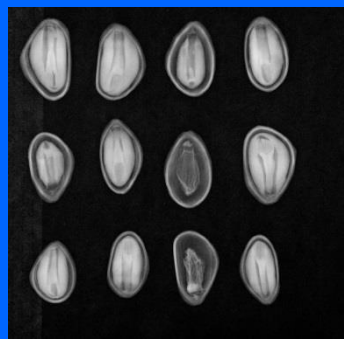
- Meet Revenue target billings for seed sales, orchard management services and cone and seed services
- Develop updated costing model, update cone and seed fee schedule

Facilities (3600 m^2)

- Ensure building , building systems, equipment and operating environments meet business needs
- Maintain and protect assets, infrastructure and site
- Capital & asset management
- Implementation of Facilities Condition Report Recommendations

Cone and Seed Improvement

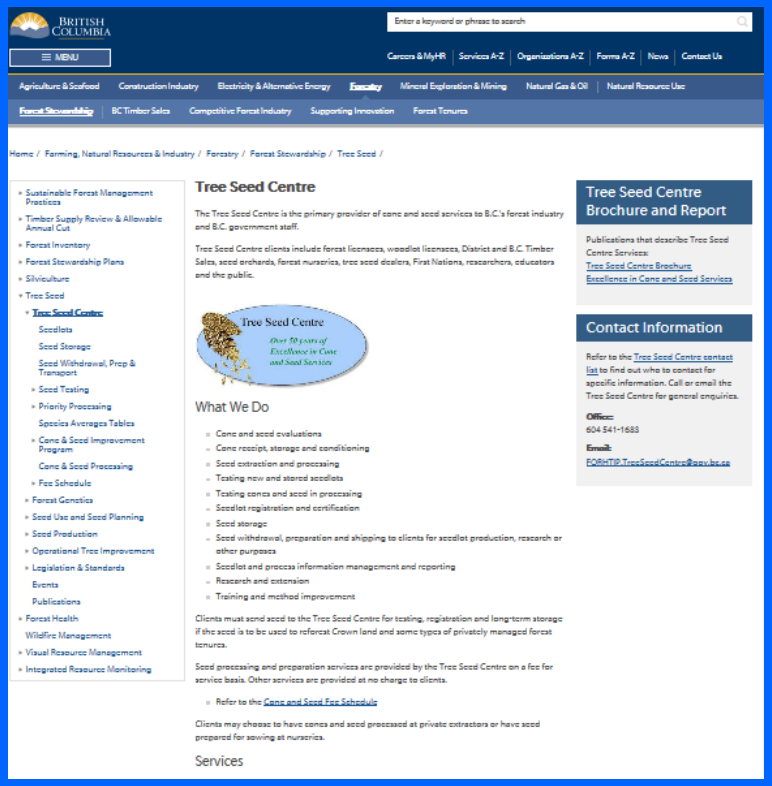
- Conduct Applied research
- Continuous improvement of TSC services, equipment, processes, and knowledge **(QA program)**
- Promote seed-use efficiency & conservation
- Provide tree seed science and technology extension to clients
- Maintain, manage and add to provincial seed bank for genetic conservation
  (over 10 000 samples)

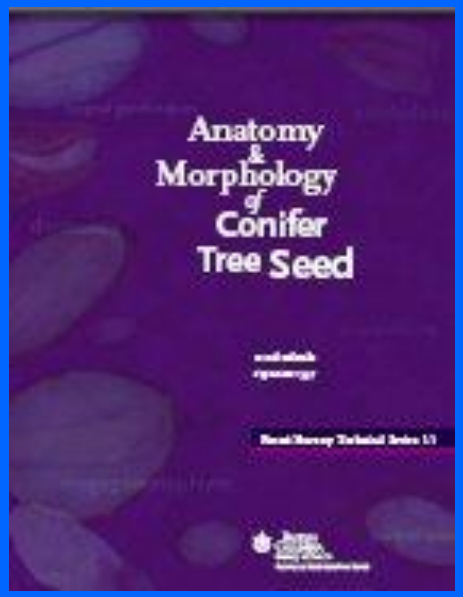


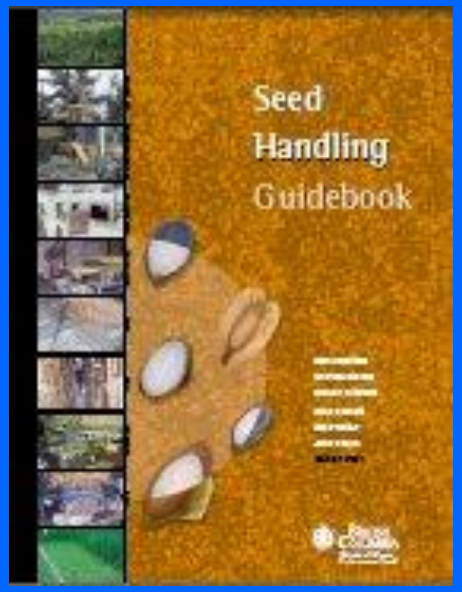
EXTENSION Resources

TSC webpage

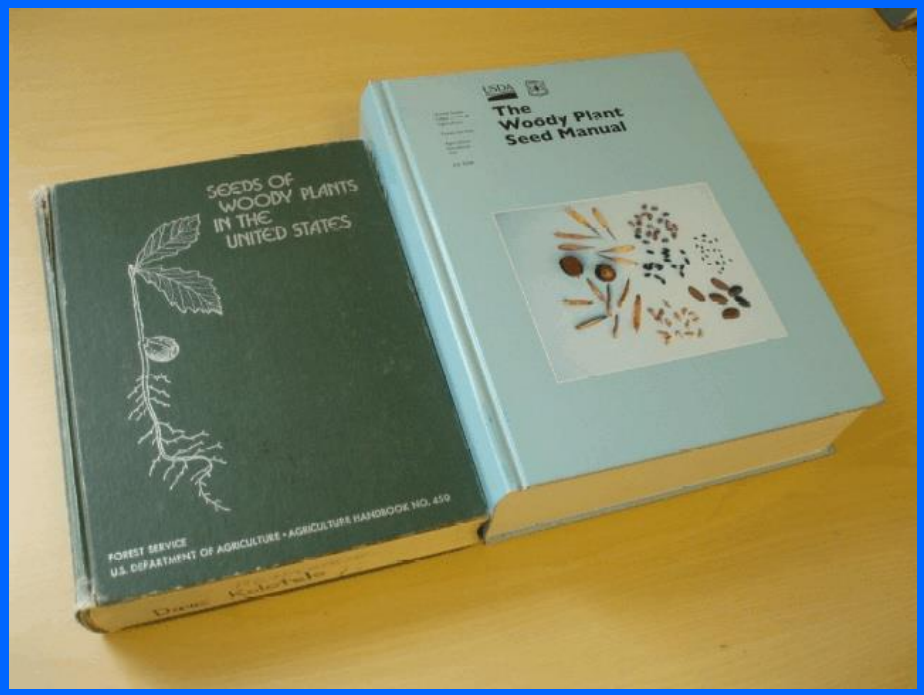
https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/tree-seed/tree-seed-centre



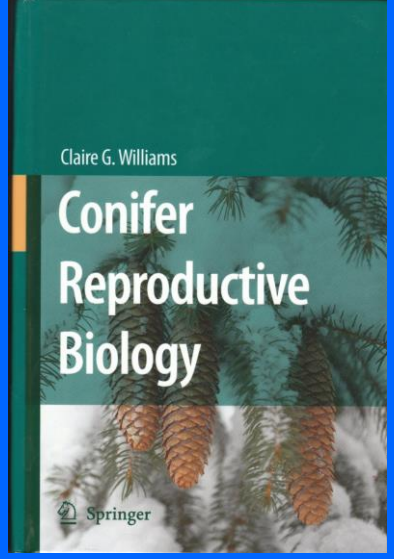


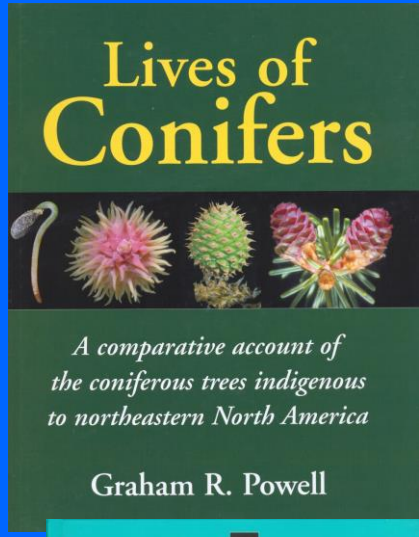


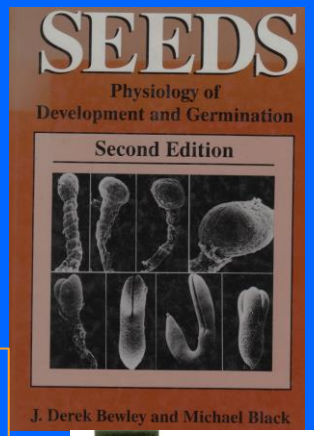
Woody Plant Seed Manual

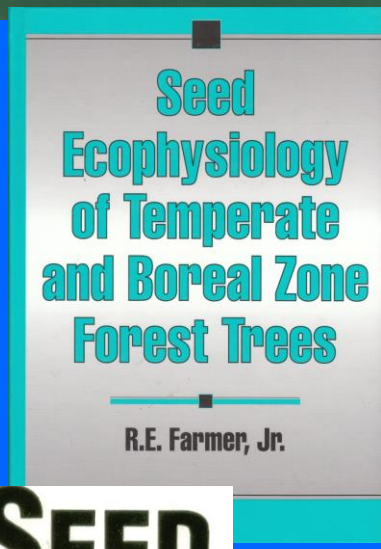


http://www.rngr.net/publications/wpsm









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