Hedysarum alpinum

Introduction to Seed Collection, Processing and Storage

Course Package

Carcross, YT
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Materials produced or adapted by the Northern Climate ExChange, Yukon Research Center at Yukon College

Introduction to seed collecting, processing and storage

Course description

This course is intended to develop basic knowledge about seed collection, cleaning, and storage. This includes ethical seed collection; the theory behind seed collection, cleaning, and storage; and practical skills required to collect seeds in the field, clean seeds, and store seeds appropriately, ensuring that seed collections are developed with maximum future utility. Traditional knowledge will be incorporated in a way that is relevant to the community. The course will be carried out over two sessions lasting two days each.

Instructors: Krystal Isbister, Josslynn James

Schedule

Session 1, Day 1

Morning

1.0 Introductions
2.0 Introduce course
3.0 Intro to seed collection
    3.1 Setting the context: Why are we doing this?
4.0 Choosing species to bank
5.0 Plant ID

Afternoon

1.0 Planning for seed collection
    1.1 Planning for seed collection
    1.2 Field safety
2.0 Mapping collection areas
    2.1 Locating and tagging populations
    2.2 Suitability of populations

Session 1, Day 2

Morning

1.0 Morning reflection
2.0 Seed Basics
    2.1 Storage Behavior
    2.2 Basic Seed Structure
    2.3 Types of Fruit
    2.4 Plant propagation & reproduction
3.0 Germination & Dormancy
    3.1 What is Dormancy
    3.2 Dormancy Breaking

Afternoon

1.0 Forecasting
    1.1 Benefits
    1.2 Data collection
2.0 Collection strategy
    2.1 Site assessment
    2.2 Seed assessment
    2.3 Seed collection

Session 2, Day 1

Morning

1.0 Introductions
2.0 Introduce second half of course
3.0 Pre-collection info session
    3.1 Collection methodology
    3.2 Materials
    3.3 Data collection
    3.4 Temporary storage

Afternoon

1.0 Planning for collection
    1.1 Material preparation
    1.2 Locating populations
    1.3 Site assessment
2.0 Collection of seed

Day 2, Session 2

Morning

1.0 Seed drying
    1.1 Conditions that influence drying
    1.2 Seed characteristics that influence drying
    1.3 Small-scale seed drying methods
2.0 Native Seed Cleaning
    2.1 Challenges of cleaning native seed
    2.2 Fleshy Fruit

Afternoon

1.0 Seed drying set up
2.0 Native Seed cleaning: Dry fruit
3.0 Native seed storage

Storage conditions

Seed Collection Protocols

1. *Betula neoalaskana*

2. *Calamagrostis canadensis*

3. *Hedysarum alpinum*

4. *Juniperus horizontalis*

5. *Lupinus arcticus*

Scientific Name: *Betula neoalaskana* **Common Names:** Alaska paper birch, Alaska white birch, Alaska birch

Life Form: Tree

Site Preferences: Bogs, poorly drained soils, commonly found in stands with black spruce in wet soils and white spruce in better drained soils (British Columbia Ministry of Forestry, 2003).

Tolerances: Acidic soil, very nutrient-poor soil, frost, fluctuating water table, wet sites (Forests Lands and Natural Resource Development, n.d.)

Distribution: Yukon, Northwest Territories, British Columbia, Alberta, Saskatchewan, Manitoba, Ontario (USDA NRCS, 2018)

Left: *Betula neoalaskana*. Alfred Cook, some rights reserved, CC BY, cropped from original, http://www.alaskawildflowers.us/Kingdom/Plantae/Magnoliophyta/Magnoliopsida/Betulaceae/Betula_neoalaskana/Neoalaskana_16.html

Plant Identification:

Betula neoalaskana is a species of birch which typically grows to 15 m tall. It can have one or many trunks covered in dark brown bark when the tree is young, maturing to a whitish pink with age. The bark is papery and peels off in thin layers. Leaves are flat and smooth at the base, with rounded, doubly saw-toothed sides tapering to a sharp point. Leaves are shiny and dark green with small resin glands on underside. This species can be easily confused with *Betula papyrifera*, however, it is smaller in size and can most simply be differentiated by the presence of resin glands on the twigs (British Columbia Ministry of Forestry, 2003). Seeds develop in dry, cone-like fruits called catkins that split open at maturity (J. M. Baskin, 2009). The fruit are 2-4 cm long, and contain small nutlets with broad wings on either side (British Columbia Ministry of Forestry, 2003).

Above left: *B. papyrifera* twig. Note absence of resin glands. Paul Wray, Iowa State University, Bugwood.org. some rights reserved CC BY-NC

Above right: *B. neoalaskana* twig. Note presence of resin glads. Alfred Cook, some rights reserved, CC BY, cropped from original, http://www.alaskawildflowers.us/Kingdom/Plantae/Magnoliophyta/Magnoliopsida/Betulaceae/Betula_neoalaskana/Neoalaskana_05.html

Harvesting Considerations:

Male and female catkins occur on the same tree. The female catkins can be differentiated in that they are shorter and thinner than male catkins (Banerjee, Creasey, & Gertzen, 2001). When very ripe, catkins can shatter, so they are best collected when the nutlets within the catkin are brown (mature) but the catkin is still green enough to hold together (Banerjee et al., 2001; J. M. Baskin, 2009). This species should be ready to harvest between August 1 and September 15 (Smreciu, Gould, & Wood, 2013). This may vary in the Yukon and should be determined by forecasting earlier in the season (Banerjee et al., 2001). *Betula* species commonly hybridize, so when choosing a population to collect from it is important to ensure the stand is isolated from other varieties. Although these species generally produce abundant seed regularly, there can be variability in the proportion of viable of seed (J. M. Baskin, 2009). Collect a representative sample of 10-20 seeds, cut open with a sharp blade or crush, and examine the inside with a 10x or 20x hand lens to determine proportion of hollow, damaged, or infested seeds. These seeds are small and winged, so it is recommended to place seeds on a piece of tape when cutting open for ease of handling. If possible, increase harvest to accommodate for proportion of hollow seeds. Ensure your harvest plans will not remove more than 20% of the available seeds (Way & Gold, 2014).

Above left: *B. neoalaskana* male catkin. Alfred Cook, some rights reserved, CC BY, cropped from original, http://www.alaskawildflowers.us/Kingdom/Plantae/Magnoliophyta/Magnoliopsida/Betulaceae/Betula_neoalaskana/Neoalaskana_29.html

Above right: *B. neoalaskana* female catkin. Alfred Cook, some rights reserved, CC BY, cropped from original, http://www.alaskawildflowers.us/Kingdom/Plantae/Magnoliophyta/Magnoliopsida/Betulaceae/Betula_neoalaskana/Neoalaskana_23.html

Below: *B. neoalaskana* seeds. Alfred Cook, some rights reserved, CC BY, cropped from original, http://www.alaskawildflowers.us/Kingdom/Plantae/Magnoliophyta/Magnoliopsida/Betulaceae/Betula_neoalaskana/Neoalaskana_37.html

Seed Collection:

Assess ripeness of catkins before collection. Collect only female catkins. Because catkins can shatter easily, they should be put directly into paper bags, either by stripping seeds from catkins or clipping entire catkins. Do not fill bags more than half full. Use ladders to access higher catkins (Banerjee et al., 2001).

Post-Harvest Handling:

Remove large debris from bag. Staple tops of paper bags to prevent seed loss. Ensure seeds do not overheat in direct sunlight or in a parked car. Label all bags inside and out, and inspect collections from different collectors before combining (Way & Gold, 2014). Seeds should be processed as soon as possible, but can be temporarily stored in a well-ventilated area. When storing temporarily, seeds can be kept in bags or spread on trays to

begin drying (Banerjee et al., 2001). Seeds should be sealed in containers overnight to prevent reabsorption of moisture (Way & Gold, 2014).

Seed Processing:

Spread catkins out to dry in a well-ventilated area with low relative humidity. Research has shown that *Betula* species will release their seeds between -14°C and 16°C. Dry for several weeks until the catkins begin to fall apart (J. M. Baskin, 2009). The seeds can then be extracted by rubbing the catkins or shaking them inside a bag. Dry seeds in a well-ventilated area between 5°C and 20°C with low relative humidity (15% RH recommended). *B. neoalaskana* seeds likely have orthodox seed behavior and should be dried down to approximately 15% equilibrium relative humidity (eRH), or 3% of their initial fresh weight moisture content before storing (Smreciu et al., 2013). eRH is a measure of the relative humidity of seeds at equilibrium with air in a sealed chamber and can be measured with a hygrometer (Linington & Manger, 2014). Screen seeds with 3.2 mm round hole screen to remove scales and separate from debris (J. M. Baskin, 2009).Seeds should be placed in labelled, air-tight containers for storage.

Seed Storage:

Store seeds in freezer at -18 °C ± 3 °C for long-term conservation (FAO, 2014). (FAO, 2014). Seeds of *betula* species are orthodox, but will quickly lose viability if not dried and stored at low temperatures (C. C. Baskin & Baskin, 2014). For active collections being stored for 10 years or less, seeds can be stored between 0°C and 10°C. (Rao et al., 2006). Seeds from *Betula alleghaniensis Britt.* were stored for 8 years at 3°C with only 2% viability loss (J. M. Baskin, 2009). Longevity of orthodox seeds increases with low moisture content and low temperatures (Rao et al., 2006).

Germination Pre-treatment:

Fresh seeds collected for reclamation in the Athabasca Oil Sands region of Alberta were shown to germinate after 30 days of cold stratification, however, it has been noted that *Betula* species can vary significantly in germination requirements based on their location of growth (Smreciu et al., 2013). Light can assist in breaking dormancy in *Betula* species and has been shown to reduce required cold stratification times (J. M. Baskin, 2009). If seeds have been dried prior to germination, soaking seeds in a solution of 0.5% sodium hypochlorite (NaOCl) for 10 minutes, then rinsing with water for 1 minute prior to germination will reduce the chance of rehydration damage. If this treatment is not available, suspend dry seeds over water in a sealed container for 24 hours (Davies, Sacco, & Newton, 2015).

Seed Germination:

For germination testing, label germination containers with collection number, species, germination conditions, start date, and number of seeds. Place germination paper into petri dishes. Wet paper just enough so that paper is moist but there is no standing water. Place a representative sample of seeds into Petri dish and space in an even grid. Multiple dishes may be required depending on sample size. Place lids on Petri dishes and place in germination chamber (or area with stable temperature) at 25°C (C. C. Baskin & Baskin, 2014). Place lids on

Petri dishes and place in germination chamber (or area with stable temperature) (Davies et al., 2015). Seeds should not be in direct sunlight but exposed to daylight. Monitor seeds daily and record proportion of seeds having germinated. Moisten filter paper as necessary. Most seeds will have germinated by 3 weeks; however, it is advisable to run germination tests for as long as possible to ensure all seeds are being germinated (Yelenosky, 1961). Continue test until no more seeds germinate or all seeds have germinated. 42 days is the recommended time for germination testing unless slow germination is expected (Davies et al., 2015). Seeds that have not been germinated should be assessed. If seeds look healthy inside, it is possible that gemination conditions or length of germination is not suitable for a portion of the seeds. A tetrazolium test can be used to determine viability of remaining seeds to determine if germination is due to inappropriate conditions or seeds that are unviable (Hay & Probert, 2013).

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Scientific Name: *Calamagrostis canadensis (Michx.) Beauv* **Common Names:** Bluejoint Reedgrass, Macoun's Reedgrass

Above: *Calamagrostis canadensis*, Rob Routledge, Sault College, Buggwood.org, some rights reserved CC BY

Life Form: Graminoid

Site Preferences: Moist to wet bogs, meadows, prairies, open forests. Low to high elevations, wet permafrost sites, performs best on deep wet soils with high organic content (Burton & Burton, 2003; Matheus & Omtzigt, 2013; Wynia, 2002)

Tolerances: High flood tolerance, can be drought tolerant once established, very winter hardy, can be shade tolerant, tolerant to nutrient-poor soils, permafrost, slightly acidic soils, slightly saline soils (Banerjee, Creasey, & Gertzen, 2001; Matheus & Omtzigt, 2013)

Distribution: Across Canada (Wynia, 2002)

Plant Identification:

This plant is a tall grass with erect, slender stems which are generally between 2 and 4 feet tall (Burton & Burton, 2003), but has been reported to grow up to 6 feet in Alaska (Banerjee et al., 2001). Stands of this species often appear hummocky due to creeping rhizomes and root stocks. Long narrow leaves are tinted blue and rough to the touch. The flowering head is open with a main axis and several branches that are further branched. Each branch ends in a flower which turns into a single seed. The flowering head often turns purplish in color (Wynia, 2002). Seeds are approximately 3 mm in length with callus hairs at the base (Banerjee et al., 2001).

Harvesting Considerations:

In Bulkley Valley, northwestern British Columbia, *C. canadensis* is ready for harvest between September 10th and October 17th (Burton & Burton, 2003). This may vary in the Yukon and should be determined by forecasting earlier in the season (Banerjee et al., 2001). This grass has very light seeds which spread through wind dispersal. Seeds produced are primarily the result of cross pollination, and populations tend to have considerable genetic variability (Macdonald & Lieffers, 1991). Collect as many individuals as possible (between 50 and 200) to capture as much of this genetic diversity as possible. This species can also reproduce through rhizomes, so there is potential that what appear to be individuals are actually clones. To reduce chances of collecting

Above: *Calamagrostis canadensis* leaf and stalk Rob Routledge, Sault College, Buggwood.org, some rights reserved CC BY

from an individual resulting from the spread of rhizomes, inspect population and set a minimum collection distance between plants. Determine sampling strategy based on size and makeup of population. This grass often grows in large, monospecific stands (Burton & Burton, 2003), so using a grid or transect to sample individuals will likely be successful. If there is variation in environmental features within the population, break the population into groups based on this and sample individuals randomly within each group, choosing a proportional number of individuals based on its size relative to the entire population (Way, 2003). There is also a potential for seed yields of this species to be quite low (Tesky, 1992).

Above: *Calamagrostis canadensis* seed. Steve Hurst - USDA-NRCS PLANTS Database - Not copyrighted image

Seed Collection:

Assess ripeness of seeds before collection. To harvest, cut stems with sharp clippers or hand sickle (Burton & Burton, 2003). Harvest into heavy-duty paper bags. Cloth bags are not recommended as seeds can catch on cloth (Way & Gold, 2014b). Do not fill bags more than 50% (Banerjee et al., 2001).

Post-Harvest Handling:

Remove large debris from bags. Staple tops of paper bags to prevent seed loss. Ensure seeds do not overheat in direct sunlight or in a parked car. Label all bags inside and out, and inspect collections from different collectors before combining (Way & Gold, 2014a). Seeds should be processed as soon as possible, but can be temporarily stored in a well-ventilated area. When storing temporarily, seeds can be kept in bags or spread on trays to begin drying (Banerjee et al., 2001). Seeds should be sealed in containers overnight to prevent reabsorption of moisture (Way & Gold, 2014a).

Seed Processing:

Spread out to dry in a well ventilated room between 5°C and 20°C with low relative humidity (15 % RH is recommended) (Hay & Probert, 2013). Grass seeds usually dry in anywhere from a few days to two weeks. *C. canadensis* seeds likely have orthodox seed behavior and should be dried down to 15% equilibrium relative humidity (eRH), or 3-7% of their initial fresh weight moisture content before storing. eRH is a measure of the relative humidity of seeds at equilibrium with air in a sealed chamber and can be measured with a hygrometer (Linington & Manger, 2014). Once dry, seed heads can be tapped against the edge of a tub, or placed into a bag and shaken to remove seeds (Smreciu, Gould, & Wood, 2013; Tallgrass Prairie Centre, 2009; Terry & Sutcliffe, 2014). Screen seeds through a 4.9 mm round holed screen and use fingers to rub seeds through and remove callus hairs, then screen through a 1.2 mm screen to remove dirt (Burton & Burton, 2003). Seeds should be placed in labelled, air-tight containers for storage. Ensure containers are clearly labelled.

Seed Storage:

Store seeds in freezer at -18 °C ± 3 °C for long-term storage (FAO, 2014). For active collections being stored for 10 years or less, seeds can be stored between 0°C and 10°C (Rao et al., 2006). However, *C. canadensis* seeds have remained viable for at least 4 years when stored at room temperature (Burton & Burton, 2003; Smreciu et al., 2013).

Germination Pre-treatment:

Pretreatments include 5 days of cold stratification (Baskin & Baskin, 2014), however other resources report that stratification was not beneficial (Burton & Burton, 2003; Wynia, 2002). When attempting to germinate seeds, it is important to note that seeds of the same species can have different germination requirements based on their location of growth. Dormancy can also vary based on storage conditions. For example, drying seeds can induce dormancy in some seeds, while others lose their dormancy during storage (Basey, Fant, & Kramer, 2015; Probert, Manger, & Adams, 2003). If seeds have been dried prior to germination, soaking seeds in a solution of 0.5% sodium hypochlorite (NaOCl) for 10 minutes, then rinsing with water for 1 minute prior to germination will reduce the chance of rehydration damage. If this treatment is not available, suspend dry seeds over water in a sealed container for 24 hours (Davies, Sacco, & Newton, 2015).

Seed Germination:

For germination testing, label germination containers with collection number, species, germination conditions, start date, and number of seeds. Place germination paper into petri dishes. Wet paper just enough so that paper is moist but there is no standing water. Place a representative sample of seeds into Petri dish and space in an even grid. Multiple dishes may be required depending on sample size. Place lids on Petri dishes and place in germination chamber (or area with stable temperature). Place lids on Petri dishes and place in germination chamber (or area with stable temperature) (Davies et al., 2015). Expose to daylight for 8 hours at 25 °C and in darkness for 16 hours at 10°C. Seeds should not be in direct sunlight but exposed to daylight. Monitor seeds daily and record proportion of seeds having germinated. Moisten filter paper as necessary. Seeds should germinate within 34 days (Royal Botanic Gardens Kew, 2014). Continue test until no more seeds germinate or all seeds have germinated. 42 days is the recommended time for germination testing unless slow germination is expected (Davies et al., 2015). Seeds that have not been germinated should be assessed. If seeds look healthy inside, it is possible that gemination conditions or length of germination is not suitable for a portion of the seeds. A tetrazolium test can be used to determine viability of remaining seeds to determine if germination is due to inappropriate conditions or seeds that are unviable (Hay & Probert, 2013). When planting in soil, seed between 0.6 cm and 1.2 cm. Grows best in warm, moist soils in spring.

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Scientific Name: *Hedysarum alpinum L.* **Common Names:** Bear root, Alpine Sweetvetch, Alpine hedysarum, alpine sweet-broom, pink hedysarum, purple sweetvetch

Life Form: Forb

Site Preferences: Mesic to moist grasslands, open woods, rocky slopes, roadsides (Pahl & Smreciu, 1999) Coarse textured soil, medium textured soil (USDA NRCS, 2018)

Tolerances: Moderate drought tolerance, medium fire tolerance, cold tolerant, nutrient poor soil, pH 4.5 to 8.4 (Gucker, 2007; Matheus & Omtzigt, 2013; USDA NRCS, 2018)

Distribution: Across Canada (Gucker, 2007; International Union for Conservation of Nature and Natural Resources., 2000)

Left: *Hedysarum alpinum*. Alfred Cook, some rights reserved, CC BY, http://www.alaskawildflowers.us/Kingdom/Plantae/Magnoliophyta/Magnoliopsida/Fabaceae/Hedysarum_alpinum/Alpinum_06.html

Plant Identification:

H. alpinum is a perennial comprised of several stems clumped together in a woody, persistent base with deep tap roots and rhizomes (Carter, 2014; Gucker, 2007). It produces purple to pink pea-like flowers attached by short, equal stalks in a dense line along the top portion of each stem (raceme). The average height of the plant is 20-70 cm (Gucker, 2007; Smreciu, Gould, & Wood, 2013). Leaves are long and narrow, with an odd number of leaflets arranged in an alternating pattern. The plant produces flat, sectioned pods that hang from stems and do not split open when ripe (Gucker, 2007), however pods can break between sections. Individual seeds are kidney shaped and range from brown to very dark purple in color (Smreciu et al., 2013). This plant can be very difficult to differentiate from *H. boreale*, however two can be differentiated by their leaves. The veins in the leaves of *H. boreale* are much less visible, and the underside of the leaf is harrier. *H. alpinum* leaves have quite distinct veins and have very little hair on the underside.

Above left: H. alpinum leaf. Note visibility of veins and minimal hair.
Above right: H. alpinum flower
Below left: H. boreale leaf. Note leaves have less visible veins.
Below right: H boreale flower
Photos: Mary Ellen Harte, bugwood.org, some rights reserved CC BY-

Harvesting Considerations:

The seeds are ready to be collected when green pods start to turn brown and fragment (Burton & Burton, 2003; Hunt & Wright, 2007). This can vary depending on location. For example, seeds ripen mid-July to mid-September in the Athabasca Oil Sands region of Alberta (Smreciu et al., 2013), and between July and August in Alaska (Carter, 2014). *Hedysarum alpinium L*. produces hermaphroditic flowers and commonly cross-pollinates, but can self-pollinate between two flowers on the same plant. It can also spread through rhizomes (Gucker, 2007). When choosing individuals to sample in a population, consider that side by side plants may be clones of the same individual. To reduce chances of collecting from an individual resulting from self-pollination or spread of rhizomes, inspect population and set a minimum collection distance between plants. Determine sampling strategy based on size and makeup of population. If population is small, sample as randomly as possible. If the population is large and has little variation, use a grid or transect to sample individuals. If there is variation in environmental features within the population, break the population into groups based on this and sample individuals randomly within each group, choosing a proportional number of individuals based on its size relative to the entire population (Way, 2003). This species is prone to hollow seeds due to failure of pollination. Collect 10-20 seeds, cut open with a sharp blade or crush, and examine the inside with a 10x or 20x hand lens to determine proportion of hollow, damaged or infested seeds. These seeds are small (3mm) (Smreciu et al., 2013), so it is recommended to place seeds on a piece of tape when cutting open for ease of handing. If possible, increase harvest to accommodate for proportion of hollow seeds. Ensure your harvest plans will not remove more than 20% of the available seeds (Way & Gold, 2014).

Seed Collection:

Assess ripeness of pods before collection. Collect seeds by placing entire seed head over a bucket and clip with sharp hand clippers. Alternatively, a bag can be placed over the seed head before clipping (Burton & Burton, 2003)

Above: *Hedysarum alpinum* seed pod. Photo by: Mary Ellen Harte, bugwood.org, some rights reserved CC BY-NC

Post-Harvest Handling:

Transfer seeds into cloth or heavy paper bags for transport to allow seeds to breath. Tie cloth bags or staple tops of paper bags to prevent seed loss. Ensure seeds do not overheat in direct sunlight or in a parked car. Label all bags inside and out. Inspect collections from different collectors before combining (Way & Gold, 2014). If seeds must be temporarily stored in the field, they should be kept in cool, dry, well ventilated conditions. When storing temporarily, seeds can be kept in bags or spread on trays to begin drying (Banerjee, Creasey, & Gertzen, 2001). Seeds should be sealed in containers overnight to prevent reabsorption of moisture (Way & Gold, 2014).

Seed Processing:

Hedysarum alpinium L. often produces seeds which ripen unevenly (Carter, 2014; Gucker, 2007). Spread out to dry in a well ventilated area between 5°C and 20°C with low relative humidity (15% RH recommended) (Hay & Probert, 2013) for 6 to 8 weeks (Smreciu, 1998). *Hedysarum alpinium L*. seeds likely have orthodox seed behavior and should be dried down to 15% equilibrium relative humidity (eRH), or 3-7% of their initial fresh weight moisture content before storing. eRH is a measure of the relative humidity of seeds at equilibrium with air in a sealed chamber and can be measured with a hygrometer (Linington & Manger, 2014). Remove pods by hand or with thresher. Pods can be broken open by pounding against corrugated rubber with a flat, circular piece of plywood with a handle (Smreciu, 1998), or by crushing against a screen with a rubber stopper. Seeds can also be placed in a cloth bag and agitated (Terry & Sutcliffe, 2014). Use screens to remove unwanted material from seeds. Recommended screen sizes are a 2.8 mm to 3 mm round hole top screen and a 1.7 mm round hole bottom screen (Pahl & Smreciu, 1999). Seeds should be placed in labelled, air-tight containers for storage. Ensure containers are clearly labelled.

Seed Storage:

Store seeds in freezer at -18 °C ± 3 °C for long-term conservation (FAO, 2014). For active collections being stored for 10 years or less, seeds can be stored between 0°C and 10°C. Longevity of orthodox seeds increases with low moisture content and low temperatures (Rao et al., 2006).

Germination Pre-Treatment:

Hedysarum alpinum seeds germinate best with light scarification (Hunt & Wright, 2007). Rub seed back and forth once with 150 fine grit sandpaper (Moor, Ross, & Hunt, 2004). Be careful during scarification as seeds have varying strength of seed coat and can be lost due to breakage. This treatment speeds germination but seeds used for reclamation in the Athabasca Oil Sands region of Alberta have been found to germinate with no pre-treatment (Smreciu et al., 2013). Cold stratification not required (Baskin & Baskin, 2014; Burton & Burton, 2003). When attempting to germinate seeds, it is important to note that seeds of the same species can have different germination requirements based on their location of growth. Dormancy can also vary based on storage conditions. For example, drying seeds can induce dormancy in some seeds, while others lose their dormancy during storage (Basey, Fant, & Kramer, 2015; Probert, Manger, & Adams, 2003). Seeds that have been dried to low moisture content can suffer rehydration damage. Soaking seeds in a solution of 0.5% sodium hypochlorite (NaOCl) for 10 minutes, then rinsing with water for 1 minute prior to germination will reduce the chance of this. If this treatment is not available, suspend dry seeds over water in a sealed container for 24 hours (Davies, Sacco, & Newton, 2015).

Seed Germination:

For germination testing, label germination containers with collection number, species, germination conditions, start date, and number of seeds. Place germination paper into petri dishes. Wet paper just enough so that it moist but there is no standing water. Place a representative sample of seeds into Petri dish and space in an even grid. Multiple dishes may be required. Place lids on Petri dishes and place in germination chamber (or area with stable temperature) at 22°C (Baskin & Baskin, 2014; Davies et al., 2015). Seeds should not be in direct sunlight but exposed to daylight. Monitor seeds daily and record proportion of seeds having germinated. Moisten filter paper as necessary. Most seeds should have germinated within 2 weeks; however is advisable to run germination tests for as long as possible to ensure all

seeds are being germinated (Pahl & Smreciu, 1999). Continue test until no more seeds germinate or all seeds have germinated. 42 days is the recommended time for germination testing unless slow germination is expected (Davies et al., 2015). Seeds that have not been germinated should be assessed. If seeds look healthy inside, it is possible that gemination conditions or length of germination is not suitable for a portion of the seeds. A tetrazolium test can be used to determine viability of remaining seeds to determine if germination is due to inappropriate conditions or seeds that are unviable (Hay & Probert, 2013). To germinate in soil, seed at a depth of 0.6 to 0.9 cm. Seeds should be spaced at least 1 cm apart in a row. For cultivation, rows paced at 60 to 90 cm is recommended (Smreciu et al., 2013).

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Scientific Name: *Juniperus horizontalis* **Common Names:** Creeping juniper

Above: *Juniperus horizontalis*, John Ruter, University of Georgia, Buggwood.org, some rights reserved CC BY, cropped from original

Life Form: Shrub

Site Preferences: Wide range of habitat. Open ground, sandy beaches and dunes, dry, rocky slopes, grasslands, open bogs, banks (International Union for Conservation of Nature and Natural Resources., 2000).

Tolerances: Some fire-tolerance, drought tolerant, heat tolerant, cold tolerant, tolerant to acidic and basic soils (Gucker, 2006).

Distribution: Across Canada (Gucker, 2006; iNaturalist.ca, 2018)

Plant Identification:

J. horizontalis is an evergreen shrub with long primary branches that spread horizontally forming a mat, and secondary, shorter branches which grow upward (CYSIP: Botany, n.d.; Natural Resources Canada, 2015). Plant size can vary based on conditions, but typical branch length and plant height are 3 – 5 meters and less than 30 cm, respectively. Leaves overlap like scales on young branches, but spread out like needles as branches mature. Leaves are long and narrow with a sharp point, and range from green to bluish in color. Seed is produced in female cones which are small, berry-like, and blue-grey in color. Each cone contains approximately 1-6 seeds. Male cones are produced on separate plants and appear as a small brown, oval cluster of scales (Gucker, 2006).

Above: *Juniperus horizontalis* leaves, Rob Routledge, Sault College, Buggwood.org, some rights reserved CC BY

Harvesting Considerations:

In central Yukon, fruit are ready to harvest in late August or early September (CYSIP: Botany, n.d.). Although collection can be delayed, it is recommended that the fruit are collected as soon as possible to prevent losses to wildlife (Banerjee, Creasey, & Gertzen, 2001; J. M. Baskin, 2009; Smreciu, Gould, & Wood, 2013). *J. horizontalis* female and male cones occur only on separate plants, so these plants cannot self-fertilize. The fruit do not fully mature until the second year after formation (Gucker, 2006), so it is important to ensure that seeds being collected are from the correct year. Plants often regenerate through sprouting roots from branches (Miller, 1978). When choosing individuals to sample in a population, consider that side by side plants may be clones of the same individual. To reduce chances of collecting from clones, inspect population and set a minimum collection distance between plants. Determine sampling strategy based on size and makeup of population. If population is small, sample as randomly as possible. If population is large and has

little variation, use a grid or transect to sample individuals. If there is variation in environmental features within the population, break the population into groups based on this and sample individuals randomly within each group, choosing a proportional number of individuals based on its size relative to the entire population (Way, 2003). Numbers of hollow seeds can vary considerably between individuals. Collect 10-20 fruit from several individuals in the population and remove seed. Cut seed with sharp blade and examine the inside with a 10x or 20x hand lens to determine proportion of hollow, damaged or infested seeds. If possible, increase harvest to accommodate for proportion of hollow seeds. Ensure your harvest plans will not remove more than 20% of the available seeds (Way & Gold, 2014).

Seed Collection:

Assess ripeness of fruit before collection. Pick or strip fruit by hand directly into a collecting bag. Do not strip fruit if there are large quantities of green fruits present (Banerjee et al., 2001; Smreciu et al., 2013).

Above: *Juniperus horizontalis* fruit, Rob Routledge, Sault College, Buggwood.org, some rights reserved CC BY

Post-Harvest Handling:

Remove large debris and transfer seeds into aerated plastic bags or other breathable container. Ensure seeds do not overheat in direct sunlight or in a parked car (Gold, 2014). Fruit can be spread to prevent overheating, but should not be allowed to dry too much as this causes flesh to be more difficult to remove (J. M. Baskin, 2009). Label all bags inside and out. Inspect collections from different collectors before combining (Way & Gold, 2014).

Seed Processing:

Debris can be removed by winnowing (J. M. Baskin, 2009). Place a box fan at the end of a tarp and turn on low speed to begin with. Pour a small amount of fruit in front of fan. Leaves and twigs should be blown further than fruit and therefore be separated. Adjust speed if this is not happening and pour a few more seeds. When speed has been determined, slowly pour all fruit in front of fan. Brush away debris (Tallgrass Prairie Centre, 2009). To remove flesh from seeds, place in a blender with taped or rubber coated blades to prevent damage to seeds (Matheus & Omtzigt, 2013; Rao et al., 2006). Macerate with a water to fruit ratio of 1:2½. Pulp and remaining debris can be floated off the top while full seeds sink to the bottom of the blender (J. M. Baskin, 2009). Use short pulses and low speeds to further reduce damage to seeds (Rao et al., 2006). Spread out to dry in a well-ventilated area between 5°C and 20°C with low relative humidity (15% RH is recommended). *J. horizontalis* seeds likely have orthodox seed behavior and should be dried down to 15% equilibrium relative humidity (eRH), or 3-7% of their initial fresh weight moisture content before storing. eRH is a measure of the relative humidity of seeds at equilibrium with air in a sealed chamber and can be measured with a hygrometer (Linington & Manger, 2014b). (J. M. Baskin, 2009; Hay & Probert, 2013; Linington & Manger, 2014a). Seeds should be placed in labelled, air-tight containers for storage. Ensure containers are clearly labelled.

Seed Storage:

Store seeds in freezer at -18 °C ± 3 °C for long-term conservation (FAO, 2014). For active collections being stored for 10 years or less, seeds can be stored between 0°C and 10°C. Longevity of orthodox seeds increases with low moisture content and low temperatures (Rao et al., 2006).

Germination Pre-treatment:

These seeds require cold stratification for 90 days prior to germination (C. C. Baskin & Baskin, 2014). Place seeds on a moist substrate at 3°C to 5°C. This can be done in a refrigerator. When attempting to germinate seeds, it is important to note that seeds of the same species can have different germination requirements based on their location of growth. Dormancy can also vary based on storage conditions. For example, drying seeds can induce dormancy in some seeds, while others lose their dormancy during storage (Basey, Fant, & Kramer, 2015; Probert, Manger, & Adams, 2003). If seeds have been dried prior to germination, soaking seeds in a solution of 0.5% sodium hypochlorite (NaOCl) for 10 minutes, then rinsing with water for 1 minute prior to germination will reduce the chance of rehydration damage. If this treatment is not available, suspend dry seeds over water in a sealed container for 24 hours (Davies, Sacco, & Newton, 2015).

Seed Germination:

For germination testing, label germination containers with collection number, species, germination conditions, start date, and number of seeds. Place germination paper into petri dishes. Wet paper just enough so that paper is moist but there is no standing water. Place a representative sample of seeds into Petri dish and space in an even grid. Multiple dishes may be required depending on sample size. Place lids on Petri dishes and place in germination chamber (or area with stable temperature) (Davies et al., 2015). Seeds should not be in direct sunlight but exposed to daylight. Monitor seeds daily and record proportion of seeds having germinated. Moisten filter paper as necessary. Most seeds will have germinated by 28 days; however it is advisable to run germination tests for as long as possible to ensure all seeds are being germinated (Smreciu et al., 2013). Continue test until no more seeds germinate or all seeds have germinated. 42 days is the recommended time for germination testing unless slow germination is expected (Davies et al., 2015). Seeds that have not been germinated should be assessed. If seeds look healthy inside, it is possible that gemination conditions or length of germination is not suitable for a portion of the seeds. A tetrazolium test can be used to determine viability of remaining seeds to determine if germination is due to inappropriate conditions or seeds that are unviable (Hay & Probert, 2013). When planting in soil, seed between 0.6 cm and 1.2 cm. Grows best in warm, moist soils in spring.

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Scientific Name: *Lupinus arcticus* **Common Names:** Arctic Lupine

Life Form: Forb

Site Preferences: Early successional ecosystems, moist to mesic meadows, gravel bars roadsides, open forest, dry slopes, disturbed areas, loam, sandy loam, or gravelly soil (Burton & Burton, 2003; Kinkenberg, 2017)

Tolerances: Low nutrients, limited drought (Matheus & Omtzigt, 2013)

Distribution: Yukon, Northern Northwest Territories and Nunavut, and British Columbia (iNaturalist.org, 2018; Kinkenberg, 2017)

Left: *Lupinus arcticus*. Alfred Cook, some rights reserved, CC BY, cropped from original, http://www.alaskawildflowers.us/Kingdom/Plantae/Magnoliophyta/Magnoliopsida/

Plant Identification:

This plant is a perennial herb comprised of several stems clumped together in a woody, persistent base. Stems are covered in short, silky hairs. 6 to 10 leaflets radiate from the end of the leaf stalk. In the northern subspecies, leaves originate at the base of the stem, while in the southern subspecies they originate along the stem (Burton & Burton, 2003). Flowers are purple-blue and pea-like, and run along the top potion of the stem. Plant height ranges from approximately 20 to 60 cm tall (Burton & Burton, 2003; Kinkenberg, 2017). Seeds are produced in dehiscent pods which turn black or dark brown when ripe (Banerjee, Creasey, & Gertzen, 2001). *Lupinus arcticus* can be confused with *Lupinus kuschei*, or Yukon Lupine. *Lupinus arcticus* has a fuller, brighter flowering head and less hair on the leaves and around the flower. The veins in the leaves are also more defined. Plants not edible!

Top left: L.arcticus leaf. Damontighe, Some rights reserved, CC BY-NC, cropped from original, https://www.inaturalist.org/observations/7991211
Top right: L. arcticus flower. Alfred Cook, some rights reserved, CC BY, http://www.alaskawildflowers.us/Kingdom/Plantae/Magnoliophyta/Magnoliopsida/Fabaceae/Lupinus_arcticus/Arcticus_20.html
Bottom left: L. kuschei leaf. kisbister, Some rights reserved, CC BY-NC, cropped from original.

Harvesting Considerations:

Harvest timing is very important as pods break apart very quickly when they become ripe. Pods ripen unevenly on stalk, but entire stalks can generally be clipped as soon as some pods begin to ripen and allowed to continue ripening on stalk.

Harvest times fall between the middle of July and end of August in northern British Columbia (Burton & Burton, 2003). This may vary in the Yukon and should be determined by forecasting earlier in the season (Banerjee et al., 2001). Determine sampling strategy based on size and makeup of population. If population is small, sample as randomly as possible. If population is large and has little variation, use a grid or transect to sample individuals. If there is variation in environmental features within the population, break the population into groups based on this and sample individuals randomly within each group, choosing a proportional number of individuals based on its size relative to the entire population (Way, 2003)

Above: *Lupinus arcticus* pods, Alfred Cook, some rights reserved, CC BY, http://www.alaskawildflowers.us/Kingdom/Plantae/Magnoliophyta/Magnoliopsida/Fabaceae/Lupinus_arcticus/Arcticus_10.html

Seed Collection:

Assess ripeness of pods before collection. Collect seeds by placing entire seed head over a bucket and clip with sharp hand clippers. Alternatively, a bag can be placed over the seed head before clipping (Burton & Burton, 2003).

Post-Harvest Handling:

Remove large debris from bags. Transfer seeds into cloth or heavy paper bags for transport to allow seeds to breath. Do not fill bags more than half full (Banerjee et al., 2001). Tie cloth bags or staple tops of paper bags to prevent seed loss. Ensure seeds do not overheat in direct sunlight or in a parked car. Label all bags inside and out, and inspect collections from different collectors before combining (Way & Gold, 2014). Seeds should be processed as soon as possible but can be temporarily stored in a well-ventilated area. When storing temporarily, seeds can be kept in bags or spread on trays to begin drying (Banerjee et al., 2001). Seeds should be sealed in containers overnight to prevent reabsorption of moisture (Way & Gold, 2014).

Seed Processing:

If some pods on stalk are not yet ripe, keep plants in similar conditions to those they would normally experience to allow continuation of ripening for 1 to 2 weeks (Probert, 2003). Caution pods explode when ripe. Cover pods when ripening and wear safety glasses when handling. When all pods are ripe, spread out to dry in a well ventilated area between 5°C and 20°C with low relative humidity (15% RH is recommended) (Hay & Probert, 2013). *Lupinus arcticus* seeds have orthodox seed behavior and should be dried down to 15% equilibrium relative humidity (eRH), or 3-7% of their initial fresh weight moisture content before storing. eRH is a measure of the relative humidity of seeds at equilibrium with air in a sealed chamber and can be measured with a hygrometer (Linington & Manger, 2014; Royal Botanic Gardens Kew, 2014). Once dry, remove large debris by hand. Pods and bulky debris can be screened away from seeds with a 4.9 mm screen. Move to a 4 mm screen to remove remaining debris. Screen though a 1.2 mm screen to remove dust (Burton & Burton, 2003). Seeds should be placed in labelled, air-tight containers for storage.

Seed Storage:

Store seeds in freezer at -18 °C ± 3 °C for long-term conservation (FAO, 2014). For active collections being stored for 10 years or less, seeds can be stored between 0°C and 10°C (Rao et al., 2006). Longevity of orthodox seeds increases with low moisture content and low temperatures (Rao et al., 2006).

Germination Pre-treatment:

Lupinus arcticus has a water-impermeable seed coat and requires scarification by scraping/chipping seed coat with a scalpel or forceps (Baskin & Baskin, 2014; Royal Botanic Gardens Kew, 2014; Smreciu, 1998). When attempting to germinate seeds, it is important to note that seeds of the same species can have different germination requirements based on their location of growth. Dormancy can also vary based on storage conditions. For example, drying seeds can induce dormancy in some seeds, while others lose their dormancy during storage (Basey, Fant, & Kramer, 2015; Probert, Manger, & Adams, 2003). If seeds have been dried prior to germination, soaking seeds in a solution of 0.5% sodium hypochlorite (NaOCl) for 10 minutes, then rinsing with water for 1 minute prior to germination will reduce the chance of rehydration damage. If this treatment is not available, suspend dry seeds over water in a sealed container for 24 hours (Davies, Sacco, & Newton, 2015).

Germination:

For germination testing, label germination containers with collection number, species, germination conditions, start date, and number of seeds. Place germination paper into petri dishes. Wet paper just enough so that paper is moist but there is no standing water. Place a representative sample of seeds into Petri dish and space in an even grid. Multiple dishes may be required. Place lids on Petri dishes and place in germination chamber (or area with stable temperature) (Davies et al., 2015) at 20 °C(Royal Botanic Gardens Kew, 2014). Seeds should not be in direct sunlight but exposed to daylight for 8 hours and darkness for 16 hours per day. Monitor seeds daily and record proportion of seeds having germinated. Moisten filter paper as necessary. Seeds should germinate to 50% by about 2 weeks; however it is advisable to run germination tests for as long as possible to ensure all seeds are being germinated (Banerjee et al., 2001). Continue test until no more seeds germinate or all seeds have germinated. 42 days is the recommended time for germination testing unless slow germination is expected (Davies et al., 2015). Seeds that have not been germinated should be assessed. If seeds look healthy inside, it is possible that gemination conditions or length of germination is not suitable for a portion of the seeds. A tetrazolium test can be used to determine viability of remaining seeds to determine if germination is due to inappropriate conditions or seeds that are unviable (Hay & Probert, 2013). For germination in soil, plant at 1 cm in loam, sandy loam, or gravely soil (Banerjee et al., 2001).

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Activities

1. Planning for seed collection using protocols

2. Seed germination and emergence

3. Breaking seed dormancy

4. Small-scale seed drying

Activity 1: Planning for seed collection using protocols

Background: Understanding the species you are about to collect is very important. This ensures you are collecting species at the correct time and with the correct methodology. It also helps you identify any notable characteristics of a species that may affect your collection strategy. This information is available in the harvesting considerations section of the protocols.

Activity

1. Divide into pairs and read through the harvesting considerations section of the protocols for the focal species (these will be species you are harvesting later today, so you will need this information!). Look for information that would be important to know before going out to harvest the species.

2. Write a list of this information for each of the species you are working on. For example, this could include when the species is ready for harvest, how the species disperses seeds, etc.

3. Going through one species at a time, each group will share their ideas in a group discussion with the instructors and they will be written up on a flip chart. Copy down any additional information that is written on the chart.

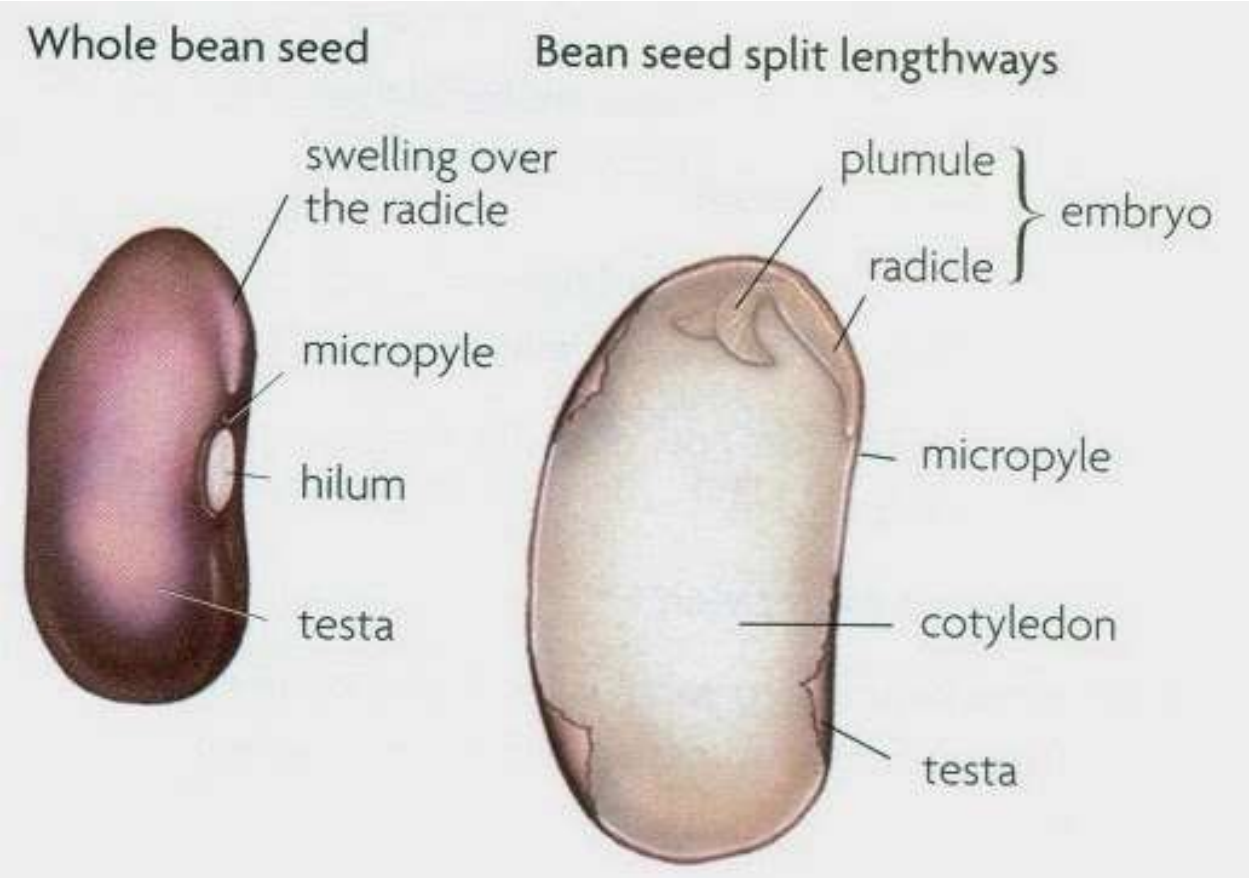
4. Imagine you had previously visited this population. Would you have information right now that would improve your ability to harvest these species? Write down 3 ways your seed collection planning could be improved by visiting a site before collecting.

Activity 2: Seed Germination and Emergence **Name:**_____

The seed is the reproductive unit of gymnosperms and angiosperms. The advantages of seeds over spores is seeds are better protected by the seed coat and have a supply of nutrients from the parent plant. In mosses, ferns and other seedless plants, the spores have to develop and survive without any assistance from the parent plant.

For this lab, we have pea seeds that have been soaked for 24 hours.

1) Select one pea seed from the jar
2) Locate the hilum
3) Slice the pre-soaked pea seed lengthwise
4) Compare the internal structures with the diagram on the back of this sheet
5) Draw one side of the pea seed and label each structure
6) Record the function of each structure:
    a. Hilum
    b. Micropyle
    c. Testa
    d. Plumule
    e. Radicle
    f. Cotyledon



Activity 3: Breaking Seed Dormancy

Background

Many northern seeds have factors which keep them from germinating in conditions that are unsuitable for growth. For example, conditions can be similar in fall and spring, but germinating in fall would mean the plant would likely freeze before it could fully grow and produce seed. Mechanisms to prevent this from occurring are called seed dormancy mechanisms.

Dormancy can be caused by physical characteristics of the seed, for example, seed coats which prevent water from reaching the embryo, which is required for germination. This this can be broken through mechanical or chemical breaking of the seed coat, called scarification, to allow water to enter the seed. Other forms of dormancy can be due to characteristics of the embryo, including under-developed embryos or physiological inhibitors present in the embryo or surrounding tissue. Several treatments can be applied to break this type of dormancy, including exposure to periods of heat, cold, and light, called stratification. Seeds can exhibit both types of dormancy and require multiple dormancy-breaking treatments.

Materials:
- Practice seeds (ideally relatively large)
- 150 grit Sandpaper
- Tape
- Scalpel
- Paper towels or filter paper
- Ziploc bags or other tightly sealing container
- Water
- Durable work surface (cutting board, work bench, etc.)
- Activity Sheet

Scarification (two methods)

1. Set up your work station, ensuring you have all materials in the above list
2. Tape a piece of sandpaper (gritty side up) to your work surface to prevent it from moving
3. Collect 10 sample seeds from the instructor
4. Take half of your seeds and place them on the sandpaper

Method 1: Sandpaper scarification. This works well for seeds that need light scarification (eg. *Hedyserum alpinum*).

1. Rub on side of seeds bank and forth once and examine surface of the seeds. Different seeds have different strengths of seed coat and therefore need a different level of scarification (will be indicated in protocol). However, when the seed coat has a visible change in colour it should allow water to pass through it.
2. Turn seeds over and repeat

Method 2: Scarification with a scalpel. For use in seeds that need heavier scarification (e.g. *Lupinus arcticus*)

1. Place the other half of your seeds on your work surface
2. Very carefully nick the seed coat of one seed with a scalpel. Be careful not to cut too deep into the seed and damage it (see picture below for reference). Be careful of your fingers!
3. Repeat with each seed

Cold Stratification)

1. Label Ziploc bags or other sealing container with the species name, date, temperature of stratification (usually 3-5 degrees Celsius, or refrigerator temperature), and length of time of stratification
2. Collect 10 sample seeds from instructor
3. Fold a piece of paper towel in half and add water to it so it is wet but there is no excess water dripping off the paper towel (can also use filter paper)
4. Place seeds onto folded, wet, paper towel and fold further to keep seeds inside
5. Place folded paper and seeds into a Ziploc bag or other sealing container
6. These bags would then be placed in a fridge (between 3-5 degrees Celsius) for varying amounts of time (indicated in protocol for species, e.g. 30 days for *Betula neoalaskana*), but they should be occasionally monitored to ensure the paper towel is still wet.

Activity 4: Small Scale Seed Drying

Background: In an ideal situation, seeds are dried in a specifically designed drying room with a constant humidity and temperature. However, this is not always available, especially for small scale drying operations. Drying seeds in sealed barrels with silica is a good option for small scale operations, and is used successfully

Materials:
- 2 x 60L barrel with sealing top
- 6 gallons silica gel (ideally with a small proportion of indicating silica mixed in)
- Chicken wire
- Craft or other thin wire
- 10%-60% RH humidity indicator strips
- Small gasketed containers
- Seeds in paper or cloth collection bags
- Activity sheet

Seed Drying Setup

1. Place the two barrels in an area where they can stay for the duration of seed drying and are not in direct sunlight. Make sure the barrels can be easily opened during this time.
2. Fill approximately 20% of the volume of the barrel with silica gel. This should be 3 gallons of silica per barrel
3. Depending on the size and quantity of seeds, make different sized tubes with chicken wire. Cut desired length of wire. Roll so cut ends touch and fold over excess wire to form a tube (this will be stood up in barrel to hang bags with seed off of). If needed, use pieces of craft wire to attach ends.
4. Hang bags on chicken wire tubes with craft wire.
5. Seal lid of barrel.

6. Mix the silica at the base of the barrel once per week. Watch the colour indicating beads and dry the silica if the colour shifts to indicate saturation. Follow instructions on silica gel package to do this
7. At the same time, mix seeds in each bag and take a small sample of each type of seed. Put sample in clear, sealable container (fill at least ½ full). Place moisture indicating card on top of the seeds. Do not leave in direct sunlight. Leave until there is no change in the moisture indicator (seeds have equilibrated with surrounding air). This may take several hours.
8. Continue testing the seeds until the moisture readings fall between 10 and 20%.
9. Once seeds are dry, they can be packaged for storage.

Forms

1. Daily Safety Meeting Record

2. Seed Forecasting Data Form

3. Seed Collection Data Form

4. Seed Storage Form

SAMPLE Pre-Field Activity Meeting/Daily Safety Meeting Record

Date: _____ **Course:** _____ **Site:** _____

Persons Present:

Name (Print) Use reverse of sheet if necessary	Signature	Organization	Position

Discussion with group:

Description of Activities:				
Emergency Muster Point:				
Location of First Aid Kit(s):				
Latitude and Longitude of main location (where applicable):				
Barriers to providing First Aid to an injured worker on any part of the activity site (long walks, steep slopes etc.):				
Communications devices checked?	☐ Radio, Channel ____	☐ Sat Phone	☐ Cell Phone	☐ Other
Radio channel confirmed:				
Primary First Aid Attendant:		Secondary First Aid Attendant:		
Potential hazards of Activities/Location:				

Types of injuries associated with today's activities or location:	
PPE required:	
Personal protective equipment being worn and in good condition by all?	
Tools/equipment available on site for safety:	
Check in frequency agreed to:	Check in person:
Warning signage placed? Barriers positioned?	
Safety Alerts discussed by (name)?	
Identified risks and hazards on site (e.g. steep slopes, overhead activity/equipment, water bodies, weather, traffic, road conditions, new activities?). Concerns raised by team members:	
Comments/Notes:	
Briefing Leader Name	**Signature**
On-site Supervisor (Instructor) Name	**Signature**