# **Developing protocols for the collection and valuation of wild native seed from the Hudson Bay Lowland.**

by

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## Abstract

Native species are being more commonly used and often even mandated in restoration projects. However, commercial seed sources are often unavailable or not of a suitable provenance. Collecting seed from wild sources is an alternative, but it can be challenging. The objectives of this study were to: 1) identify key attributes that influence the value of seed and to evaluate and quantify these differences for 57 native species with potential for restoration in subarctic Ontario; 2) determine if fertilizers could increase the seed yield of wild species with a low seed output; 3) determine and compile simple and effective protocols for the collection, processing, storage, and germination of 60 wild species native to northeastern Ontario. Field studies were conducted at De Beers' Victor diamond mine, located in the Hudson Bay Lowland in north-central Canada from 2014 to 2016.

To complete the first objective, I evaluated the attributes that affect the time and cost of using wild seeds from upland native plants. Taking into account the regional abundance of species, collection obstacles, requirements for identification, ease of processing and storing seeds, and propagation effort, I ranked the results for each species within each attribute. Each category provided a relative value reflective of the effort required to collect, process, store, and propagate seed of a given species. I demonstrate how these relative values could be used to prioritize species in revegetation planning. These relative seed values can also be used to determine seed prices for a variety of projects and locations.

For my second objective, I fertilized wild populations of American vetch (*Vicia americana*) and silverweed (*Potentilla anserina*). These herbaceous upland species may be useful in reclamation, but had low seed yields in 2014. Fertilization had no effect on seed yield and neither species set seed, regardless of treatment, except for a single American vetch plot. I discuss various environmental factors that may have had an influence on the poor seed yields.

Fertilizing wild populations may not be an effective approach to increase seed yield for these species in a subarctic environment, although testing a variety of fertilizer rates and environments could guide future studies.

For the final objective, I field-tested seed collection and seed processing protocols for native species desired for revegetation, and I compiled information from the literature on their storage and propagation requirements. I produced both a general guide and profiles for 60 species. The guide is written in lay language, with many photographs and provides an overview of the required knowledge for harvesting seed from wild plants. This guide will be useful to people who wish to begin collecting seed for any reason, including restoration projects, nursery establishment and even gardening.

The demand for native and local seed is growing. With increased mining development in remote areas, the demand for local native seed for restoration will continue to increase. This research will contribute to the knowledge of collecting wild seed from native species and improve the success of these collection programs. This work could provide a base for small business development in remote communities.

**Keywords**: seed collection, native plant, ecological restoration, seed value, subarctic

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# Preface

The use of native plants to rehabilitate habitats for species at risk, roadsides and mine sites is becoming more common (Riley *et al*. 2004, Haan *et al*. 2012, Naeth and Wilkinson 2014). Native plants are used because they promote biodiversity (Jones 1997, Harrington *et al*. 1999, Peppin *et al.* 2011, Naeth and Wilkinson 2014) and to avoid the later costs associated with eradicating non-native species (D'Antonio and Meyerson 2002). Stricter regulations, agreements with local communities, and scientific support are compelling the increased use of native species.

Commercial availability of native plant material is limited despite increasing demand (Jones 1997, Mortlock 2000). In remote regions, such as in northern Canada, seed is commercially available for only a few common native species and is not locally sourced. Vander Mijnsbrugge *et al*. (2010) identifies four potential concerns when planting non-local material. (1) Non-local genotypes may be poorly adapted to local conditions, and this lack of adaptation may only be evident later for longer-lived species (O'Brien *et al*. 2007, Vander Mijnsbrugge *et al*. 2010). (2) Hybridization with local genotypes may lead to reduced fitness of offspring (Hufford and Mazer 2003). (3) The non-local genotypes may be superior in some way and may invade local ecosystems, displacing local flora (Hufford and Mazer 2003). (4) The non-local genotypes may also interact differently with local fauna, for instance, by having unsynchronized flowering times for local insect pollinators (Jones *et al*. 2001). Genetic adaptation within a species is especially noticed along gradients of moisture (O'Brien *et al*. 2007) and latitude (Bevington 1986).

The importance of using local sources may depend on the goals of the project and location. Seeds are collected from plant communities within rare or frequently exploited habitats in order to preserve their unique population genetics (Mattner *et al*. 2002, Volis and Blecher, 2010). Those working in disturbed areas in remote regions, such as remote mine sites, are also collecting their own plant material for revegetation (Naeth *et al*. 2005). Some species, such as willows (*Salix*) or poplars (*Populus*), may be successfully planted using stem cuttings (Hagen 2002, Landis *et al*. 2003). Moreover, seeds differ genetically from their mother plant, providing genetic variability. Perhaps another important factor is that seed collection can be done non-destructively, so parent plants and populations can remain unaffected in future years, unlike vegetative harvesting techniques that disturb parent plants or substrates. In this study, I focused on seed as a planting material.

Resource developments are expected to increase in remote regions in the coming decades, such as in northern Canada (Rhéaume and Caron-Vuotari 2013). The industries will be required to restore damaged ecosystems and almost certainly to use native species for the revegetation. Seed collection by local communities could provide an economic opportunity for nearby First Nations where employment opportunities are very limited (Far North Act 2010, AANDC 2013). An assessment of the relative value of wild collected seed would be useful for determining seed prices. This is the focus in Chapter 1, written as a manuscript.

Collecting a variety of seeds from the wild can be a challenging task. For many native plants in cold climates, seed output is low, fertilizers may be used to improve the seed yield of desired species (Greipsson and Davy 1997) but the few studies that have measured changes in seed or flowering outputs at the species level in boreal and arctic climates have found that responses have been variable and often species-specific (Shaver and Chapin 1995, Philipp *et al*. 1996, Grainger and Turkington 2013, Petraglia *et al*. 2013, Thorpe *et al*. 2013). I present a short study on fertilization trials in Chapter 2, again written as a manuscript.

Other obstacles to seed collection program success are a result of the variations between species. This affects the timing and methods required for collecting seed, the steps and effort for seed cleaning, the storage requirements and germination requirements. Databases and specialist forums are growing, such as the *Native Plant Network* that regularly publishes propagation protocols from nursery growers (https://npn.rngr.net/propagation/protocols). Recently, a guide on how to collect, clean, store and propagate native seed was compiled to restore bitumen mine sites in boreal Alberta (Smreciu *et al*. 2013), but no such resource is available in eastern Canada. Continuing to improve access to this literature, through compilations and online databases, and expanding research will improve the success of wild native seed collections. This is our goal for Chapter 3 and in the supplementary materials. I wrote Chapter 3 and Appendix B in lay language as an instructional guide containing seed collection best practices; I will combine both for eventual online public access.

I co-authored the manuscripts in Chapter 1 and Chapter 2, the general online guide in Chapter 3 and the Appendix B with my supervisor, Daniel Campbell. For the chapter 1 manuscript, I compiled the background literature, determined which seed value attributes to sample and contributed heavily to sampling design. I was also responsible for the data collection in the field and in the lab, most of the data analyses and the writing. In chapter 2, I compiled the literature and contributed to the experimental design. Due to my maternity leave, the experimental setup in the field was carried out by Dr. Daniel Campbell and other students. I collected the field data over two summers, analysed the data and wrote the first draft of the manuscript. I tested protocols and compiled the extensive background literature and wrote the general guide in Chapter 3 and the species profiles in Appendix B. Daniel Campbell had the initial ideas, helped with study design and some experimental set-up, performed some of the analyses for chapter 2, and helped direct and edit the writing. Given my role in these chapters, I am submitting them in the form of my Master of Science thesis.

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**Chapter 1: Should I pick that?**
**An approach to prioritize and valuate native wild seed**

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**Abstract**

The use of native species for ecological restoration is increasing and is often required for revegetation in remote regions. However, commercial sources of planting material are often unavailable from, or not grown in a suitable provenance. Collecting seed from a diversity of species can be a challenge due to physical, biological, and even chemical differences between species. By quantifying important differences between species, we may be able to prioritize which species are easiest to collect, clean, store and propagate, to improve the success of wild collection programs. This approach can also be used to determine relative seed values for a seed valuation scheme. The purpose of our study was to identify key attributes that influence the value of seed and to determine how we could evaluate and quantify these differences. Field studies were conducted at De Beers' Victor diamond mine, located 90 km from Attawapiskat in the Hudson Bay Lowland in north-central Canada. We evaluated attributes that affect the time and cost of using wild seeds including: plant abundance, collection obstacles, requirements for identification, ease of processing and storing seeds, seed viability, and propagation effort. Based on the range of results for each attribute, we ranked our data to reflect relative effort. We calculated a relative effort score for each species in each category (collection, processing, storage, and propagation). We used the relative effort scores to prioritize species using the Victor mine as a case study. These relative seed values can also be used to determine seed costs for seed collectors such as consultants or community members in remote communities where wild seed collection may be the only option for obtaining plant material. This approach is not limited to northern Canada, but can be applied in other locations and to broader restoration applications.

Keywords: local native seed; seed collection; seed cleaning, seed storage, seed propagation; restoration planning; ecological restoration; seed value; subarctic environment

Botanical nomenclature: ITIS (www.itis.gov).

Data archived in the Scholars Portal Dataverse data repository.

## Introduction

Ecological restoration aims to accelerate the recovery of a damaged landscape (SER International 2004). Restoration is considered successful when the landscape contains enough biotic and abiotic resources to function without assistance, interact naturally with surrounding ecosystems, and adapt to environmental changes in the same way as existing or reference ecosystems (SER International 2004). Managers may use both native and non-native plants to reach these targets. Non-native species establish and grow rapidly, and can promote early ecosystem development in severely disturbed landscapes (Lawrence & Ratzlaff 1989; Asay *et al*. 2001). However, they often outcompete native species (Rayfield *et al*. 2005; Skousen & Venable 2008) and are known to spread and invade natural environments, altering their community composition and diversity (Flory and Clay 2009). Native plants are now more commonly used following landscape disturbance to promote biodiversity (Jones 1997, Harrington *et al*. 1999, Peppin *et al*. 2011, Naeth and Wilkinson 2014) and to avoid the later costs associated with eradicating non-native species (D'Antonio and Meyerson 2002). Stricter regulations, agreements with local communities, and scientific support are strongly encouraging the increased use of native species.

Restoration managers select desired native species based on several considerations. First, in severely disturbed ecosystems, they choose species that are able to tolerate the specific conditions of an amended substrate and stabilize exposed soil surfaces (Haan *et al*. 2012). Second, they will consider species that contribute to ecosystem succession and function, through biomass production, nutrient fixation and sequestration, soil development and the production of shade and suitable microclimates for later successional species (Walker *et al*. 2007). These may include nurse species (Ren *et al*. 2008). Third, managers should use nearby reference ecosystems as their restoration target (Ruiz-Jaen and Aide 2005) and may select species present in these reference ecosystems (Shinneman *et al*. 2008, Rochefort *et al*. 2016). Fourth, the desired species must be both available and economical. This study focuses on this last consideration.

Commercially-sourced seed or plant material is limited for native species, despite increasing demand (Jones 1997, Mortlock 2000). In remote regions, such as in northern Canada, seed is commercially available for only a few common native species, and that seed is only sourced from distant provenances in western or southern Canada. Vander Mijnsbrugge *et al*. (2010) identified four potential concerns when planting non-local material. (1) Non-local genotypes may be poorly adapted to local conditions, and this lack of adaptation may only be evident later for longer-lived species (O'Brien *et al*. 2007, Vander Mijnsbrugge *et al*. 2010). (2) Hybridization with local genotypes may lead to reduced fitness of offspring (Hufford and Mazer 2003). (3) The non-local genotypes may be superior in some way and may invade local ecosystems, displacing local flora (Hufford and Mazer 2003). (4) The non-local genotypes may also interact differently with local fauna, for instance, by having unsynchronized flowering times for local insect pollinators (Jones *et al*. 2001). Genetic adaptation within a species is especially noticed along gradients of moisture (O'Brien *et al.* 2007) and latitude (Bevington 1986). The concept of using local seeds in not new, but the increased understanding of genetic transfer and importance of ecological impacts has led to the creation of practitioner tools, such as seed transfer guidelines and seed zone mapping (Ying and Yanchuk 2006). Current seed zone mapping is intended to identify areas where natural genetic exchanges can occur, delineated on the basis of climate, geographical distance, geomorphology and plant populations (Ying and Yanchuk 2006, Vander Mijnsbrugge *et al.* 2010). Collecting within seed zones and from a comparable habitat (i.e., moisture regime, soil type) poses the lowest ecological risk and may lead to better survival over the long term (Jones *et al*. 2001, O'Brien *et al*. 2007).

The importance of using local sources for native plant material often conflicts with the commercial unavailability of desired seed. The lack of seed sources has led remote restoration projects, such as mine sites, to collect their own plant material for revegetation (Naeth *et al*. 2005). Some species, such as willows (*Salix*) or poplars (*Populus*), may be successfully introduced through vegetative transplanting as cuttings (Hagen 2002, Landis *et al*. 2003). However, seeds offer several advantages. Seeds differ genetically from their mother plant, providing genetic variability. Using seeds also provides dioecious species with balanced sex ratios, unlike clones produced by vegetative cuttings (Landis *et al*. 2003). For instance, branch cuttings of the tree *Populus balsamifera* are commonly used in restoration, but because this species is dioecious and often occurs in vast clonal colonies, a higher harvesting effort to collect cuttings is required to maintain genetic diversity and an even ratio of male to female plants. Moreover, the time required to obtain and plant seeds with respect to the number of propagules, is often much less than that for a similar quantity of vegetative cuttings. Collecting seed can be non-destructive, unlike vegetative harvesting techniques that may disturb parent plants or substrates to some degree.

Collecting a variety of seeds from the wild for restoration projects can be a challenging task. Current documents exist detailing how to collect and propagate native seed for certain plant groups or certain regions (e.g., Young & Young 1992; Banerjee *et al*. 2001; Ross 2004; Bonner and Karrfault 2008). Databases and specialist forums are growing, such as the *Native Plant Network* (https://npn.rngr.net/propagation/protocols) that regularly publishes propagation protocols from nursery growers, or the *Seed Information Database*, which classifies seed storage requirements and behaviour (Royal Botanic Gardens Kew, released May 2008, http://data.kew.org/sid/). Recently, a guide to how to collect, clean, store and propagate native seed was compiled to aid in obtaining and handling seed required restore the damage caused by bitumen mining in boreal Alberta (Smreciu *et al*. 2013), but no such resource is available in eastern Canada. Continuing to improve access to this literature through compilations, online databases, and expanding research will improve the success of wild native seed collections.

Seed collection can be undertaken by local personnel in government and industry, or it may be contracted out to local communities, cooperatives, nurseries or consultants. Further planning requires cost estimates for the collected seed. The question remains: how much is this wild seed worth? Species differ in the efforts required to collect, clean, store, and propagate wild seed. Certain species may have high value for restoration, such as N-fixers, but may be locally uncommon or difficult to collect, store or germinate. Some species pose collection obstacles, such as trees that require specialized collection equipment. Other species may be easy to identify and have easy to collect seed, so seed collectors may favour these species. Some species are commercially unavailable because of their poor longevity, while others can be stored for years without loss in viability. Put simply, species differ in their seed value. It is critical to consider this difference in value to ensure the success and efficiency of a local seed collection program and fair seed pricing.

Few studies have looked at an economic valuation of seed collected from wild plant sources. Do Espírito Santo *et al*. (2010) attempted to give a relative value to seed from 22 tree species collected in the Caatinga region of southeastern Brazil. They examined several plant attributes, including plant distribution, native status, risk of extinction, successional class, processing and collection efforts, seed behaviour, and number of seeds per kg. They scored these attributes to determine a price per kg of seed for restoring degraded habitats and endangered species. This pricing methodology considered both environmental and socio-economic aspects because past approaches to seed pricing were arbitrary. Their results were used by local seed collectors to determine seed prices and to promote policy development in a region suffering from land degradation and species endangerment. We know of no such valuation system for wild seed in North America.

Resource developments are expected to increase in remote regions, such as in northern Canada in the coming decades (Rhéaume and Caron-Vuotari 2013), requiring ecosystem restoration using native species. Economic opportunities are often limited in these regions, but desired by local peoples (Far North Act 2010, AANDC 2013). Seed collection by local communities provides one option. An assessment of at least the relative value of collected seed would be useful in developing such a micro-industry.

In the current study, we built from the work of Do Espírito Santo *et al*. (2010) and present a methodological approach to assess the relative value of wild collected seed from 57 species of upland plants native to north-central Canada. The purpose of the study was to identify key attributes that influence the value of seed and to determine how to evaluate and quantify these differences between species. We considered attributes that affect the effort and time of collecting, cleaning, storing, and propagating seed. We demonstrate how these attributes can be used to determine a relative seed value. Relative seed values paired with a plant's ecological value can be used for prioritizing species. We demonstrate this using an example of ecosystem restoration planning at an open pit diamond mine site in north-central Canada.

## Methods

We conducted the field studies in 2016 near the De Beers Canada Victor Mine (52°49'N, 83°53'W, 83m elevation) and Attawapiskat First Nation (52°55'N, 82°26'W, 5m elevation), both within the Attawapiskat River drainage of the Hudson Bay Lowland (HBL), Canada (Figure 1). The HBL is a vast peatland plain underlain by limestone, with calcareous glacio-marine deposits and capped by peat (Martini 1989, Riley 2003, 2011). It forms the third largest wetland in the world (Abraham and Keddy 2005). The region is characterized by a subarctic climate, with a mean annual temperature of -1.3°C (January mean: -22.3°C and July mean: 17.2°C) and 1244 annual growing degree days above 5°C, from 1971 to 2000 at the nearest long-term climate station (Lansdowne House; 52°14'N, 87°53'W, 280 km WSW; 254 m elevation; http://climate.weather.gc.ca/). Mean annual precipitation is 700 mm, 42% of which falls during the main growing season, from June through August.

The mining process is creating upland environments from its waste limestone, the calcareous silty-loam overburden, the processed kimberlite and peat, which must be restored using native species. Natural upland habitats are rare in the HBL and cover less than 5% of the landscape. They occur, in part, on raised beach ridges, palsas, and limestone outcrops (Martini 1989), with brunisols, podzols, and occasional folisols and cryosols, beneath low diversity coniferous forest vegetation (Garrah 2013). Upland habitats also occur along river valleys and shorelines. Large rivers have cut deeply within the peatland plain over millennia, allowing for drained conditions along valley walls, upper floodplains, and river islands during the growing season, favouring upland vegetation (Riley 2003). Large river ice blocks annually gouge much of the floodplain, allowing early successional upland vegetation to establish during the growing season, producing a patchwork of species-rich herb and shrub-dominated vegetation. Further upslope in these river valleys, diverse mixed or coniferous upland forests occur over regosols (Garrah 2013).

We selected 57 target species in this study (Appendix A1). They had to be indigenous vascular plants (USDA NRCS 2006, NatureServe 2015), abundant to occasional in the region (Riley 2003, Garrah 2013) and typical of upland conditions, as determined by botanical texts. We usually avoided having more than one species within a genus, unless their growth habits differed greatly. We also excluded many species with a small, vertical stature (<10 cm height), that do not play a particular functional role in restoration, to avoid too much redundancy. If common upland species were not producing seed during our field study year (e.g., *Populus tremuloides* and *Mertensia paniculata*), we excluded them from our final dataset. For each species, we gathered data on 12 poorly-correlated attributes that affect the effort associated with (i) collecting, (ii) cleaning, (iii) storing, and (iv) propagating their seed (Table 1).

We measured five attributes related to seed collection; namely, 1) the regional distribution of the species; 2) median cover; 3) the seed collection rate; 4) the identification effort by seed collectors; and 5) the number of collection obstacles faced by seed collectors. To determine the regional distribution of the species, we conducted field surveys from June to July 2016, returning in September to confirm the identity of certain graminoids or Asteraceae. We sampled a total of 56 upland plots using a stratified sampling strategy, with 42 near the Victor Mine and 14 near Attawapiskat First Nation. We attempted to sample regional uplands as a seed collector would, so we focussed on sites with easy access, different successional stages, higher overall species diversity or the presence of unique species. Our primary focus was the uplands along a 30 km stretch of the Attawapiskat River valley and upland interior islands (31 plots), because this river valley provides a long narrow corridor of collection sites with easy access by small boat; they also support a high diversity of upland plants from early to late successional stages, and represent natural reference conditions for mine site restoration (Garrah 2013). We also surveyed along the smaller Nayshkootayaow River shoreline (3 plots). We surveyed upland areas regenerating from human disturbances (10 plots), including mine overburden stockpiles, old quarries, road or trail sides, and an old exploration camp. We selected plots of upland forests based on reasonable access (moderate slopes and trail access) and appropriate size (6 plots). In addition, we surveyed an esker (2 plots), limestone islands (2 plots), and coastal shorelines (2 plots) to capture data for locally-distributed species, such as the tree *Pinus banksiana*, and the grass *Anthoxanthum nitens*.

Each plot was approximately 100 m by 15 m. We placed plots in the river valleys so the length, paralleled the river and the width extended from the shore to within the mature river valley forest. Plots were at least 500 m apart. Again, we surveyed the plots as a seed collector would. Three observers walked in a meandered pattern for 45 minutes, or until we were confident that most species were encountered within our plot. We determined the distribution of each target species in the region as the proportion of plots where it was present. Note that we also recorded the plant reproductive maturity of species based on the plant size or, if available, by the presence of fruiting materials, but this fruiting attribute was strongly correlated to the overall distribution of species as measured by its presence ($r$ = 0.98), so we did not include it as a separate attribute.

We determined the percent cover for a species by visually estimating its cover in each plot using three observers and following a modified Braun-Blanquet scale: 1, >0 to 0.1%; 2, >0.1 to 0.3%; 3, >0.3 to 1%; 4, >1 to 3%; 5, >3 to 10%; 6, >10 to 30%; and 7, >30 to 100%. This scale allowed estimates within rough intervals of 0.5 $\log_{10}$ cover percentage units. We determined the median cover for a species only using data from sites where it was present.

We quantified the seed collection rate for each species by conducting seed collection trials from July to October 2016. We first determined the most appropriate collection method for a species, either using just our hands or using berry rakes, scissors, pole clippers, a saw, a reverse leaf blower, tarps and large paper bags (chapter 3). We collected seeds actively for 15 minutes. Typically, we collected a total of three samples for each species (up to six samples when trying different methods and less than three samples for a few species that had dispersed). Three people took turns collecting, to eliminate bias resulting from a collector's experience level. If the seed collection required two people, then 15 minutes of collection was considered 30 minutes. In most cases, each sample came from a different site, except when a species was localized to one area we collected more than one sample from a single site. We cleaned the seed lot, weighed it and corrected it for seed lot purity (described below) and divided by the seed mass to express the seed collection rate as the number of seeds collected per hour, using:

$$seed\ collected/hr\ = \left(\frac{seed\ lot\ mass\ (g) \times lot\ purity\ (\%)}{collection\ time\ (hr)}\right) \Big/ seed\ mass\ (g/seed)$$

Note that we also evaluated the seed collection rate on a mass basis (grams $hr^{-1}$), however these two attributes were weakly but significantly correlated on log-log scales ($r$ = 0.49), so we only considered the seed collection rate based on seed numbers. Seed collection rate using seed numbers is more descriptive because it uses the total mass of seed collected and gives an idea of the number of propagules collected in that time frame as well. Seed mass values were taken from a previous study done in the region (Campbell and Laurin, unpublished). If seed mass values were unavailable, we counted 100 seeds from each lot to determine the overall mass and used the average of the three lots to determine the single seed mass.

To determine the identification effort and number of collection obstacles for each species, seven seed collectors completed questionnaires (Appendix A2). We asked participants to describe identification effort by answering two questions. (1) Is the species distinct? (2) Can you identify the species in the field? If both answers were affirmative, we scored the species with a low identification effort. If the answers were both negative, we scored it as high. If we received only one affirmative answer we scored the identification effort as moderate. We used the mode of the distribution to determine the final score for each species.

To rank seed collection obstacles, we asked the same participants to determine if A) fruit was generally very easy to collect, B) fruit was moderately challenging to collect (1-2 obstacles affect collection), C) fruit was challenging to collect (3 or more obstacles that affected collection). Listed obstacles can be found in Appendix A2. If the obstacle was not included in the list, we asked participants to briefly describe and justify the obstacle. We used the mode to assess the final collection obstacle score for a species.

We measured two attributes related to seed cleaning (1) seed cleaning effort and (2) seed lot purity. Seed cleaning is required for several reasons. (i) Sometimes a seed or achene requires scarification so the surrounding pulp must be removed to expose the seed. (ii) Some intact fruits inhibit germination (Cipollini and Levey 1997). (iii) There is often more than one seed per fruit. (iv) Chaff may encourage contamination by holding moisture and reducing seed longevity in storage. (v) Chaff also contributes to bulk in storage. (vi) Appendages are associated with dispersal and may result in seed movement or herbivory after field planting (Loch *et al*. 1996). (vii) Many seed appendages are cumbersome and make working with seed materials difficult. (viii) Cleaning is required to quantify accurately the amount of seed collected. (ix) Cleaning is also required to meet seed quality standards. We determined the seed cleaning effort based on the amount of equipment required and the number of steps required to clean seed to the best of our capabilities. Seed cleaning equipment included: a sieve set (5/16 inches to mesh size 140), a blender, a corrugated rubber threshing mat and paddles, buckets, and a table fan for winnowing (chapter 3). Some species required a shop vacuum or a drying oven. We ranked seed cleaning effort as easy if seed cleaning involved one or two steps and one or two types of equipment. Seed with moderate cleaning effort required three steps and two or three types of equipment. High cleaning effort was reserved for challenging species requiring three or more types of equipment or specialized equipment, costing >$500 CAN and more than three steps to produce cleaned and separated seed.

We determined seed lot purity to describe the effectiveness of these simple seed cleaning methods. If seed lot purity was poor, other more costly or complicated methods may be required to clean the seed. To measure this attribute, we subsampled each seed lot collection, using ~5 mL for small-seeded species to 15 mL for large-seeded species. We separated whole seeds from chaff and weighed them to determine the mass ratio of pure seed to pure seed plus impurities.

We determined two attributes related to seed storage, (1) storage behaviour; and (2) seed longevity. For storage behaviour, we classified the seed of a species as orthodox, intermediate, or recalcitrant, following definitions of (Hong and Ellis 1996) and using the seed storage database at the Royal Botanic Gardens Kew (accessed in November 2016 from http://data.kew.org/sid/). This classification describes the sensitivity of seeds to decreasing moisture content following harvesting, although this explanation is oversimplified. If species-specific storage behaviour was unavailable, we used the most common storage behaviour tendency for that genus. We scored storage behaviour for species according to their sensitivity, with orthodox seed species being the least sensitive and requiring the least effort post-harvest, followed by intermediate, then recalcitrant seed, which require the most effort post-harvest.

We classified seed longevity of species into three groups following the definitions of (Thompson 1993): (i) transient seed, which persists for less than one year or has a great loss in viability in the first year, (ii) short-term persistent seed, which survives for 1 to 5 years; and (iii) long-term persistent seed, which survives more than five years without much loss in viability. We classified a species's seed longevity from the literature (see chapter 3; Royal Botanic Gardens Kew 2016; Smreciu *et al*. 2013; RNGR 2017) based on the longevity of a species's seed that was dried and stored at 1° to 5°C, (normal range for refrigeration). Thompson (1993) agreed that separating transient seed from short-term persistent seeds was often difficult, therefore if we were uncertain or found conflicting reports on seed longevity for a species, we classified it as the intermediate class of short-term persistent seed.

Finally, we measured three attributes related to seed propagation, namely (1) seed viability; (2) pre-treatment requirements; and (3) germination requirements. Seed viability provides a measure of the potential number of seeds that can germinate. To measure it, we first cleaned seeds by winnowing or floatation to remove impurities and empty seeds. We then subsampled 35 seeds from each of three seed lots, for a total of 105 seeds per species. For most species, we sectioned each seed longitudinally, and judged the embryo to be viable if it appeared undamaged, plump and consistent in colour. In some species, the embryo was poorly differentiated at seed maturity, so the endosperm was examined and the seed was considered viable if the endosperm was consistent in colour, not desiccated, and if the seed was plump and firm. When a seed was too small to observe the embryo, as in *Rhododendron groenlandicum*, we performed a firmness test and considered a seed viable if it was plump and firm, and non-viable if it appeared desiccated. For two species, *Salix pseudomonticola* and *Populus balsamifera*, we germinated fresh seeds (35 from each lot) on moistened paper towel at room temperature for up to 7 days to determine their viability.

We classified species by their seed dormancy requirements prior to germination into three groups, as determined from the literature (see chapter 3; Baskin & Baskin 1998; Young & Young 1992; https://npn.rngr.net/propagation/protocols). We scored species that required no pre-treatments with the lowest dormancy breaking effort. We classified species with non-deep physiological dormancy or that require less than 90 days of cold stratification to break dormancy as needing a simple pre-treatment. We considered species requiring prolonged periods of cold stratification (more than 90 days), or with physical, chemical and/or morphological dormancies, as needing complex pre-treatments to break dormancy.

We categorized the germination requirements of species based on their needs for typical versus special germination conditions, based on literature sources (chapter 3; Royal Botanic Gardens Kew accessed in November 2016 from http://data.kew.org/sid/; Young & Young 1992; Smreciu *et al.* 2013). We considered typical conditions to be under standard greenhouse conditions, so with a temperature regime of 25°C to 15°C on a 12 to 16 hr light-dark cycle, and a non-specific substrate. We considered these species to have lower effort associated with germination. We considered species that require temperatures outside the standard range, specific light conditions, or specific substrates to have higher germination effort.

We scored each attribute with numerical data by examining the range of values and dividing data into 5 or 10 equal intervals on a linear or log scale. For attributes with categorical data, we arranged the classes so that those requiring the lowest effort had the lowest score. To summarize the overall effort scores for each species, we gave all attributes even weight and determined the mean score within each category of seed collection, cleaning, storage, and propagation efforts.

## Results

We present the full data set of attributes in Appendix A3. The regional distribution of target species followed a roughly normal distribution, with half of the 57 species being present in 30 to 50% of the plots surveyed (Figure 2A). The tree *Populus balsamifera* was the most broadly distributed; we found it at more than 80% of surveyed sites, especially along the river, represented by a few mature individuals on later successional sites and as seedlings in naturally-regenerating mine plots. A few of the other well-distributed species included the shrubs *Alnus viridis* ssp. *crispa*, *Cornus sericea* ssp. *stolonifera* and the herbs *Chamerion angustifolium* ssp. *angustifolium* and *Achillea millefolium*. In contrast, we found 11 species at less than 20% of our surveyed sites. These species mostly had specific habitat preferences. For instance, the tree *Pinus banksiana* was restricted to rare sandy upland islands. The grass *Hordeum jubatum*, was found only on human disturbed sites such as mine waste piles and roadsides, whereas the shrub *Juniperus horizontalis* was restricted to rocky outcrops. We scored the regional distribution of species based on equal intervals, with species present in <20% of sites receiving the highest effort score.

Median cover was approximately log-normally distributed, although slightly skewed toward sparse species within the plots (Figure 2B). Relatively small herbaceous species with a vertical growth habit, such as *Vicia americana*, *Sisyrinchium montanum*, and *Carex aurea* had <0.3% median cover within in the plots. In contrast, the trees *Picea glauca*, *Populus balsamifera*, and *Pinus banksiana*, had among the highest cover, with over 3% median cover within the plots.

The grass *Hordeum jubatum*, which was present in only ~5% of plots, was dominant when it was found, covering 10 to 30% of the area within plots. We scored the sparse species covering less than 0.3% of a plot area with the highest effort score.

Seed collection rates for target species followed a roughly log-normal distribution, spanning five orders of magnitude, ranging from 250 seeds $hr^{-1}$ for the large-seeded legume *Lathyrus palustris* to approximately 23 million seeds $hr^{-1}$ for the dust-seeded *Juncus dudleyi* (Figure 2C). If less than 1000 seeds $hr^{-1}$ were collected, we scored these species with the highest effort score. These included two large seeded species, the shrub *Elaeagnus commutata* and the forb *Maianthemum stellatum* and two legumes *Lathyrus palustris* and *Vicia americana*, which we commonly encountered but without seeds.

The seven seed collectors considered over 75% of species to be distinct and easy to identify (Figure 2D). Those that were ranked as moderate to identify were typically graminoids and the two legumes *Vicia americana* and *Lathyrus palustris*. The genera *Salix*, *Solidago* and some other Asteraceae (*Doellingeria* and *Symphyotrichum*) were considered as the most difficult to identify and were given the highest score.

In terms of collection obstacles, the seed collectors scored almost two thirds of the target species as being easy to collect (Figure 2E). For the other species, the most common obstacles were, in decreasing order, low or high plant height, dioecious species, plant armed with thorns or 'prickly', asynchronous ripening, singly distributed fruit (not in clumps), seed or fruit being difficult to find on the plant, and the need for specialized collection equipment. Nearly a third of the plants presented one or two of these obstacles. Only two species presented more than two obstacles. The tree *Picea glauca* was considered difficult to collect due to the height of seeds, the need for specialized equipment, its prickly nature and the need to kill or top the parent plant. The other difficult species, the shrub *Juniperus communis*, was considered prickly to touch, dioecious, had asynchronous ripening, and was said to be low to the ground. Species that were considered difficult to collect received the highest effort score.

Species were almost evenly distributed in the effort required to clean their seed (Figure 3A). Examples of easy to clean species were the herbs *Anemone canadensis*, *Carex aurea*, and *Galium boreale*, which had minimal to no secondary structures associated with their seeds. Species most difficult to clean required multiple steps and types of equipment, usually related to their dispersal structures. The forbs *Solidago* spp., the grass *Hordeum jubatum*, and the tree *Pinus banksiana* were examples. Respectively, they have hairs, long awns and winged seeds within serotinous cones. We could not clean two species beyond separation from their capsule, namely *Anemone multifida* and *Rhododendron groenlandicum*. The small seed size of *Rhododendron groenlandicum* meant we could not air separate seeds from chaff. We attributed these species to the highest effort score.

Seed lot purity was heavily skewed; we could clean three quarters of target species to over 90% purity (Figure 3B). At the other extreme, the herb *Anemone multifida* and the shrubs *Rhododendron groenlandicum, Alnus incana* ssp. *rugosa,* and *Dasiphora fruticosa* had seed lot purities of only 50 to 60%. This was the result of several factors, including seed size and strong attachment of the seed to their appendages, and for *Alnus incana* ssp. *rugosa*, seeds and catkin scales were too similar in size and weight to adequately separate them. We gave species with poor seed lot purity of 50 to 60% a high effort score.

All 57 target species were described as being orthodox for their storage behaviour classification and received the lowest effort score of two (Figure 4A). We included no target species with recalcitrant or intermediate storage behaviour. Seed longevity better described the variation in seed storage. Only three species, the herb *Galium boreale*, the shrub *Salix pseudomonticola* and tree *Populus balsamifera* quickly lose viability after they are collected, which we characterized as having poor seed longevity (Figure 4B). We considered 50% of our target species to have short term viability, either because they remain viable for 1 to 5 years or because of conflicting reports in the literature. This included most species in the families Asteraceae and Betulaceae and some others. We categorized 42% of our target species as having long term seed longevity, including all evergreen species (*Juniperus* spp., Pinaceae, *Arctostaphylus uva-ursi* and *Vaccinium vitis-idaea*), members of Fabaceae, among a few other species. We gave species found to have poor longevity the highest effort score.

Species were skewed towards having higher seed lot viability (Figure 5A). Over half the species had seed lot viabilities between 80 and 100%. The tree and shrub species belonging to Betulaceae had seed lot viabilities under 60%, including *Betula papyrifera*, *Betula glandulosa*, *Alnus incana* ssp. *rugosa* and *Alnus viridis* spp. *crispa*. Parasitized seeds were common for the shrubs *Physocarpus opulifoius* and *Rhamnus alnifolius*, and the herb *Thalictrum confine* and grass *Anthoxanthum nitens*, resulting in seed viabilities less than 65%. We gave species with low seed lot viabilities the highest effort score.

Only 20% of our target species do not require some pretreatment (Figure 5B), including the tree *Populus balsamifera*, the shrub *Salix pseudomonticola*, and the herbs *Prunella vulgaris*, and *Hordeum jubatum*. Twenty-six of our target species required at least a simple pretreatment of cold stratification for <90 days, including several grasses, all Betulaceae species and many Asteraceae. The remaining third of the target species required complex germination pretreatment. They included the shrubs *Viburnum edule*, *Arctostaphylus uva-ursi*, those in the families Rosaceae, Elaeagnaceae, Cupressaceae and Cornaceae, and the forbs *Maianthemum* *stellatum, Galium boreale*, *Sisyrinchum montanum* and those in Ranunculaceae and Fabaceae. None of our target tree or grass species required complex pre-treatments. We gave the highest effort score to those requiring complex pretreatments.

Finally, fifty-three out of our fifty-seven species can germinate under standard conditions after pre-treating (Figure 5C). Only four species require specific conditions. *Juniperus* spp. require temperatures lower than 15°C, and *Vaccinium vitis-idaea* and *Rhododendron groenlandicum* require high temperatures, approximately 30°C, specific light regimes, and are sensitive to substrate conditions. We gave species that require specific conditions to germinate the highest effort score.

When we considered overall scores, mean collection effort scores were roughly normally distributed, ranging from 3 to 8 (Figure 6A). Six species were easy to collect, including the herbs *Hordeum jubatum* and *Chamerion angustifolium* ssp. *angustifolium*, the shrubs *Alnus viridis* ssp. *crispa*, *Alnus incana* ssp. *rugosa* and *Rhododenron groenlandicum* and the tree *Populus balsamifera*. The species with the highest collection effort scores included the herbs *Lathyrus palustris*, *Vicia americana*, *Symphyotrichum robynsianum*, *Solidago canadensis*, and *Doellingeria umbellata* and the shrub *Juniperus communis*. Overall cleaning scores were skewed towards those requiring lower effort (Figure 6B). Those requiring the highest cleaning effort included the forb *Anemone multifida*, and the shrubs *Alnus incana* spp. *rugosa*, *Rhododendron groenlandicum* and *Dasiphora fruticosa*. For seed storage, overall scores were a result of differences in seed storage longevity for our study species, so storage effort scores were skewed towards species requiring lower effort (Figure 6C). Finally, the overall propagation effort scores were slightly skewed towards those requiring low effort (Figure 6D). The herbs *Prunella vulgaris*, *Hordeum jubatum*, *Achillea millefolium*, *Erigeron hyssopifolius* and *Bromus ciliatus,* the shrubs *Salix pseudomonticola and Dasiphora fruticosa*, and the tree *Populus balsamifera* had the lowest overall propagation effort score, while the shrubs *Juniperus* spp. and *Rhododendron groenlandicum* had the highest propagation effort scores, followed by the shrubs *Vaccinium vitis-idaea*, *Amelanchier sanguinea*, *Alnus incana* ssp. *rugosa* and *Betula glandulosa* and the herbs *Thalictrum confine*, and *Rubus pubescens*.

**Discussion**

The purpose of our study was to build a methodological approach to determine relative seed value that reflects the effort of seed collection, cleaning, storage, and propagation, and then to validate the use of these scores. Our plan was to apply these results at the Victor mine site to prioritize species based on their effort scores and to demonstrate how individual attribute scores are used for alternative planting strategies when plants have high effort scores. We have not determined actual seed prices, but we demonstrate how they can be determined using the relative values we calculated in our study.

De Beers' Victor diamond mine must actively revegetate approximately 867 hectares of the mine site, which has an upland topography and includes the camp area, roads, tailings areas of processed kimberlite, and stockpiles of waste rock and overburden (AMEC 2014). They must use native species to restore these new uplands to reflect the regionally representative upland vegetation communities, such as the forest communities that border the Attawapiskat river (AMEC 2014). They are striving to use as many locally-sourced materials as possible and have begun a seed collection program. Beginning with bare substrates the restoration goal is to promote primary succession that will lead to a representative ecosystem that is both resilient and self-sufficient in ecosystem functioning (SER International 2004) and to maximize efficiency and minimize costs where appropriate.

First, restoration managers will plant at least one common coniferous tree species, such as *Picea glauca*. *Picea glauca* is a dominant upland tree species in the region (Garrah 2013), and is suitable for growth on the upland substrate mixes. It grows slowly (Nienstaedt and Zasada 1990), so this species must be planted at an early stage of revegetation to model recovery towards the reference condition. Second, restoration managers need to prioritize nitrogen-fixing plants to restore soil fertility in severely-damaged landscapes (Zahran 1999) and promote nitrogen cycling (Rousk *et al*. 2016). Nitrogen fixers are especially important because total nitrogen in amended mine substrates is low (Hanson & Campbell, unpublished). Third, they wish to plant a variety of plant types because this contributes to biodiversity and functional diversity that is likely to promote ecosystem resilience and balance ecosystem processes such as carbon cycling (Aerts and Honnay 2011). Plant life forms are an example of plant functional types and we use them in this example to include evergreen and deciduous trees, shrubs, forbs, and grasses. Planting a diversity of species can provide "insurance" so if one species does not establish, or if environmental conditions or pests, harm a particular species, others can take on the same functional role (Lepš *et al*. 2007). Using a variety of plant functional types is one of the most effective measures to control soil erosion (Pohl *et al*. 2009, Hu *et al*. 2013). Plant type diversity also provides a variety of plant heights that will create habitat and shading to develop a range of micro-climates.We present a framework for prioritising species using our results and the above criteria. This framework enables restoration planners to select species with seeds that are relatively easy to collect, are in large quantities, easiest to identify, easiest to clean, have the best longevity, higher viability, and the simplest pre-treatment and germination requirements.

First, we refined our species list by using the collection effort scores. We used five as the upper limit, because this value represents a species with a low (two) to below moderate (six) mean effort for that category. This criterion refined our list to 21 species, but this excluded the only two legumes. Restoration planners may wish to just assume higher associated costs and effort for obtaining these species or explore alternative planting approaches by examining individual attribute values that may reduce collection effort for one of the legumes. Collection rate and median cover were low for *Vicia americana*, resulting in a high effort score. Overall, the seed of this species was easy to clean and store, but was considered relatively difficult to propagate because of complex pre-treatment requirements. Alternative approaches that reduce collection effort may include cultivation on site, starting with vegetative transplants or fertilizing existing populations (see chapter 2, Greipsson and Davy 1997, Gustafson *et al*. 2008). However, even if abundance and collection rates could be improved using these methods, seed dormancy is still a challenge and contributes to a higher effort for propagating this species. For highly desired species with high effort scores, nursery propagation of seedlings may also present an alternative and can make the most of limited or high priced seeds.

Second, we used the seed cleaning effort scores to refine our list to 15 species, which excluded three key plants, *Picea glauca, Alnus incana* ssp. *rugosa,* and *Alnus viridis* ssp. *crispa*, associated with a high seed cleaning effort. There are few alternative options to reduce seed cleaning effort, particularly if maintaining a low cost is desired. For these species the seed must be extracted from cones and catkins to be planted and further cleaning requires separation of scales and wings from the seed. However, depending on the project goal a user may wish to consider an attribute assessment that can evaluate whether a seed needs to be isolated for propagation. For instance, is there more than one seed per propagule? Are the seed appendages cumbersome making planting and storage inefficient? Does the seed coat need to be exposed for seed pre-treatment like scarification. In all cases, seed cleaning would be required. In our study, we kept this methodology broadly applicable, in which case seed cleaning is required for meeting seed quality standards (Elias *et al*. 2006) and to determine seed quantity. *Picea glauca* was not an optional species, according to our criteria and will remain in our list. However, we will look at the overall seed value to determine which of the four nitrogen fixing shrubs should be prioritized. *Alnus crispa* ssp. *viridis* and *Elaeagnus commutata* had the lowest overall scores. Both *Alnus* sp. had a high relative cleaning effort, *Alnus viridis* ssp. *crispa* had a lower collection effort and propagation effort than *Alnus rugosa* ssp. *incana*, because it was more common in plots and had higher seed viability on average. *Shepherdia canadensis* was similar to *Elaeagnus commutata* for total effort scores, but required a higher seed cleaning effort and had lower seed viability, both species had above moderate seed collection effort and high effort for seed pre-treatments.

Third, we considered storage effort. In our study, seed storage effort was only influenced by differences in seed longevity. Species with poor longevity may need to be collected and planted annually until a desired cover is achieved. *Populus balsamifera* was one of the remaining deciduous tree species in our refined list but exhibits poor seed longevity (DenHeyer and Seymour 1978). The overall seed score for this species was relatively low (3.8), therefore, *Populus balsamifera* seed should be collected in this example, but only when it can be either planted immediately or if freezers are available for long term storage (Zasada and Densmore 1980).

Finally, we considered propagation effort. Complex seed dormancies, low seed viability, and specific germination requirements could result in little to no emergence from seed propagation. Therefore, assessing propagation effort is essential to estimate the capacity of the seed and the effort required for germinating a species that will ultimately alter revegetation success and costs. For instance, *Betula glandulosa* had an average seed viability of only 14%, and consequently had a higher propagation score and therefore, was not included in our final list.

Our refined species list includes ten species with the lowest collection, cleaning, storage, and propagation effort scores. They are the shrubs *Cornus sericea* ssp. *sericea*, *Rubus ideaus* ssp. *ideaus*, *Viburnum edule* and *Physocarpus opulifolius*, the forbs *Chamerion angustifolium* ssp. *angustifolium*, *Achillea millefollium*, and *Fragaria virginiana,* the grasses *Poa palustris*, *Calamagrostis canadensis*, and *Agrostis scabra*. In addition to this list, we would select *Populus balsamifera*, *Picea glauca*, *Alnus viridis* ssp. *crispa*, *Elaeagnus commutata*, and *Vicia americana* for their restoration value, realizing they have high effort scores in at least one category. This list is an example of species that may be useful in restoration, but does not replace the need for field trials and consideration of a plant's ecological value. Restoration planners may consider additional traits when selecting suitable species for their restoration project. When restoring sites in other biomes, planners may focus on different attributes. For instance, a planner may consider the plants ability to compete against non-native species, forage value, or rooting depth/ habit when selecting species for rangelands that are subject to overgrazing (Monsen *et al*. 2002). In the canga ecosystem in northern Brazil, planners may consider the interaction or service that a plant provides, such as with pollinators and for human economic use, in addition to functional traits (Giannini *et al* 2016).

Our valuation approach was not intended to be limited to the perspectives of restoration managers in the ecological restoration of mine sites or to northern Canada. The attributes we use are simple to describe and have broad application. A novice seed collector can measure these attributes with some direction (chapter 3) but would require some basic knowledge on seed biology and an ability to identify local flora. A seed collector may disregard propagation effort (namely pre-treatment and germination requirements) when determining which species to target, because seeds will be sold prior to their propagation. They may choose first to prioritize species that are easy to identify and then refine their list of species based on effort. They may consider species with poor seed longevity, such as *Populus basamifera* and *Salix pseudomonticola* only if they have found a committed buyer before collecting their seed. Seed collection rates and seed viability can only be determined when seeds are mature, but can be collected in the form of small samples. Most other attribute values can be determined from the literature before the collection season begins. The most challenging attribute assessments we included in our valuation approach were determining seed purity and viability, but resources are available for learning these skills (chapter 3). Alternatively, although costly, seed samples can be sent to a seed laboratory until the collector gains experience and the equipment necessary for performing these assessments. People that are collecting seed on only one occasion or for a small scale project will find this approach is too comprehensive for assessing seed value to prioritize species, but may find it useful to determine seed prices.

A seed collector will more likely be contracted or will collect seeds from species they know are in demand. There are no current guidelines and a limited commercial market in which to model prices for native, wild seed. A collector could use our valuation approach to determine seed prices. Attributes can be assessed during collection. Do Espírito Santo *et al*. (2010) determined a correction factor by dividing a fair market price for one of their study species by their calculated relative value of the same species. They then multiplied the correction factor by the relative values for all species's seed to determine the seed prices. A similar strategy could be applied that uses our approach to determine relative values, adjusted using an existing seed price. Although we have no local pricing with which to compare our seed values, one could look at prices of Ontario's trees or shrubs available from <https://www.ontario.ca/page/buy-ontario-tree-seeds-or-cones#section-2>. One could select corresponding species and compare their price with our relative value to determine a correction factor. The above website is the only listing we found that represents competitive prices for cleaned seed of common trees and some shrubs in quantity. Other native plant suppliers can be found in southern Ontario, but either offer native seeds in small quantities (eg. packets of 250 seeds) or on a contract basis so we cannot compare our relative values with these sources. Alternatively if there is no seed price available that is appropriate for comparison, a species with a low effort score in all categories could be used to set a base price by considering the time required for the collection and cleaning of x amount of seed. The price would be set to ensure the collector receives at least a minimum wage and this could be used to determine a correction factor as described above. Some people may suggest simplifying the valuation system to include only attributes that have an immediate impact on a collector's time, this would include collection rate and cleaning effort in particular. However, additional attributes such as collection obstacles that affect the comfort of the collector, or specialized equipment for harvesting, or regional variations on seed abundance and quality should also influence the price of that seed. The attributes and relative scoring proposed in this study considers these additional influences on seed value. Regional plant abundance is important when the collections being made are large and seed sources from smaller or local populations are depleted or if a species has a poor seed crop one year. In addition, seed purity, storage effort, and seed viability will affect how much seed a collector must collect to reach a certain quantity of pure live seed. However, it may be up to the user to modify the weight of the attributes that influence seed value. For example: Is the collection rate attribute as equally important as cleaning effort or seed longevity to seed value? For a seed collector that must sell clean and viable seed of a known quantity we believe the answer is yes, however, in this example of mine site revegetation, if seed is immediately planted, seed collection rates may be the more important attribute to determine seed value.

Our valuation approach can be applied to a large variety of projects and locations for seed pricing. And additional measures of value can be added depending on each specific project. Unlike some attributes outlined in the Brazilian study (Do Espírito Santo *et al*. 2010), we did not include a component of market demand or restoration value in our approach, because these attributes are highly specific to the site and type of disturbance that requires restoration. We presented an example of this earlier where a greater importance was given to legumes and other species because of the project goals. This valuation system was designed so it was not only informative for the ecological restoration of mine sites but for any reason wild seed collection is undertaken. Native seeds are collected for a variety of purposes, such as urban or coastal restoration (Gustafson *et al*. 2008) that may place a demand on seed from species with showy flowers or medicinal plants. Roadside revegetation projects may prioritize species that tolerate drought and road salts (Mallik and Karim 2008). Furthermore, the creation of wetland habitat for wildlife will place different priorities on species selection than if the wetland is being created to treat waste water. Although less fitting, the attributes from the seed collection category can even be applied to valuate seed products for medicine or berries as a food source, where pricing is currently based on demand and the quantity sold rather than the effort required by the collector or the commonness of the plant (Botha *et al*. 2007).

Our approach can be applied in many locations, not just in northern Canada. Different regions may wish to modify the way we scored our attributes. For instance seed storage behaviour in our study did not influence seed value; however, seed recalcitrance is more common in tropical environments and has more of a range in sensitivity (Hong *et al*. 1996). In other regions seed pre-treatments may be different or more complex and require further division of this attribute for a more accurate scoring relative to the variety of species in the region.

Our approach is highly applicable in remote locations where cultivation of these species is not possible and wild plants are the only appropriate seed source. But we also argue this method can be used by existing businesses that undertake contract seed collection, regardless of whether seeds are collected from the wild or cultivated. Cultivating seed will make a species more abundant, increase collection rates, and likely eliminate some collection obstacles, but all these changes are reflected in our approach to determine the seed value. If costly equipment then gets introduced, this will need to be considered in addition to our pricing method.

The demand for native seed is increasing. Our current valuation system provides a strong foundation for others to build upon or modify depending on the user, project purpose, or region. Until this approach was developed, there was a lack of a systematic method that could be applied broadly for native seed valuation. This approach to determine relative seed effort scores, has a place in revegetation planning. We have demonstrated its application for prioritizing species at the Victor mine site and the potential for broader applications to determine fair seed pricing.

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## Tables and Figures

Table 1. Seed valuation categories and attributes, with the data source and the direction of relative scoring for each attribute.

| Category | Attribute | Data source | Relative scoring | |
|---|---|---|---|---|
| | | | high | low |
| Collection | Regional distribution (% presence in plots) | field | rare | common |
| | Median cover (%) | field | low | high |
| | Seed collection rate (seeds $hr^{-1}$) | field | low | high |
| | Identification effort | questionnaires | difficult | easy |
| | Collection obstacles | questionnaires | >2 | 0 |
| Cleaning | Cleaning effort (steps and equipment needs) | lab | many | few |
| | Purity (% pure seed in seed lot) | lab | low | high |
| Storage | Storage behaviour | literature | difficult | easy |
| | Longevity | literature | short | long |
| Propagation | Viability (% viable out of total) | lab | low | high |
| | Pre-treatments | literature | complex | simple |
| | Germination conditions | literature | specific | standard |

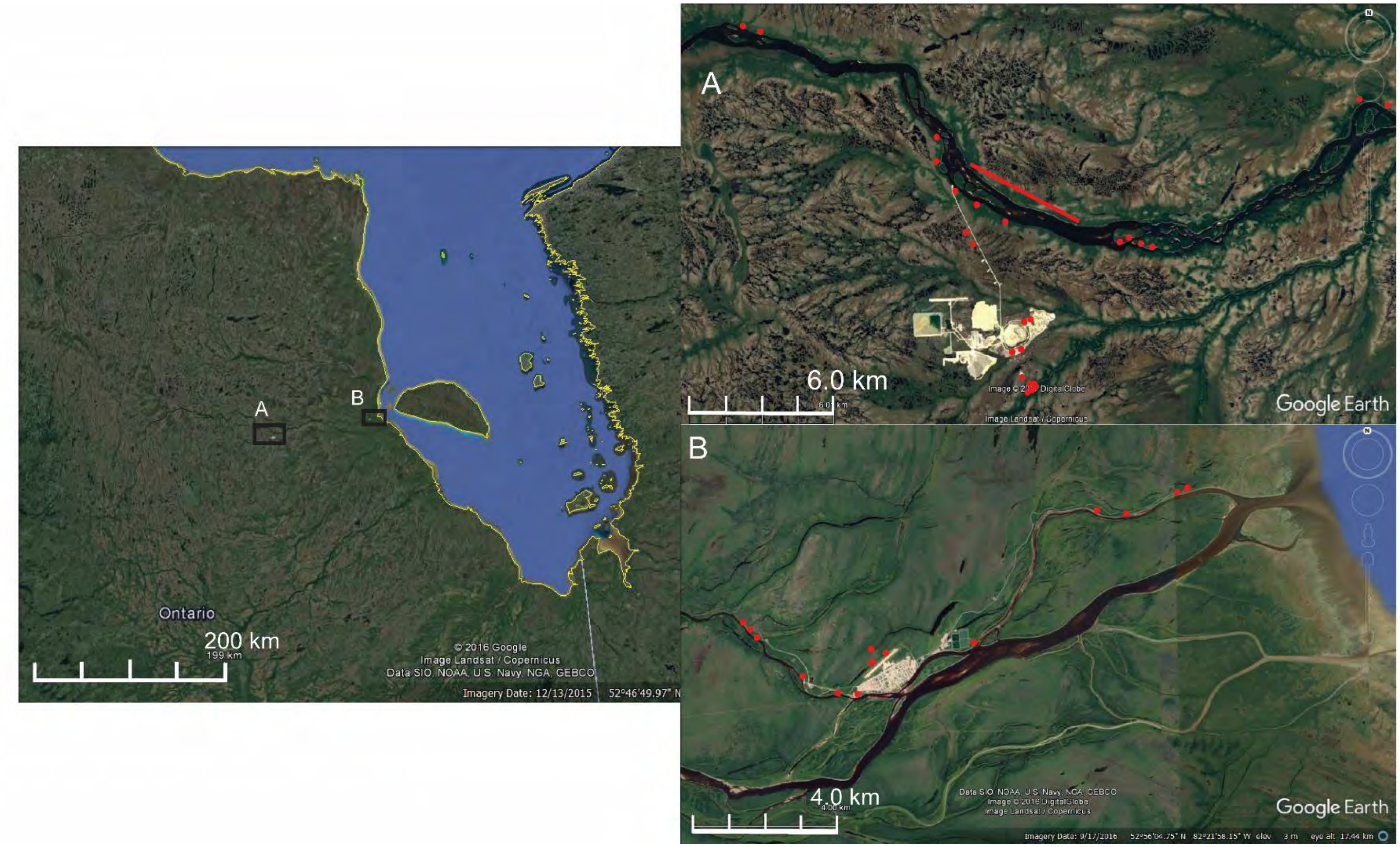


Figure 1. Locations of field sites in Ontario; source: Google Earth (Image date: December 13, 2015). Data SIO, NOAA, U.S Navy, GEBCO. Image NOAA, Image Digital Globe 2016, Image Landsat/ Copernicus. [February 23, 2017]. **Inset photo A)** Site map of Victor mine site, red marks indicate site locations. Source: Google Earth (Image date: July 6, 2013). Image Digital Globe 2016, Image Landsat/ Copernicus. [February 23, 2017]. **Inset photo B)** Site map of Attawapiskat First Nation, red marks indicate site locations. Source: Google Earth (Image date: September 17, 2016). Data SIO, NOAA, U.S Navy, GEBCO. Image Digital Globe 2016, Image Landsat/ Copernicus. [February 23, 2017].

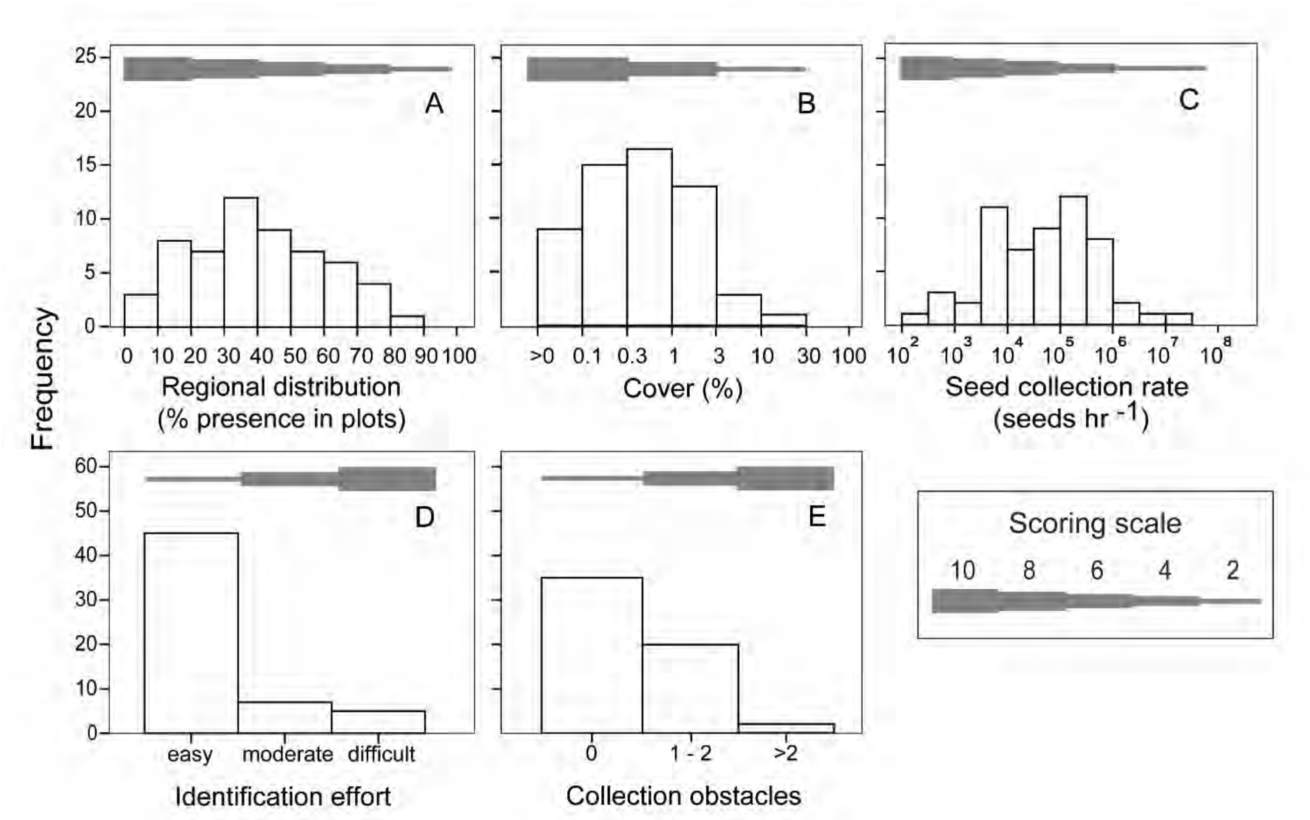


Figure 2. Frequency distributions for the five attributes that represent seed collection effort, including A) species regional distribution B) median cover, C) seed collection rate, D) identification effort, and E) collection obstacles ($n$ = 57). The gray bars above each panel show the relative effort score attributed to each frequency distribution, ranging from 2 to 10 across the range of the data. The scoring scale is shown to the right.

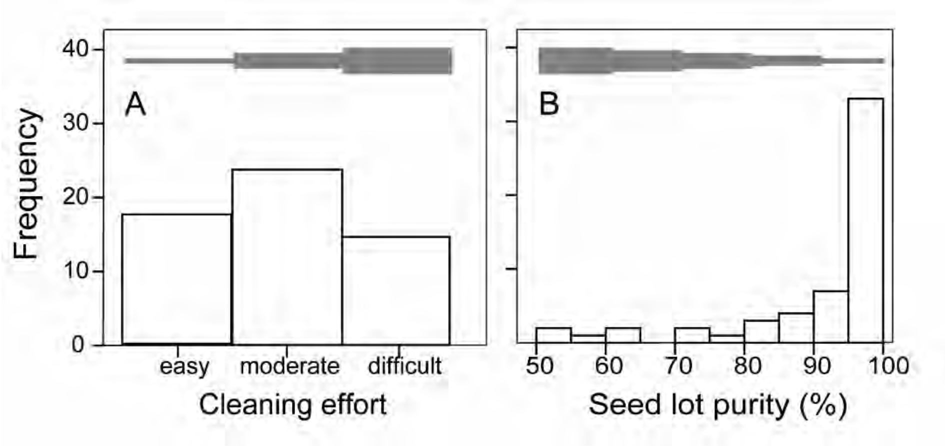


Figure 3. Frequency distributions for two attributes that represent seed processing effort, including A) cleaning effort (number of steps required to clean seeds and the amount of equipment required) and B) mean seed lot purity based on our seed collections (*n* = 57). The gray bars above each panel show the relative effort score attributed to each frequency distribution (see Figure 2).

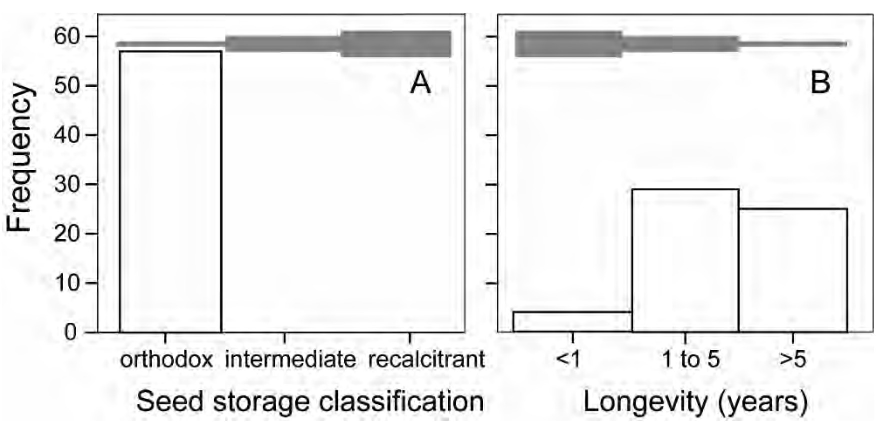


Figure 4. Frequency distributions of attributes representing seed storage effort, including A) seed storage behaviour classification and B) seed longevity (*n* = 57). The gray bars above each panel show the relative effort score attributed to each frequency distribution (see Figure 2).

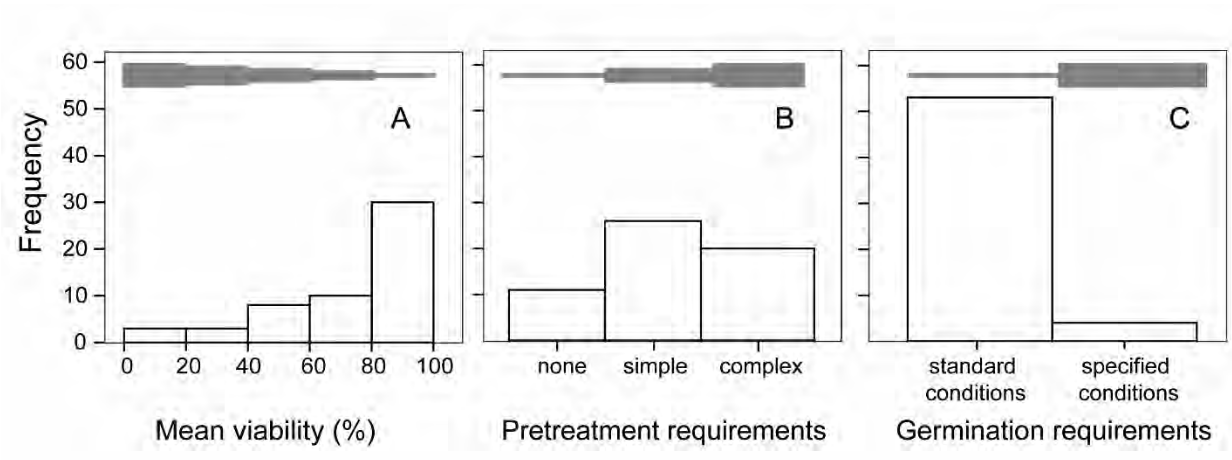


Figure 5. Frequency distributions representing seed propagation effort, including: A) average seed viability, B) pre-treatment requirements, and C) germination requirements ($n$ = 57). The gray bars above each panel show the relative effort score attributed to each frequency distribution (see Figure 2).

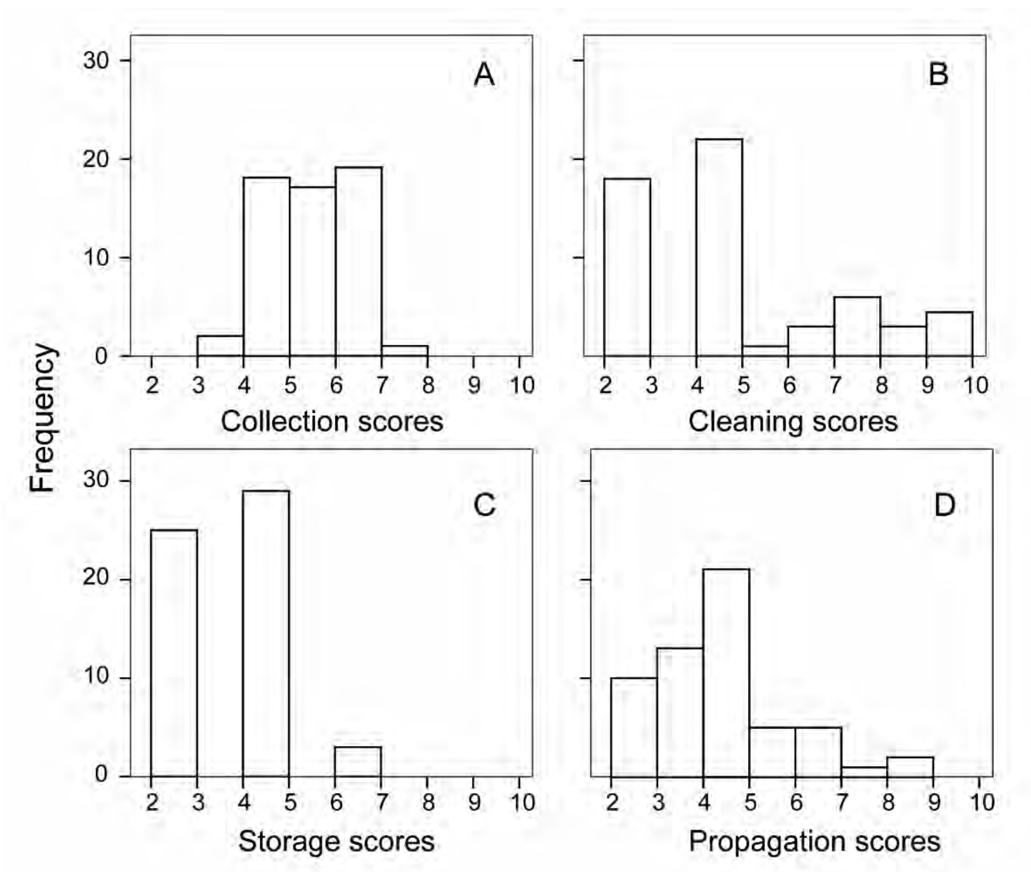


Figure 6. Frequency distributions of mean effort scores for four categories including, A) collection effort, B) cleaning effort, C) storage effort, and D) propagation effort ($n$ = 57).

## Chapter 2: Can fertilizers increase the seed yield of two native herb species in the subarctic? Implications for wild seed collection

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Key words: Seed collection, fertilizer, alkaline soil, seed yield, nutrient limiting, subarctic, native plant, *Vicia americana*, *Potentilla anserina*.

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**Abstract**

Native seed is collected from the wild for ecological restoration purposes when local commercial seed sources are unavailable. However, what if wild seed sources have low seed outputs? We wanted to determine if we could increase the seed yield of wild silverweed (*Potentilla anserina*) and the legume American vetch (*Vicia americana*) using fertilizers. Both species may be useful in restoration of damaged landscapes, but both have limited seed output in the subarctic. For two seasons we applied treatments to silverweed plots, NPK fertilizer and a control (water-only) and treated American vetch with three treatments, NPK, PK, and a control (water-only). Fertilization had little effect on silverweed plant density and flowering. No silverweed plot, regardless of treatment produced seed. NPK fertilization increased American vetch plant density, but overall flowering was minimal and only one plot produced seed. We were unable to conclude what caused such low seed output for both species. We recommend that future studies need to identify populations of species that have at least some seed output in case site characteristics, such as soil conditions, limit fertilizer affects. Ultimately, cultivation of sub-arctic seed sources in a more temperate environment or use of non-local seed sources may be required.

## Introduction

Seed from native plants is increasingly used in ecological restoration to rehabilitate habitats for species at risk, roadsides and mine sites (Riley *et al*. 2004, Haan *et al*. 2012, Naeth and Wilkinson 2014). Seed of desired species is sometimes collected from the wild because of the importance of using local provenance and also because commercial sources are lacking (Riley *et al*. 2004, Smith *et al*. 2007, Vander Mijnsbrugge *et al*. 2010). However, wild seed yields can be low, making the collection of desired species difficult. For instance, the De Beers Victor mine in north-central Canada began a wild seed collection program in 2014 to obtain seeds for their revegetation efforts. They were able to collect a diversity of native species, but seed output for several species was quite low. We asked whether we could increase the seed yield of wild plant populations to collect their seed more efficiently for restoration purposes.

Low seed yields can be a result of (i) pollen limitations (from incompatible pollen) and pollinator scarcities (Burd 1994), especially for self-incompatible species (Burd 1994, Ashman *et al*. 2004); and (ii) resource limitations, such as light, water and nutrients (Stephenson 1981). The discussion on these limiting factors is extensive and remains an ongoing debate (Campbell and Halama 1993, Ashman *et al*. 2004, Knight *et al*. 2005).The issue is complicated by the reproductive strategy of species. Annuals can allocate resources to seed reproduction, even when resources are limited, whereas perennials can prioritize mother plant fitness when resources are scarce (Wilson and Thompson 1989, Obeso 2002, Akhalkatsi and Lösch 2005) and reproduce by both asexual and sexual means (Philipp *et al*. 1996, Eckert 2002).

Pollen limitations can cause low seed output in both agricultural and natural environments (Burd 1994, Ashman *et al*. 2004), including northern biomes (Eriksson 1987, Philipp *et al*. 1996). The poor seed set in northern environments is partly linked to abiotic factors such as cold climates that reduce pollen quantity (Weis and Hermanutz 1993) and also reduce pollinator abundance (Gugerli 1997). However, pollen limitations in northern environments may be difficult for managers to circumvent if the goal is to increase seed set.

Resources that limit seed production, such as light, water and nutrients, may be more easily manipulated. In northern environments, phosphorus and nitrogen are the most commonly limiting nutrients to plant growth (Shaver and Chapin 1995, Weintraub 2011, Maslov and Makarov 2016). To demonstrate nutrient limitations, researchers have added fertilizers to view changes in community productivity, shifts in plant functional type, and nutrient allocation to vegetative structures (Shaver and Chapin 1986, Parsons *et al*. 1994, Madan *et al*. 2007). Fewer studies have measured changes in either seed or flowering output at the species level in boreal and arctic climates and for those that have, responses have been variable and species-specific (Shaver and Chapin 1995, Philipp *et al*. 1996, Grainger and Turkington 2013, Petraglia *et al*. 2013, Thorpe *et al*. 2013). In the light of existing literature we posed the question as to whether fertilizer addition over two growing seasons could increase the seed yields for desired species in a natural subarctic ecosystem.

We selected two self-incompatible, perennial herbs to study: silverweed (*Potentilla anserina* L.), a good potential ground cover (Figure 1), and American vetch (*Vicia americana* Muhl. ex Willd.), one of the few N-fixing legumes encountered in the region (Figure 2), although we observed little nodulation in this species in 2014 prior to the experiment. Eriksson (1987) found that nutrient additions increased the number of ovules per flower in silverweed, but did not increase seed yield or stamen abundance. To our knowledge, no studies have described the effect of fertilizers on wild populations of American vetch. We hypothesized that fertilization would increase flowering, seed set, and total seed yield after two seasons in silverweed and American vetch. In addition, we investigated the requirement for nitrogen fertilization in the legume American vetch by using both PK and NPK fertilizer treatments.

## Methods

We conducted our study along a 1.5 km south-facing section of the upper floodplain of the Attawapiskat River, in the Hudson Bay Lowlands in north-central Canada (52°52'51” N, 083°54'53” W, 83m elevation). During spring melt, ice blocks annually disturb the upper floodplain, creating conditions for only pioneers herbs and small shrub vegetation to establish. The substrate has calcareous, poorly-developed soils, with alkaline pH (range: 8.0 to 8.5), a silt to silty loam texture and high stoniness in some plots. Organic layer development was minimal, typically 0cm up to 2cm in some patches with less disturbance from ice scouring. Prior soil analyses revealed low total N and bioavailable P within primary rooting zones (median total N: 6 mg $g^{-1}$; median $LiNO_3$-extractable P: 0.28 µg $g^{-1}$; Garrah 2013). The mean annual temperature for 2015 and 2016 was -0.15°C (January mean: - 22.2°C and July mean: 17.7°C) at Lansdowne House (approximately 280 km SW; http://climate.weather.gc.ca/). Mean precipitation at Landsdowne House during the growing season (May through September) was 443 mm in 2015 and 305 mm in 2016, with notably high river water levels in the fall of 2015.

Both silverweed and American vetch are frequent in the region (Riley 2003), occurring on open sites in the floodplain of the Attawapiskat River, commonly seen flowering but with low seed output. Silverweed is a widely-distributed stoloniferous herb, that tolerates a variety of substrates from mudflats to rocky outcrops and disturbed habitats like roadsides and alkaline or saline soils (Miyanishi *et al*. 1991). American vetch is a rhizomatous herb, that is drought-tolerant and has been used as a cover crop for introducing soil nitrogen in a variety of restoration projects (Kirk and Belt 2010, Allen and Tilly 2015), growing in a variety of habitats from forest understories (Pengelly and Cartar 2011) to open clearings (Allen and Tilly 2015). Both species are self-incompatible (Gunn and Kluve 1976, Miyanishi *et al*. 1991). Silverweed is pollinated by insects (Eriksson 1987) whereas American vetch has a stigmatic membrane and must be visited by specific pollinators that can puncture this membrane, for fertilization to occur (Gunn and Kluve 1976).

In early June 2015, we set up ten blocks of $1m^2$ plots along the river floodplain, containing a minimum of one plant of either American vetch or silverweed. We made some initial effort to ensure the number of plants per plot and plant size was similar within a block. American vetch plots occur further up slope than silverweed plots. We applied two treatments for silverweed (control and NPK) and three for American vetch (control, PK and NPK). We applied urea [$CO(NH_2)_2$] for N, superphosphate [$Ca(H_2PO_4)_2$] for P, and potash [KCl (95%) NaCl (5%)] for K. We applied fertilizers in June 2015 and again in June 2016 at a rate of 8.7 g $m^{-2}$ urea, 45.82 g $m^{-2}$ superphosphate, and 8.04 g $m^{-2}$ potash, contributing 4 g $m^{-2}$ for each N, P, and K. Fertilizer rates in the literature are highly variable, with positive results in alkaline soils ranging from 0.5 g $m^{-2}$ to 50 g $m^{-2}$ (Greipsson and Davy 1997, Bolland *et al*. 1999, 2000, Holloway *et al*. 2001, Madan *et al.* 2007), so we chose an intermediate fertilization level. We evenly watered all plots with 3L immediately following fertilizer application.

In August 2016, we assessed each plot for i) number of plants per plot (we considered a daughter ramet as a separate plant if it was anchored to the soil by roots), ii) the number of flowers per plant, and iii) the number of flowers per plot. We documented inflorescences of plants, if flowers had abscised. Given the non-normal distributions of the results, we tested for significant differences among treatments for each dependent variable using a permutation test with 10,000 random shuffles, using Resampling Stats® software. For silverweed, we resampled the difference between the two treatment means, and for American vetch with three treatments, we resampled the F statistic and then the pairwise difference in the three means. We used a 5% Type I error rate, but we also considered borderline results below a 10% Type I error rate.

**Results**

For silverweed, we found no significant differences between treatments in the total number of plants per plot (*P* = 0.28; Figure 3a), but we found a borderline difference in the total number of flowers per plot (*P* = 0.08; Figure 3b). Unfertilized plots had a mean of only 1.3 flowers per plot, versus 5.4 flowers per plot for fertilized plots. The mean number of flowers per plant was the same between the treatments (*P* = 0.16), but when we combined the data on flowers per plant across all plants and plots, unfertilized plots had a much lower frequency of flowers per plant than fertilized plots (*P* = 0.0008; Figure 4), with a mean of 0.13 (max. 2) versus 0.34 (max. 3), respectively. However, none of the silverweed plots produced any seed and we found no immature seed or developing seed.

For American vetch, we found a borderline difference in the number of plants per plot among the three treatments (*P* = 0.068; Figure 3c), with significantly more plants in the NPK than in the control treatment (*P* = 0.025). The PK treatment was intermediate and not significantly different from the control (*P* = 0.2328) and a borderline difference from the NPK (*P* = 0.0595) treatment. Only three of all the American vetch plots produced flowers, so there were insufficient numbers of flowers per plot to observe differences among the fertilizer treatments (*P* = 0.28; Figure 3d). In two of these plots, the flowers were either deteriorating or the flowers had abscised, with only the inflorescence stalks remaining. Only one American vetch plot produced seed. American vetch plant sizes were highly variable between plots, as well as the density of other species in the plots. Leaf herbivory was common on vetch plants, but not to the extent of complete defoliation for any plant.

**Discussion**

The purpose of this experiment was to increase the seed yield of two wild species using fertilizers. We were not able to conclude that fertilization increases seed output, nor were we able to conclude whether NPK or just PK fertilization was superior. We did not expect negative results from this experiment. Our discussion is focused on the investigation of potential causes for sustained limitations to seed production in these two species and the implications for future studies.

We observed productive plants outside of our experiment, within 5 km of our fertilized plots. We examined differences between sites that provided insight into our results. Although climate commonly causes a reduction in sexual reproduction for perennial angiosperms (Eckert 2002, Grainger and Turkington 2013, Straka and Starzomski 2015), we have observed seed production in nearby sites for both these species and therefore, we cannot use climate to explain our results entirely.

Overall, we had high variability in silverweed plant density and total flowers per plot which led to low experimental power in our analyses and yielded non-significant trends. Plant density was highly variable between plots and likely accounted for overall variability in the total number of flowers per plot, because overall trends, although not significant, were similar for both total number of plants and total number of flowers per plot. In addition, a large number of plants produced no flowers and contributed to the skewed flowering results. Unfertilized silverweed plots overall had a higher frequency of plants with zero flowers compared to fertilized plots that more frequently produced plants with flowers. Increased flowering frequency was likely a response to fertilizers. However, none of these flowers set seed which was the goal of our experiment. Silverweed seed production was shown to be pollen limited rather than nutrient limited in a Sweden population (Eriksson 1987), but this result was likely spatial or temporal rather than consistent at the species level. Their control plot however, still produced a mean of 9.5 seeds per flower with only 17 to 19% of flowers producing no fruit. Where we found silverweed plants producing seeds outside our experimental plots, soils were sandy or sandy loam and plant densities were observably higher (Figure 1). In our plots, soils were often a fine silty texture, associated with poorer drainage. Miyanishi *et al.* (1991) also found silverweed plant density decreased as soil moisture increased. In our experimental plots, ramet density was much lower (2 to 35 ramets $m^{-2}$) than the 53 to 575 ramets $m^{-2}$ reported by Eriksson (1986). Low plant density can reduce the number of compatible pollen sources and decrease pollinator attraction (Ashman *et al*. 2004, Waites and Ågren 2004). Furthermore, silverweed commonly undergoes clonal reproduction, therefore possible high rates of geitonogamous pollen sources could have further limited successful pollination within this population. Both pollen quantity and quality was limiting to dwarf birch seed production at the northern limit of its range (Weis and Hermanutz 1993). Poor seed set in this population of silverweed may have been a result of severe pollen limitations. However, we cannot rule out persistent nutrient deficiencies as the cause for absent seed set without further investigation.

Unfertilized American vetch plots had a lower plant density than NPK fertilized plots. The higher density of plants in NPK fertilized plots was likely a result of asexual reproduction by rhizomes, rather than germination of new seedlings. Plant density in control plots was not significantly different from plots fertilized with PK. PK fertilization however, may have caused other unmeasured effects. When nutrients have been consistently limiting, allocation of newly introduced nutrients might go to improving aspects of plant fitness before sexual reproduction. This is a common trade-off allocation strategy among perennial plants (Bazzaz *et al*. 1987, Wilson and Thompson 1989, Obeso 2002). In legumes such as American vetch, nitrogen fixation requires a fairly high phosphorus investment for both nodule formation and the fixation process (Graham 1992), in which case nutrient investments may have been allocated to other plant organs. In another northern ecosystem study, fertilization with NPK had a species specific response and caused an increase in vegetative cover in the perennial herb *Mertensia paniculata* but did not alter this species sexual reproductive output (Grainger and Turkington 2013).

Only three American vetch plots had evidence of flowering, and only one plot had plants which set seed. In general, possible explanations for low floral production include; unfavourable annual weather such as a late frost, plant age or size (Obeso 2002, Akhalkatsi and Lösch 2005), insect herbivory to flowers (Spira and Pollak 1986), resource limitations including water (Akhalkatsi and Lösch 2005) and nutrients (Campbell and Halama 1993). We do not suspect weather events caused poor floral production because we found some reproductive individuals outside of our experimental plots. Many American vetch plants within our plots had evidence of leaf herbivory, which may indicate that the flowers were also heavily predated prior to site assessments, but we did not find evidence of flower herbivory in particular. We believe that low flower production in our American vetch plots may have been due to sustained nutrient limitations. The only American vetch plot that was found producing seed within our study area was found growing adjacent to a drainage area among speckled alder (*Alnus incana* ssp. *rugosa*) and was observably larger than others (Figure 2). In some of our plots, plants were small and this may have led to the allocation of any available nutrients to vegetative rather than sexual resources (Obeso 2002). Reproductive success is positively correlated with plant size, intra-specifically for other species including members of Fabaceae (Lawrence 1993, Frazee and Marquis 1994, Ollerton and Lack 1998). We found seed producing American vetch plants outside our experiment that were observably larger than many plants within our plots. They were growing among Alder shrubs (primarily *Alnus viridis* ssp. *crispa* or *Alnus incana* ssp. *rugosa*). Alder shrubs are capable of nitrogen fixation and they may create a suitable microenvironment for American vetch. They allow plants to climb and reach a larger size, offer root protection during annual ice break up, and increase nutrient supply. Co-planting with Alders has been studied in agroforesty systems and has significantly increased pod production in cardamom and N and P concentrations in plant tissues (Sharma *et al*. 1994).

Furthermore, Shaver and Chapin (1995) found fertilizer applications only impacted the amount of flowering after three years of application in an Alaskan sedge community. In addition to the short timeframe of our study, cool climate and soil pH contributes to rapid fixation of added nutrients, especially phosphorus (Hinsinger 2001, Weintraub 2011, Vincent *et al*. 2014), further limiting nutrient availability. Given these factors, fertilizer rates may have been too low to see a significant change in sexual reproduction after only two seasons, in either species.

Although, our observations may suggest that increasing fertilizer rates would have affected our results, it is difficult to predict the possible outcomes of increasing fertilizer rates. Fertilizing natural populations, has not always had a desired or expected result. Several studies have reported an increase in vegetative biomass rather than allocation of nutrients to sexual resources and increased competition from surrounding species, or even a shift to more competitive plants (Daws *et al*. 2013, Petraglia *et al*. 2013, Mauchamp *et al*. 2016), even after only three years (Schmitz *et al*. 2014). Further research should consider using different fertilizer rates to determine their effect on seed yield and changes to plant abundance in a natural environment. A study on *Leymus arenarius* grass emphasized the interaction between fertilizers and the health of their targeted populations (Greipsson and Davy 1997). They identified the best fertilizers and rates to increase the seed yield of this species, except in moribund or late-successional populations, where fertilizer applications were ineffective or reduced the abundance of the target species plants.

Although further, more comprehensive, studies would help reveal underlying limitations to seed production, it takes considerable effort and is not always realistic for a project where the goal is to increase seed yield non-destructively and quickly. Furthermore, manipulation of the natural environment is not always practical. For instance, if pollen is a limiting factor to silverweed seed set in certain populations, is it efficient to hand-pollinate individual flowers of silverweed? Or possible to increase pollinator frequency in the short term? Therefore, while identifying these interactions may reveal reproductive limitations, from a practical standpoint, manipulating such conditions may not be the best solution. It may be beneficial to increase plot area to include a variety of environments knowing that environmental interactions can influence reproductive success for these species and may help to determine which environments will yield desired results so they can be targeted. If seed production is totally absent in a natural area, then environmental factors that are difficult or impossible to manipulate, at least in a short-time frame, may limit the enhancement effect from fertilizers and, in turn, limit the use of a particular species in reclamation.

Findings from our study emphasize the influence of environment and population on plant responses to fertilization. Ultimately, using fertilizers to increase seed yield in a natural population may not always be possible. Cultivation of desired species in a more favourable environment and climate or using alternative sources of seed or vegetative propagules may be required, despite the increased efforts or ecological downfalls associated with these alternate approaches.

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Figure 1. Silverweed population found producing seed outside experimental area. The inset shows the capsules with ripe seed. Silverweed spreads via stolons and may be a valuable species for restoration on sandier soils.

Figure 2. American vetch developing seed with an inset of the flower. American vetch is one of the few common N-fixing legumes in the region.

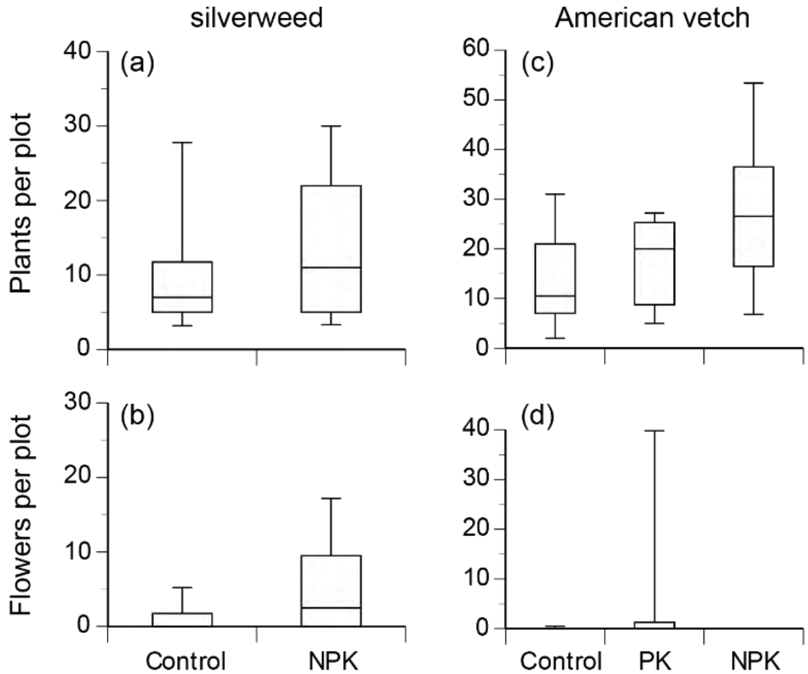


Figure 3. Box plots of the total numbers of (a) plants per plot and (b) flowers per plot for silverweed and (c) plants per plot and (d) flowers per plot for American vetch.

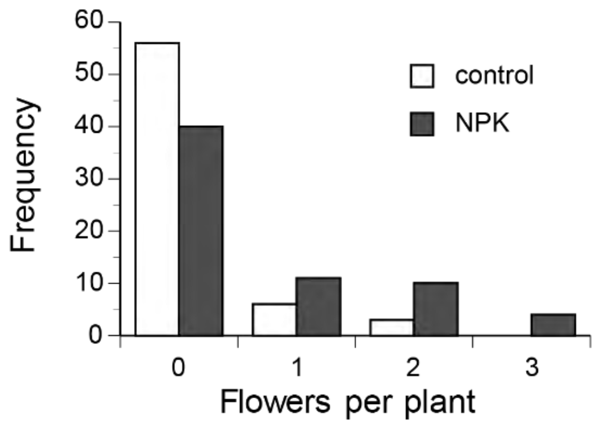


Figure 4. Frequency of the number of flowers per ramet for silverweed between unfertilized and fertilized plots.

# Chapter 3: Simple protocols for the harvesting, processing, storage and propagation of wild seed native to northeastern Canada

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## Summary

### Who can benefit from this guide

- Restoration planners, including mining, government, and consultants
- Seed collectors
- Nursery operators
- Horticulturalists, landscapers, or gardeners
- Remote communities, First nation communities

### When to collect seed

- Collect seed if it easily detaches from the plant.
- Look for a colour change from green to yellow or tan (usually colourful for berries).
- If only half the fruit/seed is ripe, clip the stem or branch allowing further ripening.

### How to collect

- Use a collection container that will allow you to have both hands free to collect, if you need to move frequently make sure your container moves with you. If you are stationary because there are so many seeds, consider either laying out a tarp, or using large paper bags, if your collections are bulky.
- Simple tools like scissors (for herbaceous plants), a berry scoop and a pole with a hook (for taller shrubs or short trees) will improve collection efficiency.

### Post harvest

- Many seeds should be dried after their collection to prolong their life, however certain types of seed will die if dried. Find out what type of seed you have at: (http://data.kew.org/sid/).
- For orthodox seed (seed that can be dried and cooled without damage), place berries in a refrigerator until they can be processed. Place other plant material out to dry on trays. The material is ready to process when the seeds can be easily pulled from the plant or capsules have opened to release the seed.

### Seed processing

- Herbaceous plants and large seeded berries can be threshed.
- Berries can be processed in a blender with water.
- Seeds with long hairs may require forced air to separate their seed, this can be accomplished with a shop vacuum.

- Cones will need to be heated for their scales to open. They can then be tumbled and shaken to separate the seed.
- Seeds can then be cleaned by sieving (separate by size), winnowing (separate by weight), or floatation.

**Seed storage**

- If you are planning to grow your seed within one season, skip seed storage and learn about your species pre-treatment requirements.
- Orthodox seed needs to be dry and stored in a cool space to maintain viability for 2 to 5 years.
- Special storage considerations are required for willows and poplars and for intermediate and recalcitrant seed; refer to Seed storage protocols below for more information.

**Seed pre-treatment and germination**

- Many native species need some seed treatment before they are planted or they will not germinate. This is a result of seed dormancy.
- Pre-treatments vary by species and genus. In our region, the most common pre-treatments are: cool stratification, warm stratification, scarification of the seed coat or leaching of germination inhibitors and may include a combination of these techniques. Seeds need adequate moisture to germinate. They vary somewhat in their preference for temperature light, and soil conditions.

## Introduction

Over the past 20 years there has been an increased demand for native plant materials to restore disturbed ecosystems. Parallel with this demand, restoration managers desire more control over seed source and provenance[1], so that the seed is appropriately matched to soil and climate conditions of the site under restoration (Millar *et al*. 2008). Commercial production of native seeds has not met the market demands (Jones 1997), and many species remain unavailable in sufficient quantity or from an appropriate origin, especially in more remote regions. In response, several industries and government agencies have begun collecting their own seed for restoration purposes.

The seed collection and cleaning process varies widely among species due to the large variety of fruit and seed types (Figure 1). Species also differ widely in their storage and propagation requirements. Some literature has been published on native plant collection, but is more focused on their propagation. Native plant collection and propagation books include: “Collecting, processing and germinating seeds of wildland plants” (Young and Young 1986), “Growing and propagating wild flowers” a book on wildflower collection and propagation (Phillips 1985), and “Seeds of woody plants in North America” that focuses on woody plant propagation (Young and Young 1992). Other seed collection and propagation guides exist for western Canada in the Alberta oil sands (Smreciu *et al*. 2013) and for British Columbia (Banerjee *et al*. 2001, Burton and Burton 2003). More recently a database has been created to host propagation protocols of native plants in North America. Although the focus is on nursery propagation, some of the users describe seed collection and cleaning protocols (found at https://npn.rngr.net/propagation/protocols). We do not know of any guides on how to collect, process, store, and grow native species specific to eastern Canada. We performed our own field investigations on seed collection in support of ecological restoration in subarctic eastern Canada. We gathered data and ideas from books, literature and online databases, and after making many mistakes, we saw the need to compile a regional guide with simple yet detailed protocols on wild seed collection and processing. The simple techniques we have compiled will improve the success of collecting and growing native wild plants from seed. These protocols can be used as a foundation for the development of small seed collection businesses and for ecological restoration projects that require the use of local native plants. Seeds are also collected for propagating plants used for medicine, traditional use, and for food. Gardeners may also find these protocols useful for gardening with native plants.

We aimed to provide protocols for the beginner practitioner. We had five main goals. (1) To describe in detail but in plain language how to collect, process and store wild seed native to subarctic northeastern Canada. (2) Protocols that are straightforward to execute, requiring equipment that is readily available in most households or at low cost (<$500 CAN). (3) To test these protocols in the field and to report on successes and failures. (4) To review relevant aspects of the propagation of wild seed, through a review of the literature. (5) To expand from these generalizations and provide detailed species-specific protocols for a subset of species in this region. Specifically, we summarize here detailed protocols for 60 species potentially useful for the restoration of mine sites in the subarctic of Canada (Species list: **Table 1**; Species level protocols: Appendix B2). Someone may wish to apply these protocols to the cultivation of these or similar species, however we developed and tested protocols with wild collection in mind. A summary of the collection, cleaning, and pre-treatment protocols can be found in **Table 2**.

We developed and tested these seed protocols in the summer and fall of 2014 and 2016 in the area surrounding De Beers Victor mine (52°49'N, 83°53'W, 83m elevation) and 90 km east in



[1] All underlined words are defined in the glossary.

the Attawapiskat First Nation community (52°55'N, 82°26'W, 5m elevation) in the Far North of Ontario, Canada. Both sites are in the Hudson Bay Lowlands and have a subarctic climate.

Most of our seed collection took place along the Attawapiskat River shores, where every year large sheets of ice scrape the soil surfaces. We were interested in species that could grow on these exposed, well drained soils and in full sunlight, because these are the types of environmental conditions that plants will need to tolerate to grow on the mine waste soils (Figure 1). We also collected seed from areas that were previously disturbed by people. These areas and those of recent fires often provide excellent sources for seed collection (Young and Young 1986).


Figure 1. (A) A section of our 2014 and 2016 collection site along the Attawapiskat River shore; (B) An area of recent soil disturbance along the river shoreline with emerging vegetation.

There are five important questions to answer when planning to harvest seeds. 1) When do I collect their seed? 2) How do I collect their seed? 3) What do I do with the seed after I have collected it? 4) How do I process and clean seed? 5) How do I store this seed? When you are ready to grow this seed then you must consider two more main questions. 1) How do I pre-treat this seed? 2) How do I grow this species? These questions have to be considered together, because mishandling at one stage will affect seed quality and overall success. The remainder of this chapter is an instructional guide with basic information on seed biology and detailed protocols on how to collect, process, store and propagate native, wild seed. The finer, species-specific details are summarized into species-level profiles found in Appendix B.

Selecting suitable plants

Plants are selected for a certain function or use in restoration planning and even for gardening. Their aesthetic value, wildlife contribution, height and ability to grow on sloped ground and control erosion are all important attributes that must also be considered when selecting suitable plants to collect from. Planning using a table such as Table 1

Table *2*, shown below, can be a useful tool to help you select which plant species to grow.

Table 1.Traits that may be considered when selecting native plant species for restoration.

| | Present in reference sites | Erosion control | Fast growing | Nitrogen fixing | Drought tolerant | Flood tolerant | Early successional | Late successional | Height potential >3m | Horizontal spread | Tolerant to low/high pH | *Specific site tolerances |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plant A | × | × | × | × | × | | × | | | | × | |
| Plant B | × | | | | × | | × | | | × | | |
| Plant C | × | | | | | | × | | × | | × | |
| Plant D | × | × | | | | | × | | | | × | |
| Plant E | × | | | | | × | | × | | | × | |

Table 2 Traits that may be considered when selecting species for a native flower garden.

| | Flower colour | Flowering time | Height | Vegetative spread | Evergreen | Edible berries | Medicinal |
|---|---|---|---|---|---|---|---|
| Plant A | × | × | × | × | | × | × |
| Plant B | × | | | × | | | × |
| Plant C | × | | | | | | × |
| Plant D | × | × | | | | | × |
| Plant E | × | | | | × | | |

**Understanding the seed: Seeds are alive!**

Seed development is complex and varies from species to species. To help understand these protocols it is important to understand some basics of flower and seed development and seed biology. Seeds take time to develop. They begin in a strobilus (a developing cone) in conifers and in a flower in flowering plants. Not all flowers have colourful and distinct petals. Some are much less showy because they do not need to attract insects, but instead can be pollinated by wind. A flower may contain the male organs, known as the stamens that produce the pollen, and the female organs, the pistils, that contain the ovules that will later develop into seed once they are fertilized by the pollen. Both sexes may occur in the same flower (perfect flowers), or they may occur on different flowers within the same plant (monoecious plants) or on different plants (dioecious plants; Figure 2). It is important to recognize male versus female flowers to avoid focusing on male flowers that will not produce seed (Figure 3) and to identify female plants before seeds are ripe so collections can be more efficient. Once a flower opens, the female ovule is developed and can receive pollen so fertilization can occur. If successful, a seed will begin to develop under the influence of many hormones and nutrients. This process takes time, from weeks to a couple of months.


Figure 2. Some major reproductive stages of dioecious buffaloberry. (A) buffaloberry male flowers; (B) buffaloberry female flowers; (C) immature fruit from female plant; (D) mature fruit; (E) mature cleaned seeds.

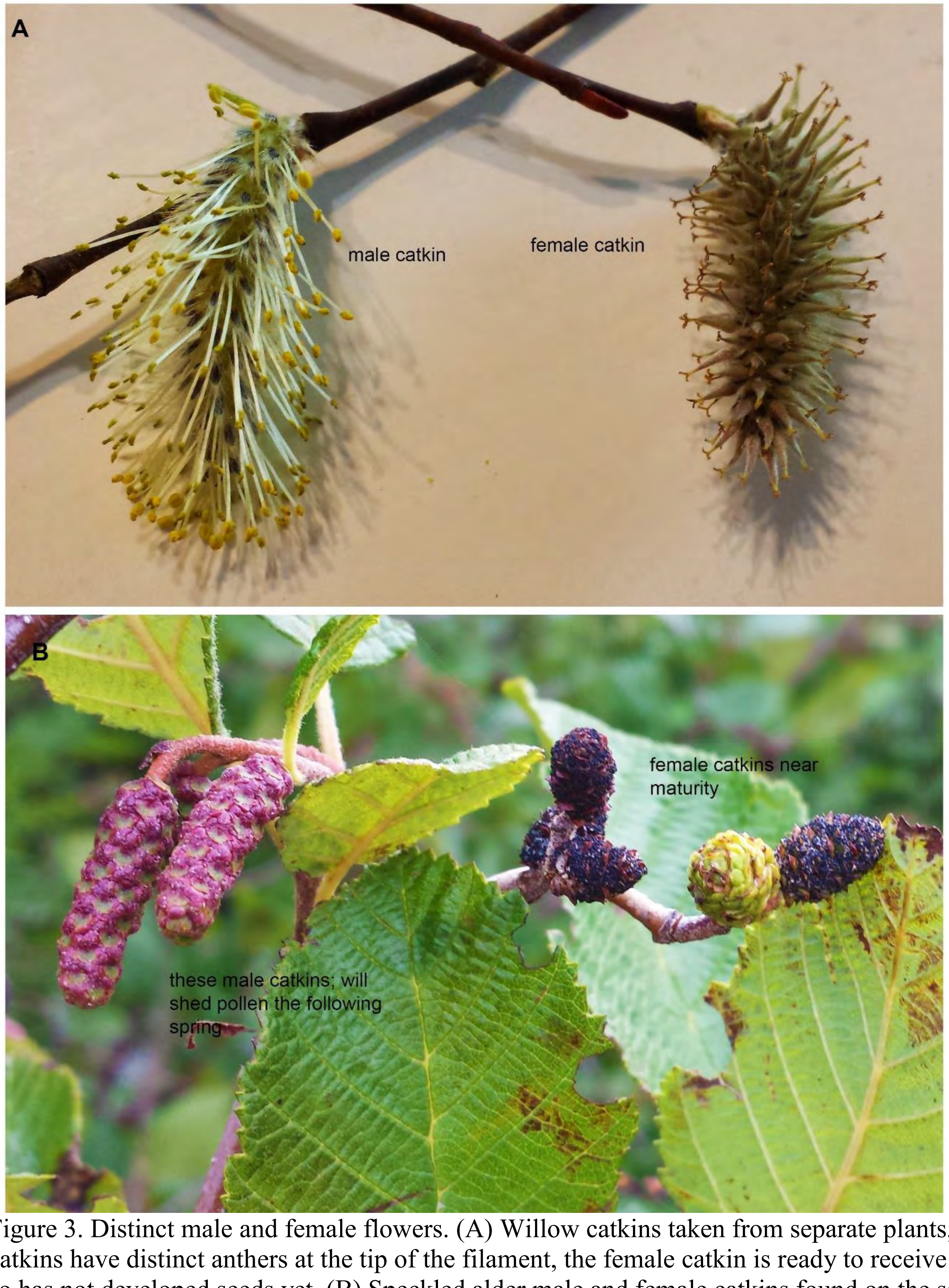


Figure 3. Distinct male and female flowers. (A) Willow catkins taken from separate plants, male catkins have distinct anthers at the tip of the filament, the female catkin is ready to receive pollen so has not developed seeds yet. (B) Speckled alder male and female catkins found on the same plant. Often male catkins fall off the plant, before the fruit is ready to collect, however alders develop new male catkins for the following year while female catkins are maturing. They could be mistaken if the collector does not know how to distinguish them.

A mature seed will eventually separate from the mother plant. Seed can separate from their fruit to disperse (dehiscent fruit; Figure 4A) or they may separate with their fruit termed an indehiscent fruit (Figure 5ABC). An indehiscent fruit is often referred to as a seed, because it only contains one seed and is treated like a seed for planting and storing. Throughout this guide we use the term seed, which refers to a single seed unit or indehiscent fruit. We also use the term fruit which can refer to any capsule, cone, catkin, berry, or other structure that contains one or more seeds. Plants produce many different types of fruit, because they have a variety of strategies for dispersing their seed throughout their environment. Some seeds or fruits are berries and may have an outer juicy pericarp to attract animals which will eat the fruit and excrete them elsewhere. Others have seed appendages like wings, hairs, plumes, corks or burs that help them disperse by wind, water or animal. A few species with dehiscent fruit rely on the bursting action of the fruit to launch their seed, often making these species particularly tricky to collect.

Figure 4. A sample of fruit diversity. (A) Blue-eyed grass capsules, starting to dehisce; (B) ninebark follicles containing seed; (C) resin birch female catkins containing ripe seed; (D) Robyn's aster ripe fruit (seed with stiff bristles) ready to disperse; (E) silverberry fruit; (F) brome grass inflorescence containing seed.


Figure 5. The anatomy of (A) whole golden sedge perigynium containing an achene; (B) sectioned achene revealing the seed of golden sedge; (C) whole and sectioned achene of silverweed revealing spongy pericarp layer and inner seed; (D) sectioned silverberry fruit containing seed; (E) sectioned buffaloberry fruit containing seeds; (F) whole tickle grass seed; (G) sectioned meadowrue seed. Meadowrue seed likely has a morph-physiological dormancy, the embryo will grow and consume much of the endosperm, before being able to germinate. Abbreviations are endosperm (end), embryo (emb), cotyledon (cot), hypocotyl (hyp), radicle (rad) and seed coat (sc), pericarp (per).

Seeds are covered by a seed coat that protects the living tissues within. Inside the seed coat is an embryo. The embryo will grow inside the seed and push through the seed coat and develop into a seedling. In some seeds, embryos are made up of a radicle (that will become a root), hypocotyl and cotyledons (the first leaves of the plant), while others are simpler (Figure 5). Many seeds have an endosperm that provides the embryo with nutrients and energy as it grows.

Seeds are sensitive to their environment. It is important to understand that most native seeds cannot be left on the counter for long periods of time like many tolerant vegetable seeds or they will deteriorate and die. They must be stored properly. Each species may require a different treatment before it is willing to grow, when these conditions are appropriate, specific signals will cause the seed to initiate embryo growth and germination. The cues that the seed needs to germinate can be complex. Becoming familiar with your species of interest and understanding its seed biology will help you to plan better and to succeed in seed collection, storage, and propagation. We describe this process in more detail below.

**Timing collections and preventing losses**

In the boreal and subarctic regions, the growing season is short, and the seed dispersal window can be very narrow. Watching seeds mature and returning to a site more than once to assess seed maturity is time consuming, but necessary in many cases. A forecasting calendar can be a helpful tool to start you off; an example can be found in Appendix B1. Record information about when seeds matured and dispersed to help get your timing right for future years. Plants should be checked early in the season so you can mark bountiful populations, this way when seeds are ready to collect, the collector does not waste time searching for productive sites.

Seeds ripen at different rates. Keep an eye on the weather, if it has been dry and hot, seeds will likely ripen and disperse quicker than when the weather has been wet and cool (Young and Young 1986). In addition, the slope and direction your collection site faces (the aspect) will affect the seed maturation and dispersal rates. Seed from plants growing on a southern exposed site can mature two to six weeks before seed from plants growing in the shade or with a northern aspect. A collector can prolong their collection window if they begin collecting at exposed sites and, once all seeds have dispersed, move to shaded areas. Or if a collection was missed at an exposed site, it may be possible still to find seed in a shaded location.

When are seeds ready to collect? The ideal time to collect is when seeds are mature but have not yet dispersed. But how do we make this distinction? Understanding how and when a plant disperses its seed helps you to determine when seeds are ready to collect. For instance, have you ever tasted a green blueberry? They are not sweet, soft or brightly coloured, as they are when they are ripe, and at this stage the seeds inside the green fruit are not fully developed either. This deters animals from consuming them until seeds have matured (Traveset *et al*. 2001). First check the structure that contains the seed. If the fruit is a berry and it is hard (often green or a non-vibrant colour), it is unripe and not ready to collect, and the seed is still developing. If the fruit is a capsule that contains the seed, and the capsule is green and leathery rather than tan or papery, the seed is likely still developing. Perhaps the most distinct change for many species is the change in colour of the fruit from green to tan, or the change from green to more colourful berries. To confirm their readiness, open the fruit (cone, capsule, berry, etc.) with a knife to check the seed. Or split a few berries open. Examine the seeds and try to split them with your finger nail. If the seed is green and can be squished between your fingers, then they are not ready to collect. Most seeds harden with maturity. This is a good indication the seed is ready. Some species need to be examined very closely because they do not show obvious physical changes that indicate they are ripe. If the seed or fruit are easily pulled or shed from the plant, firm and plump they are likely ready to collect. Sometimes this decision is difficult to make. For some species, as soon as they become mature, their seeds disperse, so it may take a great deal of practice and observation to get this timing perfected. This can become further complicated because not all the seed on a plant will become ripe at the same time.

If seeds are underdeveloped they may not grow at all, or they may germinate, but not produce healthy plants (Young and Young 1986). If the collector waits too long, seeds may disperse, be eaten, or become non-viable. You will be faced with having to make on-the-spot decisions about whether seed is 'ready enough' to collect. If at least half of the seed on the plant are fully ripe, then the seed can be collected. For herbaceous species collect the seed while keeping it attached to the plant to ensure any immature seed can further develop. For instance, clip the top of an aster or fleabane plant and collect willow catkins just as hairy seeds are apparent and as some capsules begin to open (example Figure 6).

Figure 6. False mountain willow with female catkins that are beginning to burst to disperse their seed.

Some species shed their seed more quickly than others. For these plants, prioritize their collection by checking stands frequently, or use netting or cloth to stop their seed from dispersing. Many wind dispersed species like the asters and willows should checked every few days during the peak collection window, to monitor seed readiness. If the plants are abundant, wrapping them with netting will be very time consuming and is not worthwhile if the goal is to collect large quantities of seed. However, for some species it may be necessary to wrap the branches and fruit, if collection sites cannot be regularly accessed and you are uncertain how quickly they will disperse. Another reason for using netting is to make it easier to collect fruit from a plant that ripens at different times. For instance buffaloberry fruit will be eaten by birds as they ripen, if the fruits are protected by netting, the collector can return at a later time when all fruit has ripened to improve their collection efficiency (Figure 7). The best time to set up netting is when fruits are still immature, but flowers have deteriorated. Placing sheets below the plants to catch fallen fruits or seed is ineffective because once they are on the ground they are eaten by insects or they come in contact with moisture and lose their viability.


Figure 7. Preventing buffaloberry herbivory with netting. (A) uneven ripening of buffaloberry fruit; (B) buffalo berry plant wrapped in netting, even tighter wrapping is preferred; (C) fully ripe fruit remaining on branch one month following wrapping.

## Seed Collection Protocols

Seed collection protocols and equipment for wild plants should be relatively transportable, affordable, and non-destructive to the landscape around desired populations. Collections should be taken from different locations to ensure genetic variation of your seed lots and to avoid alteration of natural populations that may rely on seeds for their establishment (Luna and Wilkinson 2009). If your seed has a known destination, collecting seed from an area that has comparable soil, moisture, elevation and climate conditions is recommended (O'Brien *et al*. 2007).

Appropriate permissions from government or land owners may be required if you are collecting from government or private properties. Seed materials from rare or endangered plants should never be collected from.

## Record Keeping

What are some of the details you should document when you are collecting? It is important to keep track of what, when and where you collect your seed. In our protocols we talk about the 'how to' of collecting, but encourage you to build from them and continue to think of ways to improve your efficiency.

## Collection containers

Equipment list: Tarpaulins or sheets, tray with a short lip, harness that attaches at waist or to chest, buckets, large paper bags; (Figure 8)


Figure 8. Examples of collection containers. (A) Hand collection of moderate sized shrubs, the bucket is tied to the collector to allow both hands for collection. (B) Tarp placed below a bountiful buffaloberry bush to increase collection rates. (C) Collecting low growing species again with buckets tied to the collector to free hands for collecting, but is adjusted to waist level. (D) Collecting poplar branches and catkins using a pole with a hook and hand pruners into a large paper bag.

Having a proper container for your collections is a very important consideration for your wild collections. Having both hands free to collect can double the amount of seed you collect in the same amount of time. Have your container rest at a suitable height to the material you are collecting as this can improve your collection efficiency and comfort. Finally, select a container with a capacity that matches the amount of material you are collecting; this will reduce the time required to empty and replace containers.

Sheets can be laid out below dense patches of fruit, especially berries. A tray with a short lip can also be useful for dense, low growing species. This allows the collector to use both hands to remove seeds and simply drop them to the surface below. Move your hand along the plant branch to detach the fruit, rather than visually picking at individuals. One can also shake the branches vigorously over a sheet, but the success of this method will depend on seed ripeness and only works well if the fruit on the plant is abundant.

Herbaceous plants that grow low to the ground and have a low density of fruit are challenging to collect. A large open basket or a container that is harnessed to your body (such as a tree planting bag) are effective because you can move quickly from patch to patch and utilize both hands. A simple homemade container, can be made by tying buckets to a strap that is wrapped around the collector (Figure 8). To harvest from shrubs with fruit growing at chest height, such as mooseberry, dogwood, and ninebark, use a container with a wide opening that is harnessed to the collector and adjust it so it sits just below the material you are collecting. Line this container with a paper or plastic bag so it can quickly and easily be emptied. Use large paper bags for species that are above arms reach or for plants with a large amount of plant material, such as grass heads and tall asters.

**Hand collection**

Equipment list: buckets and harness, scissors, hand pruners, pole pruner, pole with a terminal hook, berry scoops, hand saw, ladder, flat trays, tarpaulins or sheets, large leaf bags, plastic bags (Figure 9).


Figure 9. Simple collection tools. (A) Berry rake for collecting rose hips; (B) scissors to cut slender wheatgrass tops containing seed; (C) pole a with a hook used to pull showy mountain ash berries into the collectors reach; (D) a leaf blower set on reverse to suck seed of yarrow or grasses

There are a variety of simple and affordable tools available to improve the efficiency of hand collection. Consider the following details about your plant: What is the plants height (low to ground, chest height, above arms reach)? How does the seed disperse (animal, wind)? How is the seed distributed on the plant (dense patches/ clumps or as individuals)? Is the plant armed or poisonous? Does it have an herbaceous or woody stem? These details will help determine what extra equipment will assist you with your collections.

For grasses or other herbaceous plants with seeds at the top of the stem(s), use scissors to cut at the base of the inflorescence and place material into a large paper bag. This includes some wind dispersed species like asters, or those with capsules such as blue-eyed grass or Indian paintbrush. Berry scoops are effective for species that have fruits in clumps and that ripen all at one time, such as those in dogwood, mooseberry, alders, and roses. Berry scoops are especially effective for collecting rosehips because their plants have thorny branches that can poke through a gloved hand.

The pole and hook is effective for tall shrubs or younger trees such as paper birch and young balsam poplar. Their slender branches can be pulled into arms reach for collection, rather than using a ladder or pole pruners. This can increase access to some seeds borne on taller branches and improve the comfort of the collector so their arms do not need to remain above his or her head. A collector can hold the pole and hook between their legs and use two hands to collect, reducing the need for a second person. Pole pruners are required for tall trees like older balsam poplar and jack pine. Often taller trees are older and produce more seed than younger plants, but reaching their seed is more challenging. A saw can be used to cut trees when cones occur at the very top of the tree, such as spruce. This method of course kills the tree. Selectively cutting trees down and in moderation can benefit the smaller trees in a forest, by opening up the canopy and thinning the stems. If possible, consider partnering with people cutting trees for firewood or lumber, such as for poplars in the spring and spruce or pines (or other conifers) in the late summer or fall. Jack pine and black spruce cones remain closed for several years and their cones can be harvested in any season (Haavisto 1975). Seeds and branches are often discarded when wood is harvested. A permit or permission may be required if harvesting from government or private land. If one wishes to avoid cutting a living tree, there are other options. A collector can scout for trees that have recently fallen in the spring, and harvest the cones in the fall once mature. Another option is collecting from squirrel caches as long as the caches are made from fresh cones.

**Vacuum harvesting**

Vacuum harvesting uses a leaf blower on the reverse setting to suck seeds into a bag (Figure 9). Vacuum harvesting is only effective when seeds are at the brink of dispersal and only superior to hand collection methods when a species grows in dense stands. The most effective plants for vacuum harvesting are herbaceous plants with wind dispersed seed such as asters.

**Mechanical seed harvester**

The mechanical seed harvester works by cutting material and propelling it into a cloth bag attached to the unit (Figure 10). It costs approximately $2500 CAN. It is effective for harvesting grasses growing in monoculture, otherwise it is nearly impossible to keep other seeds from entering the mix. It may be useful to create seed mixes with species that ripen at similar times. If you are cultivating materials such as grasses, this equipment also separates some of the seed from the plant material, making seed processing easier.

Figure 10. The mechanical seed harvester for collecting fowl blue-grass.

**Post-harvest conditions**

Equipment list: a draft free room, heater, trays, newspaper or paper towel for moisture absorption, thermometer and hygrometer.

For post-harvest handling of seed, you will require some space in a refrigerator and a room which can be kept both draft free and warm to allow your seeds to after-ripen and dry. Some collectors allow seed to dry outside in a shed or sheltered area that allows for ventilation of seed materials. Not all species can have their seed dried. It is very important to determine the species seed storage behaviour. This information is now largely available at the seed information database (http://data.kew.org/sid/). Seeds that are considered intermediate or recalcitrant cannot be dried and are sensitive to temperature changes (Hay and Probert 2011); refer to storage protocols for proper handling. In northeastern Canada, Oaks (*Quercus* spp.) and beaked hazel (*Corylus cornuta*) are sensitive to drying.

The majority of seed in northeastern Canada is orthodox, which means the seed can be dried and stored cool (as low as -20°C if dried very well, or in the refrigerator 1 to 5°C) to maintain its longevity. Well dried seed has a seed moisture content typically between 5 to 10%, acceptable for most orthodox seed. Wet collections are at risk of moulding and should be placed immediately to dry. High moisture is the most damaging factor to orthodox seed viability (Gold 2008). Place berries in the refrigerator until they can be processed, if some berries are slightly unripe this time delay will allow the berries to ripen and improve seed processing. Lay all other materials, such as grasses, catkins, and capsules out to dry on flat trays lined with newspaper or paper towel. Any seeds with hairs of bristles for wind dispersal should be contained in large paper bags but in thin layers and regularly turned to ensure even drying. The room temperature should be kept below 30°C and less than 50% relative humidity (Gold 2008). A dial hygrometer can determine the humidity of your drying room. Seed should be processed after drying and should not be kept in these conditions for prolonged periods, because heat will reduce seed viability. If you cannot process your seeds after harvesting, it is best to dry your collections and then store materials in a cool place (below 5°C) until processing is possible. There is no simple answer to determine how quickly seed will dry and it is difficult to tell when a seed is dry enough for long term storage. If you are planning to grow your seed immediately determining your seeds moisture content is not necessary. If you are planning to store seeds for longer periods (over two years), reducing your seed's moisture content will ensure seed viability is maintained. To learn the methods for determining seed moisture content, refer to further reading; Seed storage: How to determine seed moisture content.

**Seed processing and cleaning protocols**

Equipment list: trays, newspaper, sheets or tarps, threshing mat, threshing paddles, blender (and file), buckets (5 gallons and smaller), sieve set with several sizes from 0.105 mm opening (mesh size 140) to a 8 mm opening sieve (5/16inch), coarse sieves, space heater, table fan, shop vacuum, drying oven (required for some pine and spruce cones, but a homemade kiln can be used as an alternative), microscope (for seed purity measurements).

Seed processing and cleaning are required for several reasons. If you are selling your seed you will need to know how much seed you have. Bulky material like seed hairs or barbs can make storing and planting seeds a challenge and several fruits like cones and berries have more than one seed per fruit. Once you begin this process you will see the diversity of seed and fruits. This can be overwhelming as you determine how to isolate the seed. Some species have fruits that are typically mistaken for the seed itself, like nuts and achenes (ex. golden sedge and silverweed; Figure 5ABC). For these species, removing the seed from the fruit is not necessary and may actually damage the seed, instead the goal is simply to separate the fruits from one another, remove seed appendages, and remove any plant material like leaves and stems.

Seeds can be cleaned using simple and relatively low cost equipment. We describe seed cleaning here as further separation of chaff and empty seeds from the final lot. Seed processing can include this step, but may just entail separating seeds from one another. These methods are effective for seed processing and cleaning but are sometimes time consuming. There are more sophisticated, but also more costly equipment available for seed cleaning on the market, we have listed some links below in further reading; seed processing.

## Processing

### Threshing

Threshing is a very effective technique for seed cleaning. We use a rubber mat with one flat side and one corrugated side, available for purchase from most hardware stores. To make the paddle, cut a strip from this mat and wrap it around a sandpaper paddle to make a threshing paddle (Figure 11). Place the plant material on the mat and rub it against the ridges using the paddle, mature seed separates easily from the plant material. This also creates a lot of chaff, such as broken pieces of stems and leaves which can be cleaned later. For some seeds such as asters and birch, use the flat side of the threshing mat to remove the stiff hairs and wings from the seed. Take caution when applying pressure because too much force can cause seed damage. Hard seeds will not be damaged, but those with thinner seed coats will need regular examination for seed damage. The threshing mat is also useful for processing large seeded berries and those with mealy fruit, for instance, red osier dogwood (Figure 11), silverberry, juniper, and alder-leaf buckthorn that may be damaged in a blender.


Figure 11. Threshing mat and paddles. (A) Threshing to open ninebark follicles and tumble seed out between the ridges on the mat, this is done within a short homemade box to contain the seed. (B & C) Crushing large seeded berries like dogwood that are damaged in the blender. (D) Aster seeds still attached to stiff bristles were threshed on the flat side of the mat to break bristles off the seed. (E) Threshing dry slender wheat grass on corrugated side of mat, the rubbing action will free the seed from the plant.

**Blender method**

A blender is used for berries, with small to medium sized seed and when the berry is very soft and juicy, rather than fleshy. Dull the blades of the blender using a file. Alternatively, the blades can be wrapped with electrical tape, but the tape will need to be replaced in between uses. For small seeds, such as mountain cranberry and strawberry, berry to water ratios of 1 to 2 will effectively crush the berries to separate the seed. For medium sized seeds, such as raspberries (Figure 12) and buffaloberry, it is better to have higher berry to water ratios of 1 to 3, this extra water seems to protect seeds from damage. To further protect seeds we encourage short pulses of the blender, approximately 2 seconds for medium to large seeds until you are confident you are not damaging seed. Allow the material to settle. For many berries, the full seed will sink and pulp and empty seeds will float and are easily poured out and discarded. Some berry seeds and pulp do not separate well, if this is the case reserve the sunken material by straining it into a sieve and placing it on paper towel for drying and later threshing and winnowing. If you are planning to grow your seed immediately, some practitioners recommend that certain seed should not be allowed to dry as this makes them more difficult to grow later, these species are identified in their species profiles.

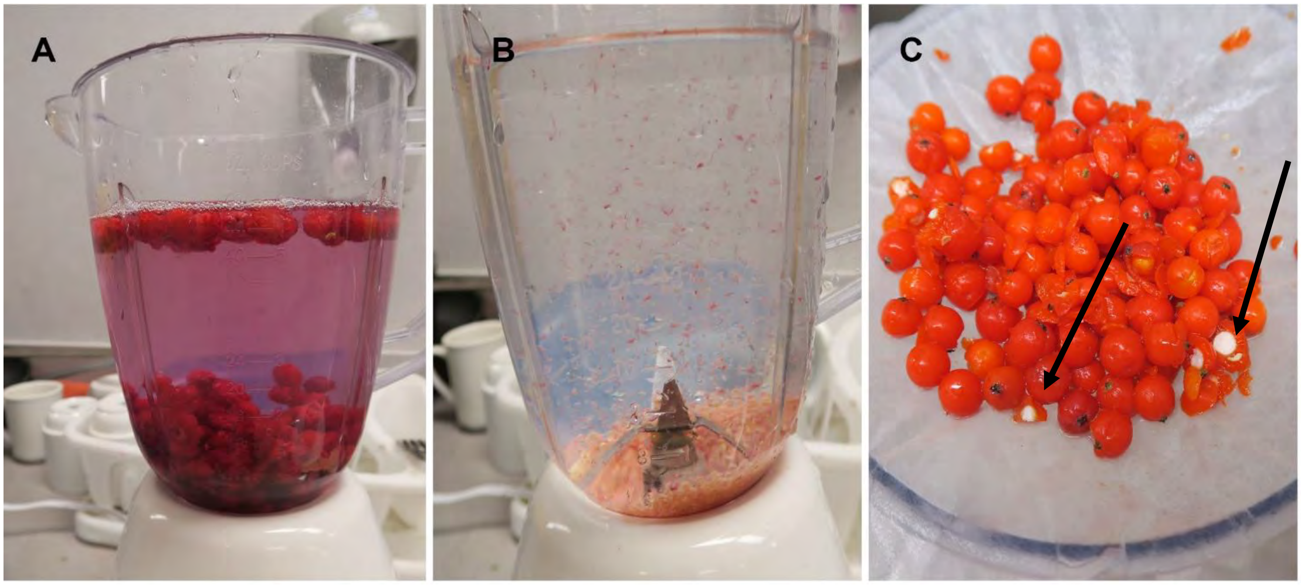


Figure 12. Blender processing of berries. (A) Raspberry fruit in a blender with a 1 to 3 berry to water ratio. (B) Cleaned and full raspberry seeds sank to the bottom of blender, pulp and floating seeds were poured off and discarded. Water is added again to rinse seed and pour of any suspended pulp. (C) False toadflax seed is large and was damaged in the blender. Arrows pointing to damaged seeds.

**Vacuum method**

Balsam poplar, willow, and fireweed seed can be cleaned using a sieve set, a 5-gallon pail and lid and a shop vacuum cleaner. These methods were modified from (Fung and Hamel 1993), originally described for trembling aspen. Cut a hole in the lid of a 5 gallon pail so it fits a sieve tightly (Figure 13). Modify the shop vacuum by wrapping a mesh cloth (approximately 2mm opening) around the filter inside. Once the capsules from these plants are dry and fully opened, suck the materials into a shop vacuum, this helps to 'tame' the airborne seed. Then transfer this material into the 5 gallon bucket and place a sieve with mesh size 60 or smaller in the opening.

Using a shop vacuum blow air into the bucket (about 30 seconds), through the sieve to separate the seeds and fibers from the capsules. Then transfer the capsules and material at the bottom of the pail into a stacked sieve set, discard the hairs if they have minimal seed, otherwise place it in the sieve with the other material. Stack the sieves in the following order from bottom to top: closed pan, 60-mesh, 40-, 20-, and 140. Having the 140 mesh sieve on top will stop seed from escaping as you blow air into the sieves. Place the capsules in the 20-mesh sieve, any separated seed will fall into 40 or 60 sieves. Using the vacuum in a blowing position, force air through the top sieve to separate the seed from the cotton. Nearly pure seed will be in the 40- and 60- mesh sieves. This process is fairly time consuming, but is an effective method and results in pure seed. Larger sieves will clean larger quantities of seed at a time.

Figure 13. Shop vacuum technique for cleaning poplar, willow and fireweed seed. (A) Dry burst capsules were placed in a 5 gallon bucket with an opening to fit a fine mesh sieve. Air is blown into the bucket for about 30 seconds to separate the 'fluff' from the capsules. (B) We placed the contents into a sieve (mesh size 20), stacked onto a 40- mesh, then 60- mesh, then a bottom pan, the top sieve should be smaller than a 60- mesh. (C) Air was blown into the top sieve for about 20 seconds to force seed from the hairs, the seed stays in mesh 40 or 60. (D) Seed is almost 100% pure.

**Cone processing**

Spruce and jack pine cones must be opened to remove seeds (Figure 14). First remove the cones from the branches as much as possible because needles are difficult to separate from seeds after drying. White spruce cones will open in a warm drying room, whereas black spruce cones are covered in resin and may require repeated wetting and drying at hotter temperatures to open scales (Karrfalt 2008). Jack pine cones will open at approximately 70°C to 80°C in an oven after several hours. Once scales begin to open, the cones should be removed from the high temperatures or the seed may become damaged (Karrfalt 2008). Small amounts of cones can be opened using a household stove but pose a fire risk. If you are collecting large quantities of conifer cones, it may be worth sending cones to seed extraction companies that are able to separate seed from cones for fairly low costs. Alternatively, consider building your own solar kiln that can be used to open cones (see further reading "seed processing equipment" for an example). The kiln will need to have a fan for air movement and racks that hold cones but allows for air flow and for seeds to fall as the scales open. On the bottom of the kiln, there should be a tray for collecting seeds. After cones have opened, they can be tumbled to remove seeds. For cones such as jack pine with hard scales, place the cones on a sheet and step on them to further open their scales. Cones can then be shaken in a closed container to release seed (such as a garbage container with a lid) and poured over a course sieve (2cm opening or less). The winged seeds can be gently threshed to break wings and further cleaned by winnowing.


Figure 14. After cones were opened, we processed jack pine and white spruce in a similar manner. (A) White spruce cones opened in a garbage bin in preparation for tumbling. (B) Jack pine cones opened and shaken, fallen seed shown. (C) Sieving white spruce cones using a milk crate. A proper sieve or racks with a mesh opening of approximately 2.5 cm or more would have worked more effectively. (D) White spruce seed mixed with spruce needles, despite their different shapes and sizes, needles were difficult to separate from seeds, it is worthwhile to remove cones from branches prior to drying. (E) Jack pine seeds ready for gentle threshing on corrugated side of rubber mat to detach wings from seeds. (F) Winnowing to remove wings from seeds. (G) Cleaned jack pine seeds.

## Value added by-products

Depending on your seed collection purpose, consider value added by-products. For instance, the pine and spruce cones left behind after the seeds have been removed can be sold for decorations. Poplar fibres (the hairs removed from seed by the vacuuming method) have been recognized as a cotton and for their superior capacity for oil absorption and insulating properties (Chen and Cluver 2010, Likon *et al*. 2013). Some species have extremely fragrant fruits and can be used for their aroma in crafts or even for flavouring cooking and teas if handled properly.

## Seed cleaning

We describe three methods for seed cleaning: sieving (separation by size), winnowing (separation by weight), and flotation (for berry species to separate empty seeds from full seeds). Stack the sieves so the larger opening is always on top of a smaller opening. Always include the closed bottom pan. Shake the sieves side to side in order to separate seed from different sized pieces of chaff. Sometimes winnowing is required after sieving. Winnowing will separate light weight plant materials like crushed leaves, seed bristles and many empty seed from full seeds. In contrast, you can use winnowing for wind dispersed species to separate the winged seeds from their scales, such as alders. Pour the seed materials back and forth in front of the air flow of a table fan until no more material is being blown out of the container (Figure 15). Begin the process using the lowest air flow possible and increase the air flow until the separation of seed and chaff is optimal. Place newspaper on the floor in case the seed is blown out of the pan, so it can easily be collected, reducing the force of the air for the next attempt. Flotation is primarily used for berry seeds immediately after processing. Place materials in a large bucket of water, full seed will generally sink and empty seed will float. Some species have floating seeds, so this is not always an indication of seed fill. If you are uncertain, take a small sample and see if they float or sink.

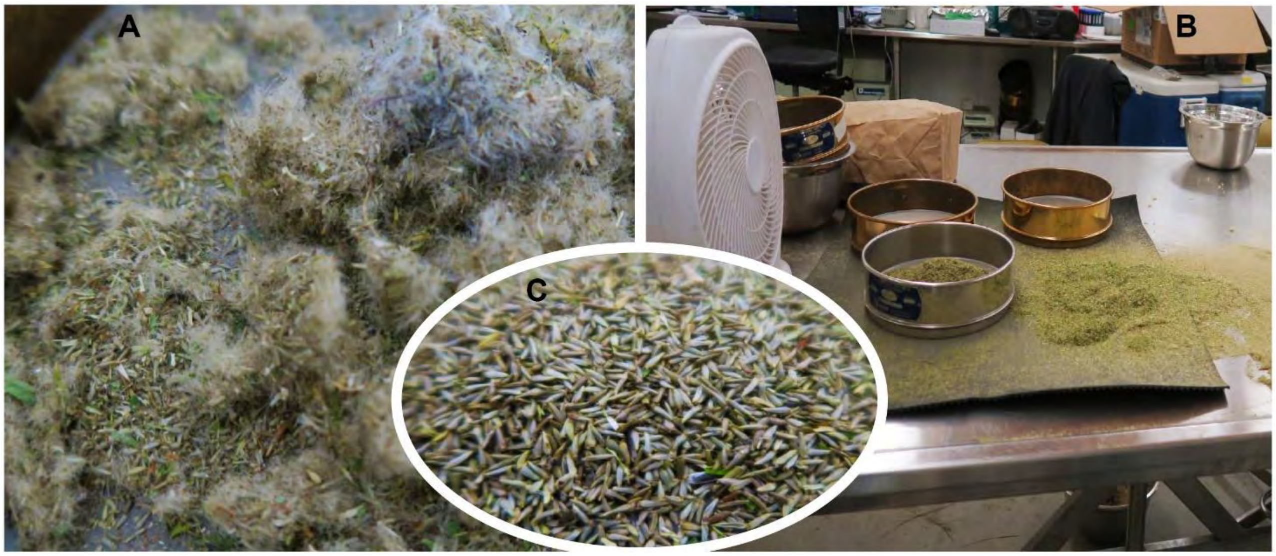

Figure 15. Cleaning by winnowing aster seed. (A) Threshed aster seed, ready for winnowing because seed bristles are no longer attached to seed. (B) Leaves and detached bristles are blown out of the sieve, while the full heavy seeds remain in the sieve. (C) Cleaned aster seed.

If there are large amounts of empty seeds, indicated by floating or being blown away from the remaining seed, check your seed lot, these notes are important for future collections. Sometimes seeds are highly parasitized in certain populations and it may not be worth your time collecting from this same location in the future.

**Seed purity**

Seed purity tells you how much actual seed is in your seed lot that does not include chaff or seed from other plant species (Figure 16). Some covering structures, such as, the lemma in grasses is not considered an impurity and is not separated in the purity analysis. Take a sample of your seed, a standard sample includes a minimum of 2500 pure seed units according to the Association of Official Seed Analysts (AOSA; http://www.aosaseed.com/). This means your sample volume will vary depending on your seed size. For many seeds you will need to magnify the contents or look under a microscope to distinguish actual seed from other materials.

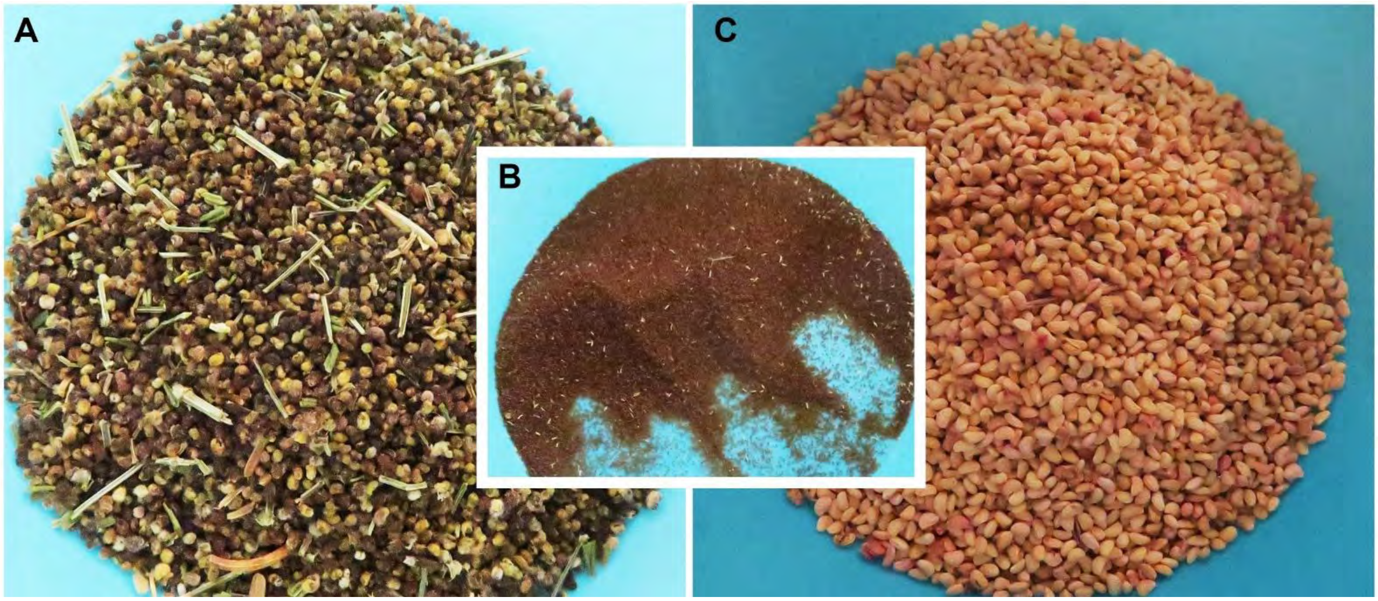

Figure 16. Cleaned seed varies in their purity. (A) Northern bedstraw seed was threshed with stems and does not separate well from the seed using sieves or winnowing. (B) Rushes have dust-like seeds, they can be a challenge to clean because they cannot be winnowed using a table fan. (C) Red raspberry seed has nearly 100% pure seed, this species cleans very easily in a blender.

**Storage protocols**

Equipment list: Refrigerator, paper bags, sealed containers or polyethylene (plastic bags)

If your seeds are going to be planted immediately in the field or planted the following spring, consider placing seeds into their pre-treatment conditions described in the next section. If you are selling your seed, it is best to store seed to maintain their viability for longer periods. These protocols are described below in pre-treatment protocols.

Seed storage behaviour is species specific and is highly variable, but generally classified into three categories orthodox, intermediate and recalcitrant (Royal Botanic Gardens Kew 2016). Orthodox seed varies in longevity, but will live longest when dried and stored in cold conditions (Hong *et al*. 1996). Optimal, orthodox seed moisture content is typically between 5 to 12%. For many species, seeds that have been dried can be placed in a refrigerator (temperatures between 1 to 5°C) in a breathable container such as envelopes or paper bags for 2 to 5 years. However, if you wish to store species such as willows and poplars for more than one year you will need to freeze their seed or much of it will die within a year. If you are freezing seed, it is much more important to determine the seeds moisture content to ensure seed is adequately dried (Hong *et al*. 1996), see further reading under seed storage: how to determine seed moisture content for detailed methods. Contrary to common conception, seed viability of orthodox seed can be prolonged when stored in sealed containers, if the seed is sufficiently dried. Until you have worked with seed routinely it is best to keep seeds in breathable containers like cloth or paper. Still seed must be regularly checked because if the moisture is too high in your refrigerator, seeds will reabsorb the water and can become moldy. See below, for further reading under seed storage for more information on long term storage of seed.

In contrast to orthodox seed, a recalcitrant seed is very sensitive to drying and temperature changes (Hong *et al*. 1996). Intermediate seeds are between orthodox and recalcitrant seeds in their sensitivity (Hong *et al*. 1996). They can be dried somewhat and can endure more temperature changes than recalcitrant seed, but may lose viability at lower temperatures. There are no perfect long-term storage solutions for recalcitrant seeds. In temperate climates, recalcitrant seed needs to be kept moist and cool (1 to 5°C) with regular air exchanges, to maintain viability for a few months up to two years (Berjak and Pammenter 2008, Hay and Probert 2011). Some examples of Ontario species with recalcitrant seed are oaks (*Quercus*) and silver maple (*Acer saccharinum*).

**Seed viability testing**

Materials**:** scalpel or razor blade, cutting board, dissecting microscope (up to 60X magnification), pliers.

Initial seed viability testing is important to understand the potential of your seed lot to germinate and to evaluate seed collection sources. Seed viability can be estimated using a cutting test. Take your seed and section it longitudinally. For small seed we are looking to see that it is full and for larger seeds we can examine the embryo colour and appearance (Figure 17). The embryo is typically white, but for some species is coloured, therefore we recommend assessing the embryo for uniformity of colour and appearance. Some species also have an endosperm at maturity, while others do not. For very small seeded species, like rushes and Labrador tea, you may only be able to examine the whole seed and perform a firmness test. In this instance if seeds appear plump and secrete an oily material when crushed, they may be considered viable. Tetrazolium tests are commonly used to determine if a seed is viable, but the results can be more complicated to interpret and requires knowledge on individual species to determine the staining concentration and the length of time to apply the stain.

If you are planning to sell seed, you will need to have a least this basic understanding of your seed quality by measuring seed fill and seed purity. You can send seed samples to certified seed laboratories that will assess seed viability using Tetrazolium and determine seed purity, but these tests are typically quite costly. Refer to further reading below; Seed quality standards for links to learn more about seed viability testing.

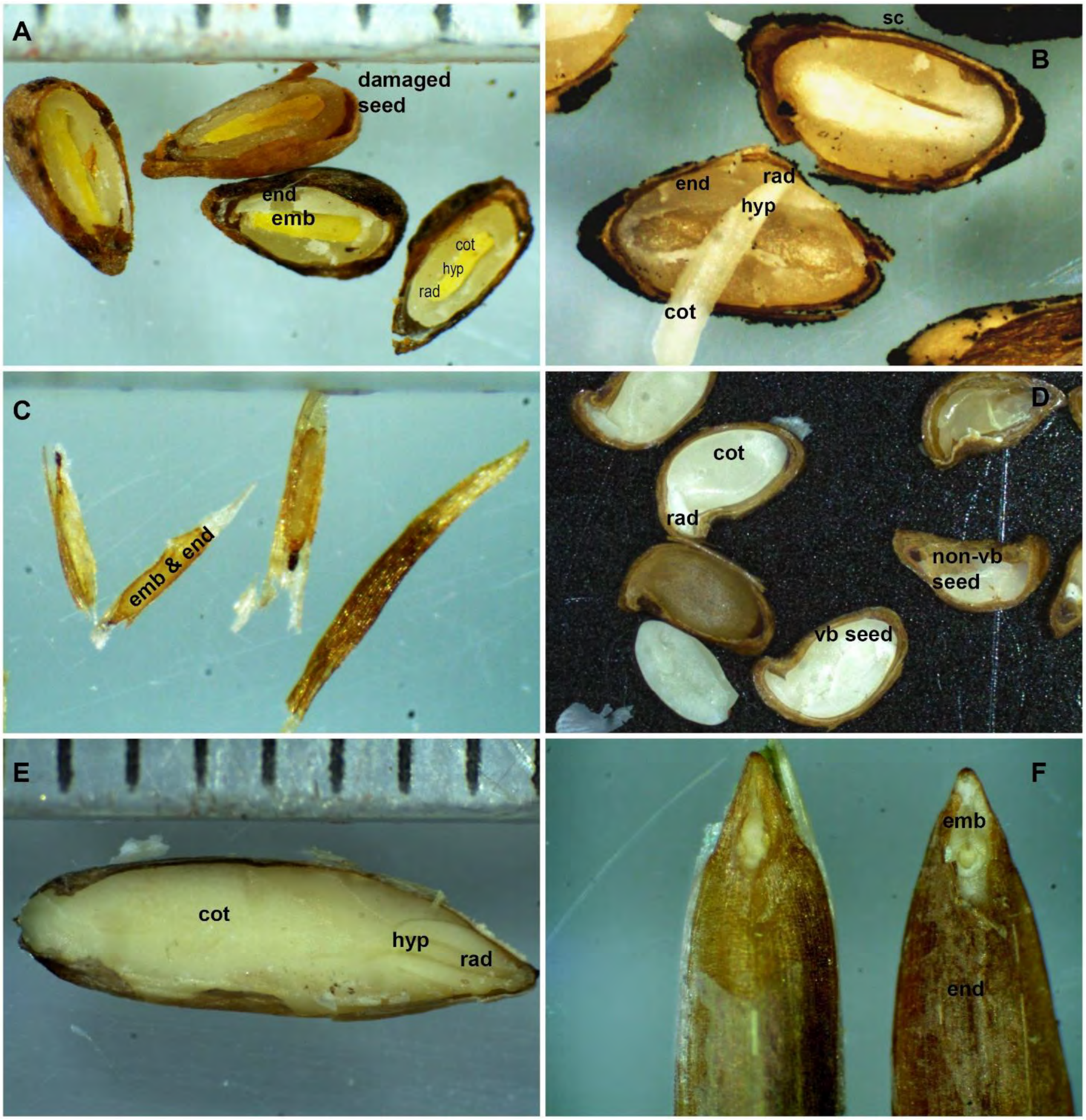

Figure 17. Sectioned seed for seed fill and viability assessments. (A) Sectioned white spruce seed, embryo and endosperms consistent in colour were viable, damaged seed was considered non-viable. (B) Sectioned jack pine seed with an embryo isolated, both seeds were viable. (C) Sectioned and whole Labrador tea seed, we could not differentiate embryo from endosperm, seed to the far left was considered non-viable and the others were considered viable. (D) Sectioned round-leaf serviceberry seed. (E) Sectioned silverberry seed (removed from fruit). (F) Sectioned slender wheatgrass embryo, the endosperm makes up most of the seed. Abbreviations are endosperm (end), embryo (emb), cotyledon (cot), hypocotyl (hyp), radicle (rad), seed coat (sc), and viable (vb).

**Pre-treatment protocols: Before planting your seed**

Equipment list: Refrigerator, planting containers such as: petri dishes or pots, planting medium such as: potting mix, agar, paper towel.

Seeds from native plants often must be treated before they can be planted, or they may not grow. This is especially true for orthodox seed that exhibits many types of seed dormancy. These dormancies inhibit germination until treatments are applied. There are seven types of seed dormancy described by Baskin and Baskin (1998). However, only the most common dormancies for our 60 species are described here. They include physiological, morpho-physiological, and physical seed dormancies. Several species were considered non-dormant which means they can be planted without pre-treatment. The most common pre-treatment recommendations to overcome these dormancies includes: cool-stratification, warm-stratification, scarification, chemical leaching, and a combination of these methods. Pre-treatment protocols are perhaps the most diverse and species specific of all protocols.

**Cool-moist stratification**

Some species are listed as non-dormant, but may benefit from some period spent in cool-moist conditions if they are collected from northern climates (Baskin and Baskin 1998). Many seeds with physiological dormancy can be treated with the pre-treatment: cool-moist stratification. Moistened seeds are placed in temperatures of 1 to 5°C for a period of 30 to over 120 days depending on the depth of the dormancy. This emulates the winter that seeds would endure under natural conditions, before growing in the spring. Seeds can be placed between moistened paper towels in any suitable container. Some people may place seed immediately into their planting medium, with moist soil, but this makes it difficult to monitor seeds. Seed should be checked periodically to ensure the paper towel is moist and that mould has not developed.

**Warm-moist stratification**

Warm-moist stratification is often used along with cool-moist stratification for species with morpho-physiological dormancy. These seeds have underdeveloped embryos at maturity (Baskin and Baskin 1998). In order for these seeds to germinate, embryo growth must occur and physiological dormancy must be broken. For some species, it is important which occurs first: i.e. embryo growth or breaking physiological dormancy. These seeds are often referred to as two-year seeds, because they require two winters and one summer before germinating in the spring. We emulate these conditions by exposing seed to cool-moist stratification as above and then to warm-moist stratification which requires a temperature increase to approximately 20°C or higher and then repeating the process of cool stratification. For some species, the first cool-stratification period is not necessary and practitioners begin with warm-stratification. Embryo growth may occur during warm or cool- moist stratification and the cool-moist stratification overcomes dormancy. The order of these stratification periods and the duration varies for each species, but is typically around 30 to 90 days. This process is species specific and the protocols can be found in Appendix B2. Often a seed will germinate during warm stratification, but it is important to continue with pre-treatments as described to ensure the seedling fully emerges. If a seed has fully emerged (showing both the root and first leaves) it can be carefully transplanted to soil medium.

**Seed coat scarification**

Some species require scarification of the seed coat so water can reach and be taken up by the embryo, called imbibition (Baskin and Baskin 1998). Scarification is commonly required for legumes and species that are animal dispersed, including many of our berry producing shrubs.

There are many methods for overcoming physical dormancy listed in Baskin and Baskin (1998). Two of these methods were recommended for our study species. Scarification can occur through chemicals such as 50% to 98 % sulphuric acid, or physically by damaging the seed coat, such as rubbing seeds between sandpaper, or shaking seeds in a container with rocks or other abrasive materials. Bearberry has a plug made of woody material that blocks a channel in the seed coat that stops the radicle from emerging and water from entering the seed (Young and Young 1992). Soaking this seed in sulphuric acid dissolves this plug and allows water to enter the seed.

**Leaching germination inhibitors**

The last pre-treatment protocol is the leaching of germination inhibitors, such as in silverberry seeds (Fung 1984). This seed must be repeatedly soaked in warm water to remove germination inhibitors before placing the seed into cool stratification.

**Germination protocols**

After overcoming dormancy in your seed using pre-treatments, seeds can germinate if temperature, light, and substrates conditions are appropriate. Moisture must be adequate for the germination of all species. Seeds can be planted in a soil medium such as a potting mix that retains water, but allows for drainage and for young roots to easily move through the soil. Most of our species germinate in typical greenhouse conditions, with fluctuating temperatures of approximately 25/15°C and light/ dark cycles of 12/12 hours to 8/16 hours a day. Some species, such as junipers, require cooler temperatures to germinate (Tylkowski 2009). Labrador tea and mountain cranberry germinate best at higher temperatures, approximately 30°C and are sensitive to soil pH (Karlin and Bliss 1983, Royal Botanic Gardens Kew 2016). Some species are mycorrhizal and may require inoculation with fungal spores to thrive, or they may be parasitic and rely on other species for nutrients, shortly after their seeds have germinated. For instance, Indian paint brush will lose vigor if host plants are not introduced shortly after they begin to grow (Luna 2005).

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Young, J.A., and C.G. Young. 1992. *Seeds of Woody Plants in North America*. Revised edi. Timber Press, Portland, OR.

## References and further reading

## Native plant resources general:


1. Plant distributions, photos, may include some detailed characteristics of common native plants: https://plants.usda.gov/java/
2. From the Native Plant Society of Saskatchewan, general collection, processing and growing of prairie plants: https://www.npss.sk.ca/docs/2_pdf/NPSS_NativeSeedHarvestingandMarketing.pdf
3. Nursery manual for native plants: A guide for tribal nurseries www2.gov.bc.ca/.../farming.../agriculture.../nursery-plant-production-guide.pdf
4. Contains links to many sources related to native plant propagation and collection: https://www.nsl.fs.fed.us/nsl_wpsm.html
5. Plant guide for Alberta species restoration, includes collection, processing, storage and propagation information for individual species: https://era.library.ualberta.ca/files/gm80hv565#.WPjV12nyvIU
6. The Woody Plant Seed Manual https://www.treesearch.fs.fed.us/pubs/32626
7. Seed collecting manual https://www.kew.org/sites/default/files/ENSCONET_Collecting_protocol_English.pdf
8. Grow me instead guides, for native plant gardening: http://www.ontarioinvasiveplants.ca/resources/grow-me-instead
9. Links for seed collection protocols, seed banking, and a full manual for seed collectors http://www.kew.org/science/collections/seed-collection/millennium-seed-bank-resources


## Books:


1. Young, J. A., and C. G. Young. 1992. *Seeds of Woody Plants in North America*. TimberPress, Portland.
2. Young, J., and C. G. Young. 1986. *Collecting processing and germinating seed of wildland plants*. Timber Press, Portland, OR.

3. Phillips, H. 1985. *Growing and propagating wild flowers*. University of North Carolina Press, Chapel Hill and London.

### Seed development:

1. From forestry department of the Food and Agricultural Organization (FAO) of the UN: http://www.fao.org/docrep/006/ad232e/AD232E02.htm

2. http://rubisco.ugr.es/fisiofar/pagwebinmalcb/contenidos/Tema27/seeds.pdf (advanced)

### Books:

1. Baskin, J., and C. Baskin. 1998. *Seeds: Ecology, Biogeography, and Evolution of Dormancy and Germination*. Page Crop Science. Academic Press, San Diego.

### Seed processing equipment:

1. Seed processing equipment for sale and descriptions: http://reveg-catalog.tamu.edu/12- Seed%20Processing.htm

2. Make your own solar kiln. http://www.popularwoodworking.com/projects/solar-kiln

### Seed quality standards

1. Native seed quality bulletin, seed purity, viability testing https://d3n8a8pro7vhmx.cloudfront.net/aosa/pages/33/attachments/original/1422394702/Nati ve_Seed_Quality_Bulletin_Sept_2012r.pdf?1422394702

2. Association of Official seed analysts, link to seed quality standards and testing procedures: http://www.aosaseed.com/

### Seed storage:

1. Seed storage behaviour database: http://data.kew.org/sid/

2. Resources for long term seed storage: http://www.kew.org/science/collections/seed- collection/millennium-seed-bank-resources

How to determine seed moisture content:

3. https://www.seedtest.org/upload/cms/user/GRINDINGINISTAMOISTURETESTING2008- 09-14Annex.pdf

4. http://www.bioversityinternational.org/fileadmin/bioversity/publications/Web_version/188/c h05.htm

## Seed propagation and nursery establishment:

1. Native plant network, plant propagation protocol database: https://npn.rngr.net/propagation/protocols

2. Database containing some germination protocols: http://data.kew.org/sid/

## Revegetation manuals

1. http://yukonrevegetationmanual.ca/

2. http://anpc.ab.ca/wp-content/uploads/2015/10/2001-NativePlantRevegetationGuidelinesForAlberta-Feb-2001.pdf

## Native seed marketing

1. https://www.npss.sk.ca/docs/2_pdf/NPSS_NativeSeedHarvestingandMarketing.pdf

2. https://d3n8a8pro7vhmx.cloudfront.net/aosa/pages/33/attachments/original/1422394702/Nati ve_Seed_Quality_Bulletin_Sept_2012r.pdf?1422394702

## Tables

Table 3. List of all plant species sampled for seed collection and processing protocols ($N$ = 60). Plant names validated from https://www.itis.gov/ in June 2017.

| Scientific Name | Common Name | Family |
|---|---|---|
| *Achillea millefolium* | common yarrow | Asteraceae |
| *Agrostis scabra* | ticklegrass | Poaceae |
| *Alnus incana ssp. rugosa* | speckled alder | Betulaceae |
| *Alnus viridis ssp. crispa* | mountain alder | Betulaceae |
| *Amelanchier sanguinea* | roundleaf serviceberry | Rosaceae |
| *Anemone canadensis* | Canada anemone | Ranunculaceae |
| *Anemone multifida* | cutleaf anemone | Ranunculaceae |
| *Anthoxanthum nitens* | sweetgrass | Poaceae |
| *Aquilegia brevistyla* | smallflower columbine | Ranunculaceae |
| *Arctostaphylos uva-ursi* | bearberry, kinnikinnick | Ericaceae |
| *Betula glandulosa* | resin birch | Betulaceae |
| *Betula papyrifera* | paper birch | Betulaceae |
| *Bromus ciliatus* | fringed brome | Poaceae |
| *Calamagrostis canadensis* | bluejoint | Poaceae |
| *Carex aurea* | golden sedge | Cyperaceae |
| *Castilleja septentrionalis* | Labrador indian paintbrush | Orobanchaceae |
| *Chamerion angustifolium ssp. angustifolium* | fireweed | Onagraceae |
| *Cornus canadensis* | Canadian bunchberry | Cornaceae |
| *Cornus sericea* ssp. *sericea* | redosier dogwood | Cornaceae |
| *Dasiphora fruticosa* | shrubby cinquefoil | Rosaceae |
| *Doellingeria umbellata* | parasol whitetop | Asteraceae |
| *Elaeagnus commutata* | silverberry | Elaeagnaceae |
| *Elymus trachycaulus* | slender wheatgrass | Poaceae |
| *Erigeron hyssopifolius* | hyssopleaf fleabane | Asteraceae |
| *Fragaria virginiana* | wild strawberry | Rosaceae |
| *Galium boreale* | northern bedstraw | Rubiaceae |
| *Hordeum jubatum* | foxtail barley | Poaceae |
| *Juncus dudleyi* | Dudley's rush | Juncaceae |
| *Juniperus communis* | common juniper | Cupressaceae |
| *Juniperus horizontalis* | creeping juniper | Cupressaceae |
| *Lathyrus palustris* | marsh vetchling | Fabaceae |
| *Maianthemum stellatum* | star false Solomon's-seal | Asparagaceae |
| *Mertensia paniculata* | tall bluebells | Boraginaceae |
| *Physocarpus opulifolius* | common ninebark | Rosaceae |
| *Picea glauca* | white spruce | Pinaceae |
| *Picea mariana* | black spruce | Pinaceae |

| Scientific Name | Common Name | Family |
|---|---|---|
| *Pinus banksiana* | jack pine | Pinaceae |
| *Poa palustris* | fowl bluegrass | Poaceae |
| *Populus balsamifera* | balsam poplar | Salicaceae |
| *Populus tremuloides* | quaking aspen | Salicaceae |
| *Potentilla anserina* | silverweed cinquefoil | Rosaceae |
| *Primula mistassinica* | bird's-eye primrose | Primulaceae |
| *Prunella vulgaris* | heal all | Lamiaceae |
| *Rhamnus alnifolia* | alderleaf buckthorn | Rhamnaeae |
| *Rhododendron groenlandicum* | bog Labrador tea | Ericaceae |
| *Ribes triste* | red currant | Grossulariaceae |
| *Rosa acicularis* | prickly rose | Rosaceae |
| *Rubus idaeus* | American red raspberry | Rosaceae |
| *Rubus pubescens* | dwarf red raspberry | Rosaceae |
| *Salix pseudomonticola* | false mountain willow | Salicaceae |
| *Shepherdia canadensis* | russet buffaloberry | Elaeagnaceae |
| *Sisyrinchium montanum* | mountain blue-eyed grass | Iridaceae |
| *Solidago canadensis* | Canada goldenrod | Asteraceae |
| *Solidago nemoralis* | gray goldenrod | Asteraceae |
| *Sorbus decora* | northern mountain-ash | Rosaceae |
| *Symphyotrichum robynsianum* | Robyn's aster | Asteraceae |
| *Thalictrum confine* | northern meadowrue | Ranunculaceae |
| *Vaccinium vitis-idaea* | lingonberry | Ericaceae |
| *Viburnum edule* | squashberry | Adoxaceae |
| *Vicia americana* | American vetch | Fabaceae |

Table 4. Protocols summary (N = 60). *denotes information is incomplete for species, information is best summary for genus, +denotes gibberellic acid added to replace or shorten cool stratification, (A) denotes acid scarify before stratification, (W) denotes adding a period of warm stratification for 60days.

| Plant name | Species | Collection tools | Cleaning method | Seed behaviour | Pre-treatments |
|---|---|---|---|---|---|
| common yarrow | *Achillea millefolium* | Scissors | Thresh, winnow | Orthodox | None |
| ticklegrass | *Agrostis scabra* | Scissors<br>Mechanical harvestor | Thresh, winnow | Orthodox | Cool stratification (<90 days) |
| speckled alder | *Alnus incana ssp. rugosa* | Berry rake | Thresh, winnow, thresh, sieve | Orthodox | Cool stratification (<90 days) |
| mountain alder | *Alnus viridis ssp. crispa* | Berry rake | Thresh, winnow, thresh, sieve | Orthodox | Cool stratification (<90 days) |
| roundleaf serviceberry | *Amelanchier sanguinea* | Hand<br>Berry rake | Blender, dry, thresh, winnow | Orthodox | Cool stratification (90 to 180 days) |
| Canada anemone | *Anemone canadensis* | Hand<br>Scissors | Thresh, sieve | Orthodox | *Warm (+/-90days), Cool (+/-90days) stratification |
| cutleaf anemone | *Anemone multifida* | Scissors | Uncertain | Orthodox | *Cool stratification (90 to 180 days) |
| sweetgrass | *Anthoxanthum nitens* | Scissors<br>Mechanical harvestor | Thresh, winnow | Orthodox | Cool stratification (<90 days) |
| smallflower columbine | *Aquilegia brevistyla* | Hand<br>Scissors | Thresh, sieve | Orthodox | *Cool stratification (90 to 180 days) |
| bearberry, kinnikinnick | *Arctostaphylos uva-ursi* | Hand | Thresh, float | Orthodox | Seed coat scarification (chemical) then Cool stratification |
| resin birch | *Betula glandulosa* | Hand | Thresh, winnow, thresh, sieve | Orthodox | Cool stratification (<90 days) |
| paper birch | *Betula papyrifera* | Hand<br>Pole and Hook | Thresh, winnow, thresh, sieve | Orthodox | Cool stratification (<90 days) |
| fringed brome | *Bromus ciliatus* | Scissors | Thresh (gentle), sieve | Orthodox | None |
| bluejoint | *Calamagrostis canadensis* | Scissors | Thresh (flat), sieve | Orthodox | None |
| golden sedge | *Carex aurea* | Scissors | Thresh, winnow | Orthodox | Cool stratification (<90 days) |
| Labrador indian paintbrush | *Castilleja septentrionalis* | Hand<br>Scissors | Thresh, sieve | Orthodox | Cool stratification (90 to 180 days) |
| fireweed | *Chamerion angustifolium ssp. angustifolium* | Hand<br>Scissors | Vacuum method | Orthodox | Cool stratification (<90 days) |
| Canadian bunchberry | *Cornus canadensis* | Hand | Thresh, dry, thresh, winnow | Orthodox | Cool stratification (90 to 180 days) |
| redosier dogwood | *Cornus sericea* ssp. *sericea* | Hand<br>Berry rake | Thresh, dry, thresh, winnow | Orthodox | Cool stratification (<90 days) |
| shrubby cinquefoil | *Dasiphora fruticosa* | Hand<br>Scissors | Thresh (gentle), sieve, winnow | Orthodox | None |
| parasol whitetop | *Doellingeria umbellata* | Scissors | Vacuum seed, thresh, winnow | Orthodox | *None |

| Plant name | Species | Collection tools | Cleaning method | Seed behaviour | Pre-treatments |
|---|---|---|---|---|---|
| silverberry | *Elaeagnus commutata* | Hand | Thresh, float | Orthodox | Cool stratification & chemical leaching (rinse seed in warm water 48 hours) |
| slender wheatgrass | *Elymus trachycaulus* | Scissors | Thresh (gentle), winnow, sieve | Orthodox | Cool stratification (<90 days) |
| hyssopleaf fleabane | *Erigeron hyssopifolius* | Scissors Vacuum | Thresh, winnow | Orthodox | *None |
| wild strawberry | *Fragaria virginiana* | Hand | Blender, dry, thresh, winnow | Orthodox | Cool stratification (90 to 180 days) |
| northern bedstraw | *Galium boreale* | Scissors | Thresh, sieve | Uncertain | *Cool stratification (<90 days) |
| foxtail barley | *Hordeum jubatum* | Scissors Vacuum | Thresh, repeat, sieve | Orthodox | *Cool stratification (<90 days) |
| Dudley's rush | *Juncus dudleyi* | Scissors | Thresh, sieve | Orthodox | *Cool stratification (<90 days) |
| common juniper | *Juniperus communis* | Hand | Thresh, float | Orthodox | Warm (+/-90days), Cool (+/-90days) stratification (removing seed after 6 weeks into warm stratification and allowing to dry, apparently enhances germination %), |
| creeping juniper | *Juniperus horizontalis* | Hand | Thresh, float | Orthodox | (A) Warm (+/-90days), Cool (+/-90days) stratification |
| marsh vetchling | *Lathyrus palustris* | Hand Scissors | Thresh, sieve | Orthodox | Seed coat scarification (mechanical) |
| star false Solomon's-seal | *Maianthemum stellatum* | Hand | Thresh, float, thresh, winnow | Orthodox | Warm (+/-90days), Cool (+/-90days) stratification |
| tall bluebells | *Mertensia paniculata* | Hand Scissors | Thresh, winnow | Orthodox | Cool stratification (<90 days) |
| common ninebark | *Physocarpus opulifolius* | Hand | Thresh, sieve, winnow | Orthodox | Cool stratification (90 to 180 days) |
| white spruce | *Picea glauca* | Saw | Cone extraction method | Orthodox | *None |
| black spruce | *Picea mariana* | Saw | Cone extraction method | Orthodox | Cold stratification (<90 days) |
| jack pine | *Pinus banksiana* | Pole pruner Saw | Cone extraction method | Orthodox | Cool stratification (<90 days) |
| fowl bluegrass | *Poa palustris* | Scissors Mechanical harvestor | Thresh, sieve, winnow | Orthodox | None |
| balsam poplar | *Populus balsamifera* | Pole and hook Pole pruner | Vacuum method | Orthodox | None |
| quaking aspen | *Populus tremuloides* | Pole and hook Pole pruner | Vacuum method | Orthodox | None |
| silverweed cinquefoil | *Potentilla anserina* | Hand | Thresh, winnow | Orthodox | *(A) Cool stratification (<90 days) |
| bird's-eye primrose | *Primula mistassinica* | Scissors | Thresh, sieve | Orthodox | Cool stratification (<90 days) None |
| heal all | *Prunella vulgaris* | Scissors | Thresh, sieve, winnow | Orthodox | |
| alderleaf buckthorn | *Rhamnus alnifolia* | Hand Berry rake | Thresh (firm), float, dry, thresh, winnow | Orthodox | Cool stratification (90 to 180 days) |

| Plant name | Species | Collection tools | Cleaning method | Seed behaviour | Pre-treatments |
|---|---|---|---|---|---|
| bog Labrador tea | *Rhododendron groenlandicum* | Hand<br>Berry rake | Thresh, sieve | Orthodox | Cool stratification (<90 days) |
| red currant | *Ribes triste* | Hand<br>Berry rake | Blender, dry, thresh, winnow | Orthodox | *Cool stratification (90 to 180 days) |
| prickly rose | *Rosa acicularis* | Hand<br>Berry rake | Blender, dry, thresh, winnow | Orthodox | Warm (+/-90days), Cool (+/-90days) stratification |
| American red raspberry | *Rubus idaeus* | Hand | Blender, float | Orthodox | Seed coat scarification (chemical) then Cool stratification |
| dwarf red raspberry | *Rubus pubescens* | Hand | Blender, dry, thresh, winnow | Orthodox | Cold stratification (90 to 180 days) |
| false mountain willow | *Salix pseudomonticola* | Hand | Vacuum method | Orthodox | None |
| russet buffaloberry | *Shepherdia canadensis* | Hand | Dry whole fruit OR Blender, dry, thresh, winnow | Orthodox | Seed coat scarification (chemical) then Cool stratification |
| mountain blue-eyed grass | *Sisyrinchium montanum* | Scissors | Thresh, sieve | Orthodox | (+) Warm (+/-90days), Cool (+/-90days) stratification |
| Canada goldenrod | *Solidago canadensis* | Scissors | Vacuum seed, thresh, winnow | Orthodox | Cool stratification (<90 days) |
| gray goldenrod | *Solidago nemoralis* | Scissors | Vacuum seed, thresh, winnow | Orthodox | Cool stratification (<90 days) |
| northern mountain-ash | *Sorbus decora* | Pole and hook | Thresh, float, dry, thresh, winnow | Orthodox | Cool stratification (90 to 180 days) |
| Robyn's aster | *Symphyotrichum robynsianum* | Scissors | Vacuum seed, thresh, winnow | Orthodox | *None |
| northern meadowrue | *Thalictrum confine* | Scissors | Thresh, sieve | Orthodox | *Cool stratification (90 to 180 days) |
| lingonberry | *Vaccinium vitis-idaea* | Hand | Blender, dry, thresh, winnow | Orthodox | Cool stratification (90 to 180 days) |
| squashberry | *Viburnum edule* | Hand<br>Berry rake | Dry whole fruit OR Blender, dry, thresh, winnow | Orthodox | Warm (+/-90days), Cool (+/-90days) stratification |
| American vetch | *Vicia americana* | Hand<br>Scissors | Thresh, sieve | Orthodox | Seed coat scarification (mechanical) |

*citations can be found in the appendix

## Species profile format

**Common name Family:**

**Scientific name: Cree Name:**

Synonyms: Describes a common previous name used for this species.

| **Quick Seed Guide** |
|---|
| **When and what to collect**: |
| **Seed Processing**: |
| **Storage:** |
| **Pre-treatment of seed:** |
| **How to Grow:** |

**General**
**Plant Description:** A description of the plants appearance
**Field Identification:** Similar species are identified and key physical traits to confirm a species identity in the field
**Life Form:**
**Reproduction:** Describes how this species reproduces in the natural environment.

**Continental Range:** Where this species is found in Canada and the US
**Hudson Bay Lowland Range:** How common this species is in the Hudson Bay Lowland region
**Habitat:** In what environment does this species typically grow, including exposure, soil type, recent disturbance, etc.

**Reclamation value**
**Nitrogen fixing:** yes or no
**Symbioses:** Describes any known bacterial or fungal relationships with this plant.
**Growth rate:** slow, moderate or fast as described in the literature
**Successional stage**: early, mid, to late successional

**Seed properties**
**Fruit description:** Includes the type of propagule, colour at maturity, size, etc
**Dispersal:** How does the seed from this species disperse
**Fruit weight:**
**Seeds /propagule:**
**Seed size and description:** Describes the seed dimensions and a general shape description
**Average seed weight:**
**Seeds/kg:**

**Seed Collection**
**Timing collections:** Includes the time of season for seed collection and an idea of how broad the collection window is for the species

**Collection protocols:** Describes our best approach to collecting seed for this species
**Collection effort:** (g/hour) The collection rate determined in our study from wild populations, the amount of seed collected in one hour, (seed is dried and cleaned and weight is corrected for seed purity).
**Potential density:** If available, the amount of seed that be collected in a given area.
**Cautions:** cautions such a thorns or poisonous berries are noted here

**Seed processing and cleaning**
**Post-harvest handling:** This section describes what to do with your seed once it has been collected to prepare for seed cleaning.
**Processing protocols:** We describe the best approach to seed cleaning as determined in our study.
**Cautions:** Any known cautions are described from the cleaning process

**Storage**
**Storage behaviour:** Provided from Royal botanical gardens (http://data.kew.org/sid/)
**Storage requirements and seed longevity:** Describes the best storage protocols for this species and how long seeds have been stored

**Seed propagation**
**Dormancy classification:** Seed dormancy which often describes a seeds requirements for pre-treatments, taken from Baskin and Baskin (1998)
**Potential viability:** Describes our viability results and those available from the literature.
**Pre-treatments:** This section describes the steps and protocols for treating seed, which achieved the best germination rates.
**Germination protocols:** Optimal germination environment for the species, including temperature, light/dark cycles, and soil medium is specified. Taken from the literature.
**Field planting:** If available, protocols and emergence rates from field planting seed.

**Other propagation methods:** Includes any vegetative propagation methods that are described in the literature or at the Native plant propagation database (https://npn.rngr.net/propagation/protocols)

**Canadian commercial sources:** Any known commercial sources from Canada are included here.

**Useful links and Further reading:**

**Literature cited**

**Glossary**

achene: a type of fruit that is dry and contains only a single seed, they do not dehisce to release their seed

actinorhizal: a plant that forms a mutually beneficial relationship with a bacteria that is able to convert nitrogen that is not usable by the plant into a useable form, in exchange for carbohydrates or other nutrients produced by the plant

adventitious roots: roots that develop from the stem or leaf of a plant

alkaline: a pH greater than 7

allelopathic: the chemical inhibition of plant growth from one plant to another, from germination or growth inhibitors

alternate leaf pattern: leaves occur singly, one after another, rather than in pairs or groups

alvar: a unique habitat, with almost no soil but large sheets of limestone rocks, giving rise to unique vegetation communities

arbuscular mycorrhiza: a type of fungus that lives in a plant's roots and increases the plant's access to water and soil nutrients in exchange for the carbohydrates or nutrients produced by the plant, a type of endomycorrhiza

arbutoid mycorrhiza: a type of mycorrhiza similar to ectomycorhiza but that penetrate the root cell. Arbutoid mycorrhiza associates with the plant family Ericaceae

Asteraceae: a large family of flowering plants, including the asters, goldenrods, fleabanes, and several others

awn: a slender bristle on the back of a glume or floret in grasses

basal leaves: the lower most leaves of the plant, often near the soil surface

berry rakes: a collection tool with multiple finger projections that help to collect certain berries and fruits

biennial: a lifecycle lasting two years

branch layering: a method of reproduction where a plant branch or stem develops roots from the buds that are in contact with the soil. This plant can then survive on its own if the branch is severed

broadcast seeding: seeds are simply scattered on the soil surface

bur: a seed appendage that is often hooked at the tip

catkins: a multi-flowered spike with scales, often unisexual either male or female caudex: a modified, thickened plant stem found at the base of some perennial plants, it will give rise to new shoots

chaff: a general term for plant material impurities, any material that is not required by the seed to grow. This can include leaves, stem pieces, empty seed, and pieces of seed appendages

climax communities: a plant community that does not undergo major changes in plant composition unless subject to a major disturbance (late successional)

clone: produced asexually, genetically identical

cool- moist stratification: seed is placed in moist conditions typically between 1 and 5°C for a period of time from 7 to over 120 days

compound leaf: a leaf made up of several leaflets, joined at the base by a stalk or at the branch

conifers: conifers are any plant in the order Coniferales. They are typically evergreen trees or shrubs with needle or scale-like leaves

cotyledon: the upper portion of the seeds embryo. There can be one or two cotyledons and they will form the primary leaves of a seedling

cover crop: a plant grown to improve soil conditions on the site and may be planted between other crops to improve soil fertility

cultivars: a plant species, bred in cultivation to enhance certain plant traits, such as flower colour

dark septate endophytes: a group of fungi that colonize plant roots, however they are not well described and their relationship with the plant is not well understood

deciduous: does not persist, often with reference to leaves that fall off at the end of the growing season.

dehiscent fruit: a fruit or propagule that will open to release seed dioecious: a species that has male and female organs on separate plants

disc flowers: asters have two types of flowers: the disc flowers are the center portion of the seed head, often tube shaped, the ray flowers surround these and resemble petals

druplet: an individual fruit containing a seed, that makes up an aggregated fruit, such as those in raspberries and blackberries

ectendomycorrhiza: found primarily in *Picea* and *Pinus* genera, similar to both ectomycorrhiza and endomycorrhiza, associated with disturbed sites and peatlands

ectomycorrhizal: a fungus that lives on the outside of plant roots and improves nutrient uptake for plants in exchange for carbohydrates or nutrients produced from the plant embryo: the living tissue inside the seed coat that can divide and grow to form a seedling

endomycorrhiza: see arbuscular mycorrhiza

endosperm: provides the embryo with nutrients as it develops within the seed. Usually endosperms are high in starchy, oils and/or proteins, but the presence and composition of endosperm varies by species

ericoid mycorrhiza: mycorrhiza species associated in particular with plants from the family Ericaceae, forming a network of fungal hyphae inside the root cell

erosion control: the process of stopping or controlling erosion (see erosion)

erosion: the process of soil loss or movement by wind, water, or other processes

fertilization: in plants this means a pollen grain fuses with the female gamete (ovule) to form a fertile egg that can eventually develop into a seed

fibrous roots: an extensive network of fine roots that grow in many directions through the soil

fixes nitrogen: nitrogen fixation is the process by which nitrogen from the air ($N_2$) is converted into another nitrogen compound

floret: a general term for a grass flower or seed and covering structures

follicle: a capsule-like fruit that splits open along one edge to release seed

fruit: we define fruit as both the structure that contains the seed, the seed itself and any other appendages that are attached to the seed or fruit

germinate: the emergence of the embryo through the seed coat. Once a seed germinates it can develop into a seedling if conditions are suitable

germination inhibitors: this includes any substances that stops or delays germination

gibberellic acid: a plant hormone used to enhance germination by breaking the dormancy of certain plant species

glume: a bract (often 2) at the base of a grass spikelet, containing the flowers

hardwood cuttings: cuttings taken from older growth (over 2 years), so the wood has hardened

HBL: Hudson Bay Lowlands

herbaceous plants: refers to plants without a woody stem, or with a stem that dies back every year, such as during winter

host plant: a plant that is parasitized by, or in mutual relationship with another plant or organism hybridized: two varieties of species that have cross bred to produce another plant that contains genetic components of both parents

hygrometer: an instrument that can be used to determine moisture content in the air

hypocotyl: the portion of the embryo between the radicle and the cotyledons that will push the leaves out of the soil and form a portion of the seedling stem

IBA: indole-3-butyric acid, a plant hormone that is sold to encourage plant root development on cuttings

imbibition: the absorption of water by the seed within the seed coat

indehiscent fruit: a fruit that does not separate from its seed, examples are nuts

inflorescence: the flowering portion of a plant that also includes the stalks and stems associated with the flowers

intermediate seed: seed that can withstand some drying and temperature declines, but are still more sensitive than orthodox seed and will lose viability if dried too low

involute: rolled inwards, towards the upper leaf surface

leaf sheath: in graminoids, leaves are attached to the stem by an extension of the leaf that wraps around the stem

leaflet: a leaf division, a small separated part of the leaf that makes up a compound leaf

lenticels: a small dot or line on the bark of trunks or young branches

ligule: in graminoids, a thin membranous flap found at the junction of the leaf and the stem or leaf sheath, used in the identification process

loamy sand: a soil made of a large portion sand by weight and up to 10% clay by weight

monoculture: a community or area composed of only one plant species, typical in cultivation

monoecious: a plant that has both male and female organs on one plant, but may have separate male and female flowers on the same plant

morphological dormancy: caused by underdeveloped or undifferentiated embryos at the time of seed dispersal. To break morphological dormancy the seed must be treated with conditions appropriate for embryo growth, which may be warm and/or cool stratification, depending on seed origin and species

morpho-physiological seed dormancy: this type of dormancy is the result of two dormancy causes: physiological dormancy (see physiological seed dormancy definition) and morphological dormancy

mulch: a material that provides an insulating cover to the soil surface, it is useful to reduce water loss and moderate temperatures on the soil surface mycorrhizal: an association that a plant forms with a fungi, that is mutually beneficial. The fungi forms a network with the roots of the plant. The fungi improves access to many plant nutrients and the plant provides the fungi with sugars

native plant: a plant that originated from the place that it is growing and has grown there for many years, it was not introduced to the region by human activities such as cultivation

non-dormant seed: do not have any mechanisms stopping them from germinating. By definition they do not require pre-treatments and can be immediately planted

non-dormant: seed that can be germinated at maturity

non-mycorrhizal: a plant that can grow without being associated with an endomycorhizal or ectomycorrhizal fungus

non-native plant: introduced to a region where it previously was not found to be growing, typically introduced by humans purposefully or accidentally

nurse crop: a plant grown for the purpose of helping another plant establish

open storage conditions: conditions that are exposed to air exchanges and room temperatures

opposite branching or leaf pattern: branches and/or leaves that occur along the stem in pairs, rather than one after another

orthodox seed: seed that can be dried to a low moisture content and freezing temperatures without losing viability in contrast to intermediate and recalcitrant seed

ovule: contained within the ovary of a female flower, there is often more than one ovule per ovary and they can develop into seeds if pollinated

parasitic plant: takes nutrients and resources from another living plant or organism

perennial: a plant that lives more than two years under suitable conditions

perfect flowers: a flower that has both male (stamens) and female (pistil) organs on the same flower

pericarp: derived from the ovary wall, sometimes consisting of three layers, typically the edible portion of the fruit we consume, but there are exceptions

perigynium: an outer layer that envelopes the achene of sedge or species in the family Cyperaceae

pH: a measure of acidity and alkalinity, based on the number of hydrogen ions in solution

phyllaries: small green bracts underneath the flowering head of an aster, collectively they make up the involucre physical seed dormancy: caused by the seed coat, fruit, or a structure that stop water from entering the seed, which is necessary for germination. To overcome physical dormancy, water must be allowed to enter the seed, often by scarification (see scarification definition)

physiological seed dormancy: is caused by a physiological mechanism inside the seed that prevents the radicle from piercing through the seed, rather than physical and or morphological features inside or outside of the seed. Physiological dormancy is further divided into three depths: non-deep, intermediate, and deep. Physiological dormancy is mostly overcome by warm and/or cool stratification

pioneer plant: frequently one of the first plant species found colonizing a site after a disturbance, such as fire, landslide, or from human activities

pistil: contains female reproductive organs including the stigma, style, and the ovary. This will eventually form a fruit and seed if they are pollinated

pollen: pollen is made up of many small grains or male gametes that can fertilize a female ovule, it is transported mostly by wind and insects

pre-treatment: refers to the conditions or handling that a seed requires before they can germinate

primocanes: a stem arising from existing stems, produced by raspberries (*Rubus* ssp.)

propagation: means to grow, this could include using seed or growing plants from vegetative materials, such as bulbs

provenance: the place of origin, for seed this would refer to the location that the seed was collected from

rachilla: the axis or stem of a spikelet in a grass

radicle: a radicle is a portion of the embryo that will puncture the seed coat and develop into the primary root of the seedling

ray flowers: asters have two types of flowers, the ray flowers resemble petals and surround the disk flowers

recalcitrant seed: seeds that are very sensitive to drying or moisture loss and will die if dried below a certain moisture content. They typically do not tolerate freezing temperatures, but some temperate species can be cooled without a complete loss of viability

reclamation: when referring to landscape reclamation it is the process of modifying a damaged landscape by stabilizing the terrain, making it aesthetically appealing, to a state where the site does not negatively impact the environment or human health and has a useful purpose (taken from SER international group 2004)

relative humidity: a measure of water vapour in the air relative to the possible amount of water vapour that could be held in the air at that same temperature rhizomatous: a plant that produces rhizomes (see rhizomes)

rhizomes: a modified stem that grows horizontally underground, not a true root. Rhizomes are important for plant regeneration and spread. Frequently new plants arise from buds along the length of the rhizome

root crown: the portion of the root from which the stem arises

root cuttings: pieces of root taken for propagating new plants

rooting hormone: a plant hormone that encourages a plant stem to begin producing root cells. The base of a stem cutting and the buds are often dipped in rooting hormone to encourage root development

rubber corrugated mat: refer to seed processing section of guide

saline tolerant: able to grow and survive on soils that contain higher than average levels of salt, plants that are extremely tolerant are called halophytes

scabrous: rough to touch

scarification: involves the alteration of the seed coat, in order to allow water to enter and encourage germination. This can be done using chemicals that weaken the seed coat, by heat and by scratching the seed coat

seed coat: the hardened outer layer of a seed that protects the embryo

seed dormancy: a state where seeds are not able to germinate because of physical, physiological, morphological, hormonal, and/or chemical constraints on the seed. A dormant seed cannot germinate in conditions that are typically favourable for germination until dormancy is overcome

seed purity: the percent of actual live seed your seed lot, that does not include leaf, seed appendages, visibly empty seed, and other types of chaff. For instance if your seed lot is 100g and 78g is actual seed and 22g is from chaff and empty seed, your seed purity would be 78%

seed storage behaviour: refers to the seed's tolerance to drying and cooling, orthodox seeds are one class and are the least sensitive, followed by intermediate, then recalcitrant seed

seeds moisture content: a measure of the moisture in the seed, measured as the weight of total moisture loss compared to the weight of the original sample, expressed as a percent

self-compatible: is able to be fertilized by its own pollen

semi-hardwood cuttings: a piece of branch cut from woody plants, typically from one or two year old growth, so the wood is still flexible but will break if bent in half

serotinous: an adaptation of cones or fruits to release their seeds late or after an environmental trigger such as fire or over a long period of time softwood cuttings: a stem cutting taken from the young new growth of a plant, where the wood is still soft and bendable

spike: an elongated flower head with multiple flower heads attached along the stem

spikelet: the smallest unit of flower clusters on a grass, made up of one or more florets, with two bracts at the base

stamen: contains the male anther and filament that provides pollen

stem cuttings: a piece of a plant stem taken as a propagule, will be rooted to produce another plant

stigma: the upper portion of the pistil (on a female flower) that receives pollen

stipule: a small leaf like appendage that occurs at the base of the leaf stalk where it meets the stem

stolon: a branch that grows horizontally from the base of the stem

stoloniferous: produces and spreads by stolons (see stolon)

strobilus: a cone like structure that bears spores and will eventually give rise to a cone containing seeds in conifers. They are not flowers, but have a similar function in reproduction for conifers

succession: the natural change in a landscape that occurs over time, through changes in plant species and soil

suckering: method of plant reproduction, by the production of suckers, a shoot that is produced from a root or the base of the stem, genetically identical to the plant it is developing from

Tetrazolium tests: this chemical (tetrazolium chloride) reacts with a seed's active embryo to produce a stain, if the embryo does not stain, the seed is considered non-viable (Cottrell 1948)

thicket: a dense growth of shrubby plants and stems

threshed: the separation of seed from the plant by means of hitting or rubbing materials and can be accomplished by hand, machinery, and was historically done by placing harvested material under tarps and allowing animals to walk over the plants

tillers: In grasses this is the production of new stems from existing ones, can be divided and survive on their own, or as a method of vegetative reproduction

vesicular arbuscular mycorrhiza: a type of arbuscular mycorrhiza that is characterized by the formation of vesicles

vigor: a measure of health

winnowing: the use of air streams to separate heavy materials from lightweight materials, typically seed from chaff

## Appendices

**Appendix A1: Target species list and families for Chapter 1 (*N* = 57). Plant names validated from https://www.itis.gov/ in June 2017.**

| Code | Plant scientific name | Common name | Family |
|---|---|---|---|
| ACMI | *Achillea millefolium* | common yarrow | Asteraceae |
| AGSC | *Agrostis scabra* | ticklegrass | Poaceae |
| ALIN | *Alnus incana* ssp. *rugosa* | speckled alder | Betulaceae |
| ALVI | *Alnus viridis* ssp. *crispa* | mountain alder | Betulaceae |
| AMSA | *Amelanchier sanguinea* | roundleaf serviceberry | Rosaceae |
| ANCA | *Anemone canadensis* | Canada anemone | Ranunculaceae |
| ANMU | *Anemone multifida* | cutleaf anemone | Ranunculaceae |
| ANNI | *Anthoxanthum nitens* | sweetgrass | Poaceae |
| AQBR | *Aquilegia brevistyla* | smallflower columbine | Ranunculaceae |
| ARUV | *Arctostaphylos uva-ursi* | bearberry, kinnikinnick | Ericaceae |
| BEGL | *Betula glandulosa* | resin birch | Betulaceae |
| BEPA | *Betula papyrifera* | paper birch | Betulaceae |
| BRCI | *Bromus ciliatus* | fringed brome | Poaceae |
| CACA | *Calamagrostis canadensis* | bluejoint | Poaceae |
| CAAU | *Carex aurea* | golden sedge | Cyperaceae |
| CASE | *Castilleja septentrionalis* | Labrador Indian paintbrush | Orobanchaceae |
| CHAN | *Chamerion angustifolium* ssp. *angustifolium* | fireweed | Onagraceae |
| COCA | *Cornus canadensis* | Canadian bunchberry | Cornaceae |
| COSE | *Cornus sericea* ssp. *sericea* | redosier dogwood | Cornaceae |
| DAFR | *Dasiphora fruticosa* | shrubby cinquefoil | Rosaceae |
| DOUM | *Doellengeria umbellata* | parasol whitetop | Elaeagnaceae |
| ELCO | *Elaeagnus commutata* | silverberry | Poaceae |
| ELTR | *Elymus trachycaulus* | slender wheatgrass | Asteraceae |
| ERHY | *Erigeron hyssopifolius* | hyssopleaf fleabane | Rosaceae |
| FRVI | *Fragaria virginiana* | wild strawberry | Rubiaceae |
| GABO | *Galium boreale* | northern bedstraw | Poaceae |
| HOJU | *Hordeum jubatum* | foxtail barley | Juncaceae |
| JUDU | *Juncus dudleyi* | Dudley's rush | Cupressaceae |
| JUCO | *Juniperus communis* | common juniper | Cupressaceae |
| JUHO | *Juniperus horizontalis* | creeping juniper | Fabaceae |
| LAPA | *Lathyrus palustris* | marsh vetchling | Asparagaceae |

| Code | Plant scientific name | Common name | Family |
|---|---|---|---|
| MAST | *Maianthemum stellatum* | star false Solomon's-seal | Boraginaceae |
| PHOP | *Physocarpus opulifolius* | common ninebark | Rosaceae |
| PIGL | *Picea glauca* | white spruce | Pinaceae |
| PIBA | *Pinus banksiana* | jack pine | Pinaceae |
| POPA | *Poa palustris* | fowl bluegrass | Poaceae |
| POBA | *Populus balsamifera* | balsam poplar | Salicaceae |
| POAN | *Potentilla anserina* | silverweed cinquefoil | Rosaceae |
| PRMI | *Primula mistassinica* | bird's-eye primrose | Primulaceae |
| PRVU | *Prunella vulgaris* | heal all | Lamiaceae |
| RHAL | *Rhamnus alnifolia* | alderleaf buckthorn | Rhamnaceae |
| RHGR | *Rhododendron groenlandicum* | bog Labrador tea | Ericaceae |
| RITR | *Ribes triste* | red currant | Grossulariaceae |
| ROAC | *Rosa acicularis* | prickly rose | Rosaceae |
| RUID | *Rubus idaeus* | American red raspberry | Rosaceae |
| RUPU | *Rubus pubescens* | dwarf red raspberry | Rosaceae |
| SAPS | *Salix pseudomonticola* | false mountain willow | Salicaceae |
| SHCA | *Shepherdia canadensis* | russet buffaloberry | Elaeagnaceae |
| SIMO | *Sisyrinchium montanum* | mountain blue-eyed grass | Iridaceae |
| SOCA | *Solidago canadensis* | Canada goldenrod | Asteraceae |
| SONE | *Solidago nemoralis* | gray goldenrod | Asteraceae |
| SODE | *Sorbus decora* | northern mountain-ash | Rosaceae |
| SYRO | *Symphyotrichum robynsianum* | Robyn's aster | Asteraceae |
| THCO | *Thalictrum confine* | northern meadowrue | Ranunculaceae |
| VAVI | *Vaccinium vitis-idaea* | lingonberry | Ericaceae |
| VIED | *Viburnum edule* | squashberry | Adoxaceae |
| VIAM | *Vicia americana* | American vetch | Fabaceae |

## Appendix A2: Seed Collection Questionnaire

**SPECIES COMMON NAME (LATIN NAME)**

**Part A: Please circle the best answer as it applies to each species.**

**1.** How would you describe your ability to identify this species? If you have any tips or tricks that help you to identify the plant please list below.

a. Is the species distinct from the others? Yes No

b. Can you identify/ name the plant by visual examination in the field? Yes No

**2.** How would you describe the ease of collecting this species? In addition, please circle specific obstacles from the list below and list any additional ones.

a. fruit was generally very easy to collect

b. fruit was moderately challenging to collect and had 1-2 obstacles affect collection

c. fruit was challenging to collect, 3 or more obstacles that affected collection

1. The fruit or seed is difficult to see and find on the plant.
2. The fruit is located only above arms reach.
3. The seeds are located only at ground level.
4. The seeds or fruit are singly distributed throughout plant (not in clumps or groups).
5. The plant and/or seeds are thorny or picky.
6. The plant is poisonous.
7. The fruit or seed does not easily detach from plant (ex. cannot be shaken into a bag or lightly pulled).
8. The fruit is not all ripe at the same time.
9. The plant is dioecious (Male/female separate plants)
10. Harvesting methods may cause death to parent plant.

Other_______________________________________________________________

**Part B: Best Protocols**

Please describe for the seed collection and seed processing of this species any strategies that you have found make collection and processing more efficient (faster, easier, more seeds, etc.,)

**Seed Collection** If your approach was simply by hand collection without any modified approach simply write HC. ___________________________________________

_________________________________________________________________________

_________________________________________________________________________

**Seed Processing** Please briefly describe this process, if unknown please write unknown.________________________________________________________

## Appendix A3: Data for all 12 attributes used to score the species (N=57). See text for details.

| Species | Regional distribution (% presence) | Median cover class | Collection obstacles | Identification effort | Collection rate (seeds $hr^{-1}$) | Cleaning effort | Average purity (%) | Seed behaviour classification | Longevity | Average viability (%) | Pretreatment requirements | Germination conditions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ACMI | 73 | 2 | 0 | easy | 352132 | easy | 94 | orthodox | long term | 95 | none | standard |
| AGSC | 55 | 2 | 0 | easy | 879400 | moderate | 99 | orthodox | short term | 85 | simple | standard |
| ALCR | 75 | 4 | 0 | easy | 503460 | difficult | 75 | orthodox | long term | 56 | simple | standard |
| ALIN | 48 | 4 | 0 | easy | 268307 | difficult | 64 | orthodox | short term | 19 | simple | standard |
| AMSA | 39 | 3 | 1-2 | easy | 2429 | difficult | 87 | orthodox | long term | 54 | complex | standard |
| ANCA | 45 | 2 | 0 | easy | 22513 | easy | 100 | orthodox | short term | 73 | complex | standard |
| ANMU | 14 | 1 | 0 | easy | 112937 | difficult | 52 | orthodox | long term | 86 | complex | standard |
| ANNI | 29 | 2 | 0 | easy | 119323 | moderate | 95 | orthodox | long term | 64 | simple | standard |
| AQBR | 5 | 1 | 0 | easy | 122806 | easy | 99 | orthodox | long term | 95 | simple | standard |
| ARUV | 16 | 3 | 1-2 | easy | 8102 | moderate | 99 | orthodox | long term | 73 | complex | standard |
| BEGL | 30 | 4 | 0 | easy | 372232 | moderate | 91 | orthodox | long term | 14 | simple | standard |
| BEPA | 32 | 4 | 1-2 | easy | 765908 | moderate | 85 | orthodox | short term | 21 | simple | standard |
| BRCI | 16 | 1 | 0 | moderate | 155080 | moderate | 98 | orthodox | short term | 80 | none | standard |
| CAAU | 29 | 1 | 1-2 | easy | 23569 | easy | 99 | orthodox | long term | 99 | simple | standard |
| CACA | 46 | 4 | 0 | moderate | 205387 | moderate | 97 | orthodox | short term | 74 | none | standard |
| CASE | 32 | 1 | 0 | easy | 295278 | easy | 91 | orthodox | short term | 58 | simple | standard |
| CHAN | 70 | 2 | 0 | easy | 2715238 | moderate | 98 | orthodox | short term | 64 | simple | standard |
| COCA | 39 | 3 | 1-2 | easy | 4212 | difficult | 100 | orthodox | short term | 88 | complex | standard |
| COSE | 70 | 4 | 0 | easy | 5685 | moderate | 99 | orthodox | long term | 98 | complex | standard |
| DAFR | 43 | 4 | 0 | easy | 21563 | difficult | 61 | orthodox | short term | 83 | none | standard |
| DOUM | 32 | 2 | 0 | difficult | 216666 | difficult | 88 | orthodox | short term | 65 | simple | standard |
| ELCO | 13 | 3 | 0 | easy | 828 | easy | 100 | orthodox | short term | 91 | complex | standard |
| ACMI | 73 | 2 | 0 | easy | 363270 | easy | 94 | orthodox | long term | 95 | none | standard |

| Species | Regional distribution (% presence) | Median cover class | Collection obstacles | Identification effort | Collection rate (seeds hr$^{-1}$) | Cleaning effort | Average purity (%) | Seed behaviour classification | Longevity | Average viability (%) | Pretreatment requirements | Germination conditions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AGSC | 55 | 2 | 0 | easy | 879400 | moderate | 99 | orthodox | short term | 85 | simple | standard |
| ALCR | 75 | 4 | 0 | easy | 298942 | difficult | 75 | orthodox | long term | 56 | simple | standard |
| ALIN | 48 | 4 | 0 | easy | 451867 | difficult | 64 | orthodox | short term | 19 | simple | standard |
| AMSA | 39 | 3 | 1-2 | easy | 2467 | difficult | 87 | orthodox | long term | 54 | complex | standard |
| ANCA | 45 | 2 | 0 | easy | 22513 | easy | 100 | orthodox | short term | 73 | complex | standard |
| ANMU | 14 | 1 | 0 | easy | 112937 | difficult | 52 | orthodox | long term | 86 | complex | standard |
| ANNI | 29 | 2 | 0 | easy | 119323 | moderate | 95 | orthodox | long term | 64 | simple | standard |
| AQBR | 5 | 1 | 0 | easy | 122806 | easy | 99 | orthodox | long term | 95 | simple | standard |
| ARUV | 16 | 3 | 1-2 | easy | 8102 | moderate | 99 | orthodox | long term | 73 | complex | standard |
| BEGL | 30 | 4 | 0 | easy | 372232 | moderate | 91 | orthodox | long term | 14 | simple | standard |
| BEPA | 32 | 4 | 1-2 | easy | 765908 | moderate | 85 | orthodox | short term | 21 | simple | standard |
| BRCI | 16 | 1 | 0 | moderate | 155080 | moderate | 98 | orthodox | short term | 80 | none | standard |
| CAAU | 29 | 1 | 1-2 | easy | 23951 | easy | 99 | orthodox | long term | 99 | simple | standard |
| CACA | 46 | 4 | 0 | moderate | 202113 | moderate | 97 | orthodox | short term | 74 | none | standard |
| CASE | 32 | 1 | 0 | easy | 277918 | easy | 91 | orthodox | short term | 58 | simple | standard |
| CHAN | 70 | 2 | 0 | easy | 2715238 | moderate | 98 | orthodox | short term | 64 | simple | standard |
| COCA | 39 | 3 | 1-2 | easy | 4212 | difficult | 100 | orthodox | short term | 88 | complex | standard |
| COSE | 70 | 4 | 0 | easy | 5685 | moderate | 99 | orthodox | long term | 98 | complex | standard |
| DAFR | 43 | 4 | 0 | easy | 21563 | difficult | 61 | orthodox | short term | 83 | none | standard |
| DOUM | 32 | 2 | 0 | difficult | 216666 | difficult | 88 | orthodox | short term | 65 | simple | standard |
| ELCO | 13 | 3 | 0 | easy | 828 | easy | 100 | orthodox | short term | 91 | complex | standard |
| ELTR | 29 | 2 | 0 | easy | 274544 | easy | 99 | orthodox | short term | 98 | simple | standard |
| ERHY | 30 | 2 | 1-2 | easy | 60092 | moderate | 94 | orthodox | short term | 96 | none | standard |
| FRVI | 54 | 3 | 0 | easy | 12054 | moderate | 100 | orthodox | long term | 97 | simple | standard |

| Species | Regional distribution (% presence) | Median cover class | Collection obstacles | Identification effort | Collection rate (seeds $hr^{-1}$) | Cleaning effort | Average purity (%) | Seed behaviour classification | Longevity | Average viability (%) | Pretreatment requirements | Germination conditions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GABO | 52 | 2 | 0 | easy | 105633 | easy | 98 | orthodox | transient | 89 | complex | standard |
| HOJU | 4 | 6 | 0 | easy | 586094 | difficult | 82 | orthodox | long term | 100 | none | standard |
| JUCO | 27 | 3 | >2 | easy | 5735 | moderate | 100 | orthodox | long term | 88 | complex | specific |
| JUDU | 14 | 3 | 0 | moderate | 23288915 | easy | 100 | orthodox | long term | 93 | simple | standard |
| JUHO | 13 | 4 | 1-2 | easy | 3456 | moderate | 98 | orthodox | long term | 50 | complex | specific |
| LAPA | 41 | 1 | 1-2 | moderate | 250 | easy | 100 | orthodox | long term | 97 | complex | standard |
| MAST | 48 | 3 | 0 | easy | 922 | moderate | 100 | orthodox | short term | 95 | complex | standard |
| PHOP | 30 | 3 | 0 | easy | 99164 | moderate | 99 | orthodox | short term | 54 | simple | standard |
| PIBA | 4 | 5 | 1-2 | easy | 37610 | difficult | 98 | orthodox | long term | 98 | simple | standard |
| PIGL | 64 | 5 | >2 | easy | 40705 | difficult | 80 | orthodox | long term | 32 | none | standard |
| POAN | 59 | 3 | 1-2 | easy | 7041 | easy | 98 | orthodox | short term | 88 | simple | standard |
| POBA | 86 | 5 | 1-2 | easy | 959705 | moderate | 100 | orthodox | transient | 100 | none | standard |
| POPA | 68 | 2 | 0 | moderate | 3899575 | moderate | 94 | orthodox | long term | 79 | none | standard |
| PRMI | 34 | 1 | 1-2 | easy | 100234 | easy | 98 | orthodox | short term | 100 | simple | standard |
| PRVU | 38 | 2 | 1-2 | easy | 69684 | easy | 99 | orthodox | short term | 94 | none | standard |
| RHAL | 27 | 3 | 0 | easy | 4294 | moderate | 98 | orthodox | short term | 45 | simple | standard |
| RHGR | 25 | 4 | 0 | easy | 2013090 | easy | 57 | orthodox | short term | 31 | simple | specific |
| RITR | 45 | 2 | 0 | easy | 6536 | easy | 99 | orthodox | long term | 95 | simple | standard |
| ROAC | 68 | 4 | 1-2 | moderate | 25061 | moderate | 99 | orthodox | short term | 77 | complex | standard |
| RUID | 21 | 3 | 0 | easy | 32418 | easy | 99 | orthodox | long term | 92 | complex | standard |
| RUPU | 66 | 3 | 1-2 | easy | 3878 | moderate | 99 | orthodox | short term | 46 | complex | standard |
| SAMY | 66 | 4 | 1-2 | difficult | 186942 | moderate | 94 | orthodox | transient | 83 | none | standard |
| SHCA | 43 | 3 | 1-2 | easy | 2035 | difficult | 99 | orthodox | short term | 79 | complex | standard |
| SIMO | 38 | 1 | 0 | easy | 53709 | easy | 100 | orthodox | short term | 100 | complex | standard |

| Species | Regional distribution (% presence) | Median cover class | Collection obstacles | Identification effort | Collection rate (seeds $hr^{-1}$) | Cleaning effort | Average purity (%) | Seed behaviour classification | Longevity | Average viability (%) | Pretreatment requirements | Germination conditions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SOCA | 39 | 2 | 0 | difficult | 412636 | difficult | 73 | orthodox | short term | 86 | simple | standard |
| SODE | 14 | 3 | 1-2 | easy | 6727 | difficult | 89 | orthodox | short term | 91 | simple | standard |
| SONE | 43 | 2 | 0 | difficult | 239651 | difficult | 83 | orthodox | long term | 84 | simple | standard |
| SYNO | 54 | 2 | 0 | difficult | 74863 | difficult | 85 | orthodox | short term | 71 | simple | standard |
| THVE | 63 | 3 | 1-2 | easy | 33110 | easy | 99 | orthodox | short term | 59 | complex | standard |
| VAVI | 16 | 4 | 1-2 | easy | 32090 | moderate | 96 | orthodox | long term | 92 | simple | specific |
| VIAM | 59 | 1 | 0 | moderate | 879 | easy | 100 | orthodox | long term | 98 | complex | standard |
| VIED | 55 | 4 | 0 | easy | 4711 | moderate | 99 | orthodox | long term | 99 | complex | standard |

## Appendix B1: Sample forecasting calendar for planning wild seed collection

| Species | January | | | Februar | | | March | | | April | | | May | | | June | | | July | | | August | | | September | | | October | | | November | | | December | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Picea mariana* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| *Pinus banksiana* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| *Salix myricoides* | | | | | | | | | | | | | | | | ! | ✓ | ✓ | ! | ✗ | | | | | | | | | | | | | | | | |
| *Populus tremuloides* | | | | | | | | | | | | | | | | | ! | ✓ | ✓ | ! | ! | ✗ | | | | | | | | | | | | | | |
| *Populus balsamifera* | | | | | | | | | | | | | | | | | | ! | ✓ | ! | ! | ✗ | | | | | | | | | | | | | | |
| *Anthoxanthum nitens* | | | | | | | | | | | | | | | | | | | ! | ✓ | ✓ | ! | ✗ | | | | | | | | | | | | | |
| *Fragaria virginiana* | | | | | | | | | | | | | | | | | | | ! | ! | ✓ | ✓ | ! | ✗ | | | | | | | | | | | | |
| *Mertensia paniculata* | | | | | | | | | | | | | | | | | | | F | F | ? | ? | ? | ? | | | | | | | | | | | | |
| *Erigeron hyssopifolius* | | | | | | | | | | | | | | | | | | | | ✓ | ✓ | ! | | | | | | | | | | | | | | |
| *Juncus dudleyi* | | | | | | | | | | | | | | | | | | | | ! | ✓ | ✓ | ! | ✗ | | | | | | | | | | | | |
| *Primula mistassinica* | | | | | | | | | | | | | | | | | | | | ! | ✓ | ✓ | ! | ✗ | | | | | | | | | | | | |
| *Carex aurea* | | | | | | | | | | | | | | | | | | | | ! | ✓ | ✓ | ! | ✗ | | | | | | | | | | | | |
| ***Shepherdia canadensis*** | | | | | | | | | | | | | | | | | | | | ! | ✓ | ✓ | ! | ✗ | | | | | | | | | | | | |
| *Amelanchier sanguinea* | | | | | | | | | | | | | | | | | | | | ! | ! | ✓ | ✓ | ! | ✗ | | | | | | | | | | | |
| *Potentilla anserina* | | | | | | | | | | | | | | | | | | | | ! | ! | ✓ | ✗ | | | | | | | | | | | | | |
| *Elymus trachycaulus* | | | | | | | | | | | | | | | | | | | | | ! | ✓ | ✓ | ✓ | ! | ! | ! | ✗ | | | | | | | | |
| *Hordeum jubatum* | | | | | | | | | | | | | | | | | | | | | ! | ✓ | ✓ | ! | ! | ✗ | | | | | | | | | | |
| *Cornus sericea ssp. sericea* | | | | | | | | | | | | | | | | | | | | | ! | ✓ | ✓ | ! | ! | ✗ | | | | | | | | | | |
| *Agrostis scabra* | | | | | | | | | | | | | | | | | | | | | ! | ✓ | ✓ | ! | ! | ✗ | | | | | | | | | | |
| *Rubus pubescens* | | | | | | | | | | | | | | | | | | | | | ! | ✓ | ✓ | ! | ✗ | | | | | | | | | | | |
| *Cornus canadensis* | | | | | | | | | | | | | | | | | | | | | ! | ✓ | ✓ | ! | ✗ | | | | | | | | | | | |
| *Sisyrinchium montanum* | | | | | | | | | | | | | | | | | | | | | ! | ✓ | ✓ | ! | ✗ | | | | | | | | | | | |
| *Aquilegia brevistyla* | | | | | | | | | | | | | | | | | | | | | ! | ✓ | ✓ | ! | | | | | | | | | | | | |
| *Rhamnus alnifolia* | | | | | | | | | | | | | | | | | | | | | ! | ✓ | ✓ | ! | | | | | | | | | | | | |
| *Castilleja septentrionalis* | | | | | | | | | | | | | | | | | | | | | ! | ✓ | ! | ! | ✗ | | | | | | | | | | | |
| *Anemone multifida* | | | | | | | | | | | | | | | | | | | | | ! | ✓ | ! | ! | ✗ | | | | | | | | | | | |
| *Prunella vulgaris* | | | | | | | | | | | | | | | | | | | | | ! | ✓ | ! | ! | ✗ | | | | | | | | | | | |
| *Ribes triste* | | | | | | | | | | | | | | | | | | | | | ! | ✓ | ! | ✗ | | | | | | | | | | | | |
| *Thalictrum venulosum* | | | | | | | | | | | | | | | | | | | | | ! | ✓ | ! | ✗ | | | | | | | | | | | | |
| *Rubus idaeus ssp. strigosus* | | | | | | | | | | | | | | | | | | | | | | ✓ | ✓ | ! | ! | ✗ | | | | | | | | | | |
| ***Vicia americana*** | | | | | | | | | | | | | | | | | | | | | | ! | ✓ | ✓ | ! | ! | ✗ | | | | | | | | | |
| *Poa palustris* | | | | | | | | | | | | | | | | | | | | | | ! | ✓ | ✓ | ! | ✗ | | | | | | | | | | |

| Species | January | February | March | April | May | June | July | August | | | September | | | October | | | November | | | December | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Chamerion angustifolium* | | | | | | | | ! | ! | ✓ | ✓ | ! | ! | ✗ | | | | | | | | |
| *Physocarpus opulifolius* | | | | | | | | ! | ! | ✓ | ✓ | ! | ✗ | | | | | | | | | |
| *Achillea millefolium* | | | | | | | | ! | ! | ✓ | ✓ | ! | ✗ | | | | | | | | | |
| *Dasiphora fruticosa* | | | | | | | | ! | ! | ! | ✓ | ✓ | ✓ | ! | ✗ | | | | | | | |
| *Rosa acicularis* | | | | | | | | | ! | ✓ | ✓ | ✓ | ! | ! | | | | | | | | |
| *Picea glauca* | | | | | | | | | ! | ✓ | ✓ | ! | ! | ✗ | | | | | | | | |
| *Vaccinium vitis-idaea* | | | | | | | | | ! | ✓ | ✓ | ! | ! | | | | | | | | | |
| ***Elaeagnus commutata*** | | | | | | | | | ! | ✓ | ✓ | ! | ! | | | | | | | | | |
| *Calamagrostis canadensis* | | | | | | | | | ! | ✓ | ✓ | ! | ✗ | | | | | | | | | |
| *Bromus ciliatus* | | | | | | | | | ! | ✓ | ✓ | ! | ✗ | | | | | | | | | |
| *Viburnum edule* | | | | | | | | | ! | ✓ | ✓ | ! | | | | | | | | | | |
| *Anemone canadensis* | | | | | | | | | ! | ✓ | ✓ | ✗ | | | | | | | | | | |
| *Rhododendron groenlandicum* | | | | | | | | | ! | ! | ✓ | ✓ | ! | ! | | | | | | | | |
| *Symphyotrichum novi-belgii* | | | | | | | | | ! | ! | ✓ | ✓ | ! | ! | ✗ | | | | | | | |
| ***Lathyrus palustris*** | | | | | | | | | ! | ! | ✓ | ✓ | ! | ✗ | | | | | | | | |
| *Galium boreale* | | | | | | | | | ! | ! | ✓ | ! | | | | | | | | | | |
| *Juniperus communis* | | | | | | | | | | ! | ✓ | ✓ | ✓ | ✓ | ✓ | ! | ! | ! | ! | ! | ! | ! |
| *Juniperus horizontalis* | | | | | | | | | | ! | ✓ | ✓ | ✓ | ✓ | ! | | | | | | | |
| *Solidago canadensis* | | | | | | | | | | ! | ✓ | ✓ | ✓ | ! | ! | ✗ | | | | | | |
| ***Alnus incana ssp. rugosa*** | | | | | | | | | | ! | ✓ | ✓ | ! | ! | ✗ | | | | | | | |
| ***Alnus viridis ssp. crispa*** | | | | | | | | | | ! | ✓ | ✓ | ! | ! | ✗ | | | | | | | |
| *Betula glandulosa* | | | | | | | | | | ! | ✓ | ✓ | ! | ! | ✗ | | | | | | | |
| *Solidago nemorlis* | | | | | | | | | | ! | ✓ | ✓ | ! | ! | ✗ | | | | | | | |
| *Betula papyrifera* | | | | | | | | | | ! | ✓ | ✓ | ! | ! | ✗ | | | | | | | |
| *Doellingeria umbellata* | | | | | | | | | | ! | ✓ | ✓ | ! | ! | ✗ | | | | | | | |
| *Sorbus decora* | | | | | | | | | | ! | ✓ | ✓ | ! | | | | | | | | | |
| *Arctostaphylos uva-ursi* | | | | | | | | | | ! | ! | ✓ | ✓ | ! | ! | ! | ! | | | | | |
| *Maianthemum stellatum* | | | | | | | | | | ! | ! | ✓ | ! | ? | | | | | | | | |
| Thuja occidentalis | | | | | | | | | | | ! | ✓ | ✓ | ! | ? | | | | | | | |

# LEGEND

| | |
|---|---|
| **Peak Seed Collection** | ✓ |
| **Keep a close eye** | ! |
| **Mostly dispersed** | ✗ |

## Appendix B2: Collection guides

# common yarrow

Family: Asteraceae

Scientific name: *Achillea millefolium* L.

Cree Name: ___________

Synonyms: *Achillea borealis*, etc.,

*Photo 1: Y , note the delicate fern-like leaves. Yarrow can grow in harsh conditions.*

## Quick Seed Guide

**When and what to collect**:
turns brown. Collect using scissors.

**Seed Processing**: Dry. Rub seed heads against a screen to separate seed. Sieve and winnow.

**Storage:** Dry seed, store cool 1 to 5°C.

**Pre-treatment of seed:** None required, however cool-

**How to Grow:** Seed; between 15 to 26°C, seed needs light and should not be planted deeply.

## General

**Plant Description:** Yarrow is a perennial flower ranging in height from 5cm to 65cm [1]. Typically this plant has one main stem, but can have up to 4. Leaves are fern-like, they can be stalked or not. The leaves of this plant are highly variable in size, ranging from 3.5cm to over 35cm in length and 5 to 35mm in width. The flowers are white, often with over 100 per stem. Each flower has 5 to 8 ray flowers and up to 20 disc flowers. This species has two growth forms, a rosette (lower leaves with no main stem) which does not flower and an erect form which will flower [2]. This species has both native and non-native varieties in Canada.

**Field Identification:** Yarrow leaves are quite distinct from other flowering species in Ontario. Their leaves and flowers are different from other Asteraceae in appearance. The flowers are quite fragrant. **Similar species:** Wild carrot (*Daucus carota*) is a non-native herb similar to yarrow, however its stem is noticeably hairy and has few leaves near the top or flowering head, the flower head of wild carrot is much tighter than yarrow which is somewhat branching. Native plant varieties can be distinguished from non-native plant varieties based on the flower head. For native varieties the width of the flower head is 2 to 10cm wide and has a rounded top, compared to introduced varieties that are 6 to 30cm wide and have a flattened top [3]. However in many areas non-natives and native varieties have hybridized.

**Life Form:** Forb; a perennial herb that dies back each year, overwintering by buds that are near the soil surface [3].

**Reproduction:** This species reproduces by seeds, but also spreads quickly from rhizomes [3]. Flowering occurs in July to August in the North, but some plants can be seen flowering into the fall. Over 1600 seeds can be produced on a single plant [3].

**Continental Range:** There are both non-native and native populations in North America [4]. Yarrow is widespread in Ontario and present in all Canadian provinces and in all states in the United States.

**HBL regional Range:** Yarrow is widespread and abundant to occasional in the Hudson Bay Lowlands [5].

**Habitat:** Yarrow is tolerant of disturbed sites. Common in pastures, meadows, roadsides, stream sides, woodlands, waste grounds, dry or sandy soils, also in damp, clayey, and salty soils; 0-3600 m [1].

*Photo 2:Y*

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# common yarrow

## Reclamation value

Yarrow is considered drought tolerant [3] and is effective at erosion control [6]. The species can spread by rhizomes and is moderately competitive. Yarrow is not tolerant of shaded conditions.

**Nitrogen fixing:** No.

**Symbioses:** This species has been reported to form arbuscular mycorrhizal associations and has also been reported as non-mycorrhizal [7].

**Growth rate:** Moderate [8].

**Successional stage:** Early.

*Photo 3: Yarrow seeds.*

## Seed properties

**Fruit description:** Fruits are achenes and treated as a seed unit, 1 to 2mm long, with wings (photo 3), black at maturity. Achenes are contained within the flower heads until maturity[3].

**Dispersal:** Wind.

**Fruit weight:** Achene with leaf margins; 0.14mg [9].

**Seeds /propagule:** One seed per fruit (achene). One plant can produce over 1600 seeds [3].

**Seed size and description:** Refer to fruit description.

**Average seed weight:** 0.13mg for dry cleaned seed [9].

**Seeds/kg:** Seven million/kg.

## Seed Collection

**Timing collections:** August is when the majority of seeds will have ripened. Collect when the flowering head is turning brown, just after the white flowers are disappearing (photo 4 and 5).

**Collection protocols:** Collect seeds by cutting the stem just below the entire flower head. Collect into buckets strapped to the collector and empty into paper bags. Vacuum harvesting is not effective for this species. Lay seed heads out to dry in thin layers following collection.

**Collection effort:** We were able to collect over 50g/ hour of pure, dried seed with hand collection. Another collector reported 35g/ hour on average, ranging from 1 to 124g depending on the stand density and the year [10].

**Potential density:** Harvest yields vary due to weather and age of stand. Average annual production is 41.3 kg/ha in cultivation in Montana [10].

**Cautions:** None known.

*yarrow using scorrsors as it begins to turn brown.*

*head on the right is fully ripe.*

## Propagule processing

**Processing protocols:** Process yarrow seeds after the seed heads have fully dried and seeds are easily shaken from the plant. 1. Separate seeds from plants. This can be done by rubbing the flower heads across a screen or rubber mat. You can also thresh the flower heads, however this will create a dirtier final product. 2. The seed material is then threshed on a flat rubber mat to break some of the winged margins of the seed and improve seed cleaning by winnowing. Seed was not damaged using moderate force. 3. Sieve material through a stacked sieve (mesh #18, #35, #60, bottom pan). Most chaff remains in #18 and the seed is trapped in #35 and #60. 4. Winnow to remove any remaining chaff.

**Cautions:** Threshing and winnowing can create dust, where a mask if working in a closed area.

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## Storage

**Storage behaviour:** Orthodox [11].

**Storage requirements and longevity:** Seed can be dried and stored in sealed containers at 1 to 5°C. Seeds that were stored in open storage conditions in a temperate climate still had 50% viability after 5.8 years [12]. Seeds that were dried and stored at -18°C in sealed containers have maintained viability (98%) for up to 15 years [11].

*Photo 6: Sectioned yarrow seed. The seed is primarily made up of embryo.*

## Seed Propagation

**Dormancy classification:** Non-dormant [13].

**Potential viability**: In our trial, seed viability was approximately 95%.

**Pre-treatments:** This species may not require any pre-treatments because it is considered non-dormant [13,14]. However, cool- moist stratification may increase germination rates from 65% to 92% [15].

**Germination protocols:** Seventy-nine to 100% germination was achieved at the temperatures 16°C to 26°C (either constant or fluctuating temperatures) and 8/16 hours or 12/12 hours of light/ dark [11]. Seeds require light for germination. Germination declines at temperatures higher than 26°C [6]. Germination should begin after 5 days.

**Other propagation methods**: Yarrow is rhizomatous and can be propagated by divisions [16]**.**

**Field planting:** Seeds need light to germinate so seed should not be buried deeper than 0.5cm. Seed can be planted in the fall or spring.

## Other

**Canadian commercial sources:** Commonly available, check with vendor to ensure seeds are from the native variety.
http://www.wildaboutflowers.ca/plant_detail.php?Yarrow-4

**Useful links and Further reading:**
https://plants.usda.gov/core/profile?symbol=ACMI2
https://npn.rngr.net/propagation/protocols
http://ontariowildflowers.com/main/species.php?id=765

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# tickle grass

Family: Poaceae

Scientific name: *Agrostis scabra* Willd.

Cree Name: ___________

Synonyms: *Agrostis scabra var. scabra, etc*

Photo 1: Tickle grass stand. The seed heads often have a reddish colour at maturity.

## Quick Seed Guide

**When and what to collect**: August. The seed head spreads open and is a reddish to tan colour. Collect tufts of seed head at one time using scissors.
**Seed Processing**: Dry, thresh, sieve, winnow.
**Storage:** Dry and cool (1 to 5°C).
**Pre-treatment of seed:** Cool-stratify for 10 days.
**How to Grow:** Seed: standard conditions, can achieve high rates of germination.

## General

**Plant Description:** This grass gets its name from its delicate seed head, it has long spreading branches with small single seeds in each spikelet [1]. The branches are usually scabrous (run your finger along the branch and it will feel rough and catch the skin). Tickle grass grows in tufts (clumps with many plant stems) and is 15 to 90 cm in height. The leaves are very narrow because they are rolled in (involute; 4-14cm by 1-2mm). The leaf sheath is usually smooth but sometimes scabrous. Ligules 0.7 to 5mm long, usually a round tip (pull back the leaf, where the leaf and stem meet, you will find the ligule). Leaves along the stem are flat. If you are not familiar with this grass you may need to examine the spikelet closer under magnification.
**Field Identification:** Ticklegrass is recognized by its large, delicate seed head, and the rough feeling branches (if you run your fingers along the length of the branch). **Similar species:** Tickle grass maybe mistaken for wavy-hair grass (*Avenella flexuosa*), however, if you look closely wavy-hair grass has more than one seed per spikelet and the seed has a short awn.
**Life Form:** Graminoid: Tickle grass is perennial, its stems die back during winter months, regenerating from buds at or below the soil surface.
**Reproduction:** Reproduction is done mostly by seed, but also via stolon spreading [2].

**Continental Range:** Ticklegrass is widespread in Canada, well established in all provinces. This species is also widespread in the United States, except in the southern states [3].
**HBL regional Range:** Widespread abundant in the Hudson Bay Lowlands [4].
**Habitat:** Grows in many types of habitats. Grasslands, woodlands, meadows, shrub lands, stream and lake margins, and disturbed sites like roadsides [1,5].

Photo 2: Tickle grass seed heads beginning to spread open as seed develops.

## Reclamation value

This species is moderately drought and saline tolerant, it grows well on acidic, low nutrient, and metal contaminated soils, making it a valuable species for reclamation [5,6]. This species has fibrous roots that help to stabilize soil and has been successfully established on disturbed sites in Alberta and Ontario, from seeding and natural colonization [2].
**Nitrogen fixing:** No.
**Symbioses:** This species has been reported to form arbuscular mycorrhizal associations [7].

**Growth rate:** Moderate [8].
**Successional stage:** This species likely acts as a pioneer but may persist later. Tickle grass responds well to disturbance and is shade intolerant [8,9].

*Photo 3: Collecting a small tuft of tickle grass using scissors. Cutting just below the seed head.*

## Seed and propagule properties

**Fruit description:** Single seed contained in a spikelet.
**Dispersal:** Wind. Seed heads break off and roll like tumbleweed[5,6].
**Seeds /propagule**: Only one seed per spikelet, per stem there are well over 50 seeds.
**Seed size and description:** Seeds are contained within glumes, 0.9 to 1.4mm long.
**Average seed weight:** (cleaned seed; likely dried) 0.08mg [10].
**Seeds/kg:** Eleven million seeds/ kg [5].

## Seed Collection

**Timing collections:** Seeds mature in August, when the seed head begins to spread open and has a reddish-purple tinge. Collect seeds when they are no longer green. There is about a two week window from when seeds are mature to dispersal, if the weather is hot and dry you will have less time to make your collections.
**Collection protocols:** Seed can be collected using scissors. Grab the entire tuft of plants and cut the stems below the seed head. Collect into large paper bags. Allow grasses to dry in thin layers on top of sheets or trays so seed that falls out of the seed head can be collected.
**Collection effort:** Approximately 45g (30g to 94g) clean, dry seed in one hour. Another collector yielded an average of 77g (23g to 168g) using hand collection methods [11].
**Potential density:** 142 kg/ha [11].
**Cautions:** None known.



*Photo 4 (left): Threshing tickle grass seed heads on a corrugated rubber mat. Photo 5 (center): Threshed seeds and chaff, uncleaned. Photo 6 (right). Seeds following sieving.*

## Propagule processing

**Processing protocols:** Place dry materials onto a rubber corrugated mat inside. a short box. Thresh seed using a threshing paddle to separate the seed from the spikes. Do not apply too much force because this will damage the seed. A moderate abrasion will dislodge the majority of seed. Sieve materials through a series of sieves (mesh #5, #10, #18, #30, #60, bottom pan). Sieves #30 and #60 contain the seed. Reserve this material and winnow at a low speed to remove chaff. Seed purity was approximately 99%.
**Cautions:** Threshing can create a great deal of dust particles. Wear a mask and ensure you are working in a ventilated space.

## Storage

**Storage behaviour:** Orthodox [10].
**Storage requirements and longevity:** Dry seed and store cool (1 to 5°C). It will remain viable for 5 to 7 years [11].

## Seed Propagation

**Dormancy classification:** Physiological [12].
**Potential viability**: In our study, seed viability of cleaned seed was 85% on average, ranging from 74% to 92%.
**Pre-treatments:** Seed may benefit from a short cool stratification period approximately 10 days [11] to achieve the highest rates of germination.
**Germination protocols:** Germination occurs at standard temperatures, 25/10°C and light/ dark cycles of approximately 8/16 hours [6,10,11].
**Other propagation methods:** None known.
**Field planting:** Seed can be planted in the fall and will emerge in the spring [2].

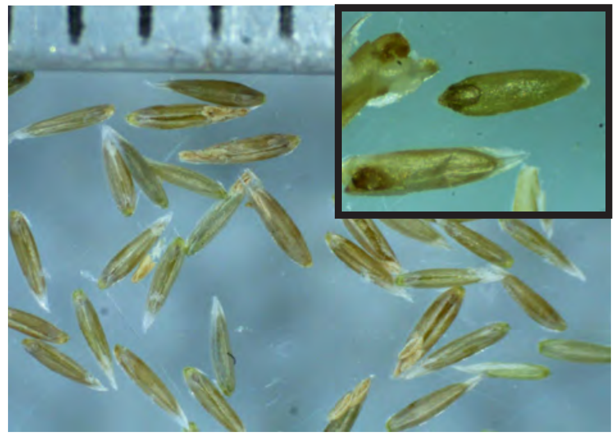

*Photo 7: Cleaned ticklegrass seed. (inset photo) external view of the seed's embryo and endosperm.*

## Other

**Canadian commercial sources:**
http://www.brettyoung.ca/html/reclamation/index.cfm
**Useful links and Further reading:**
http://michiganflora.net/species.aspx?id=1997
https://www.fs.fed.us/database/feis/plants/graminoid/agrsca/all.html

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# speckled alder

Family: Betulaceae

Scientific name: *Alnus incana* ssp. *rugosa* (Du Roi) R.T. Clausen    Cree Name: ___________

Synonyms: *Alnus rugosa*, etc.

Photo 1: Speckled alder growing in a thicket.

## Quick Seed Guide

**When and what to collect**: Collect catkins from September to October. Use berry rakes or hand collect into buckets.

**Seed Processing**: Dry catkins. Shake seeds free, thresh catkins to separate remaining seed. Winnow.

**Storage:** Dry and cool (1 to 5°C) for 5 to 7 years.

**Pre-treatment of seed:**
60 days.

**How to Grow:** Seed; temperatures between 20 to 27°C and equal light and dark cycles.

## General

**Plant Description:** Speckled alder is a deciduous shrub, typically 3m, but it can grow as tall as 9m. One plant usually has many stems (coppiced) and grows in stands with other speckled alders [1]. The bark is reddish brown with white spots called lenticels. The leaves are a dark green, distinctly veined, 4 to 11cm long, leaf margins are toothed, doubly serrate. This species is monecious; it has separate male and female catkins on the same plant. Male catkins are elongated 2 to 7cm, female catkins are round on a short stalk 1 to 5mm.

**Field Identification:** Identify this shrub by its multi-stem growth habit and bark with distinct white spots. **Similar species**: Mountain alder; speckled alder can be distinguished from mountain alder by its leaves and catkins. Speckled alder leaves are doubly toothed compared with mountain alder leaves that are continuously toothed. In addition, speckled alder female catkins have almost no stalk, compared to mountain alder catkins that are attached with a long sender stalk (over 1cm). Red alder is also similar but only found in western Canada and European alder is an introduced species with similar leaves but with catkins on longer stalks.

Photo 2: Leaf shape of speckled alder.

**Life Form:** Shrub; with a woody stem that persists through the winter season.

**Reproduction:** This species produces seed every year after 5 to 10 years of age and also reproduces by rhizomes [2]. Flowering occurs in early spring [1].

**Continental Range:** Speckled alder is found in central and eastern Canada and extends west to Manitoba. Populations are also restricted to northeastern United States, becoming imperiled south of Ohio. Western Canada populations may be of the subspecies *tenuifolia* [1,3].

**HBL regional Range:** Widespread and abundant in the Hudson Bay Lowlands [4].

**Habitat:** Speckled alder prefers wet habitats, stream banks, shorelines, bogs, swamps, ditches, and roadsides; 0-800 m [1]. Tolerant of a variety of a variety of soil types [2].

## Reclamation value

Speckled alder is a good colonizer of open sites and tolerates a variety of soil types [2]. Its leaf litter adds nitrogen to the soil. This species has potential for erosion control of stream banks.

**Nitrogen fixing:** Yes.

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**Symbioses:** Forms arbuscular mycorrhizal (AM) and ectomycorrhizal associations [5]. AM may be critical for this species to establish and for nutrient uptake [6]. This species benefits from an actinorhizal association with *Frankia* bacteria for nitrogen fixation [7].
**Growth rate:** Moderate [8].
**Successional stage:** Early. A primary colonizer after disturbance, moderately shade tolerant so plants can persist into later successional communities but is not a large component of late successional sites [9].

*Photo 3: Female alder catkin, almost fully ripe. The few white seeds suggest some seeds are still developing.*

## Seed and propagule properties

**Fruit description:** Female catkins contain multiple seeds, female catkins are round, (1 to 1.7cm × 0.8 to 1.2 cm).
**Dispersal:** Wind [10], perhaps in part by water.
**Propagule weight:** Dry whole seed (achene) with wings: 0.27mg [11].
**Seeds/ catkin:** There are numerous seeds per catkin.
**Seed size and description:** Cleaned seed is brown at maturity.
**Average seed weight:** Dry seed, no wings: 0.23mg [11].
**Seeds/kg:** 4.4 million seeds/kg [11].

## Seed Collection

**Timing collections:** Seeds are collected in the fall (September to November) depending on your region. The female catkins will be closed and green, turning yellow to brown at which point the scales begin to open to release the seed. The best time to collect is when catkins are a yellow colour. However, confirm seed maturity by cutting open the catkins. The seed should be firm and brown. Some seeds will persist in the catkins until the spring.
**Collection protocols:** Catkins can be hand collected into buckets. If required, use a pole with a hook at the end to pull branches into reach. The pole can be held between the collectors legs in order to free up both hands for collection. Berry rakes with metal fingers are also useful. Collections will contain a great deal of leaves and branches. Seed viability varies between stands; it is important to monitor seed lot to track which populations have poor seed fill. One of our seed lots had only 8% seed fill.
**Collection effort:** Approximately 103g pure dried seed in one hour.
**Potential density:** Plants form thickets and produce large amounts of seed. Seed density can be quite high.
**Cautions:** Wearing gloves makes pulling catkins from the tree easier because it is rough on the collectors hands.

*Photo 4: Dry female catkins, note scales have opened to release their seed. These catkins are ready to be processed.*

## Propagule processing

**Processing protocols:** The catkins are laid out to dry following harvest, the seeds are released as the scales of the catkins open. 1. Shake the open catkins in a container (such as a garbage bin or tote with a lid) to release seed. 2. Pour the material over a coarse sieve (mesh #5). The catkins will remain in this sieve and the seed will fall through. 3. Return catkins to a threshing mat and cover them with a sheet. Step on catkins to further release seed; this also breaks the scales from the catkins and results in a mix of scales and seed. Scales are problematic for screening because they are a similar size to the seeds. 4. Winnow; seeds are winged and will separate from scales. 5. If desired, seeds can be returned to the flat side of a rubber mat and threshed to break wings. 6. Winnow to remove wings and other chaff.
**Cautions:** None known.

## Storage

**Storage behaviour:** Orthodox [12].

**Storage requirements and longevity:** Alder seeds should be air dried and kept in sealed containers at 2 to 5°C. Seeds from thinleaf alder (*Alnus incana*) that were dried and refrigerated remained viable for 5 to 7 years [13].

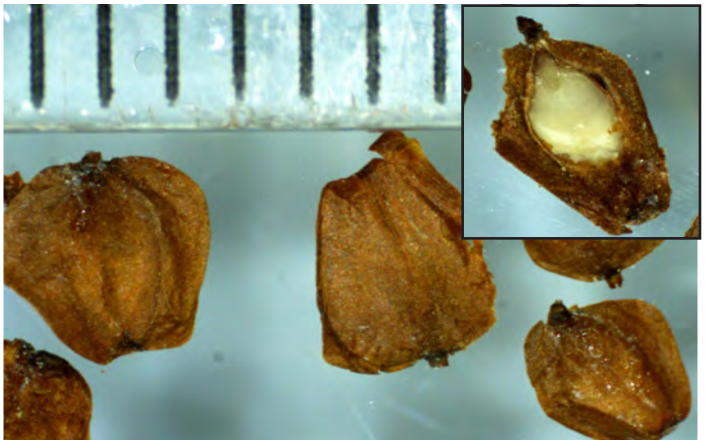

*Photo 6: Speckled alder whole seed. (inset photo) sectioned speckled alder seed.*

## Seed Propagation

**Dormancy classification:** Physiological dormancy [14].

**Potential viability:** Viability ranged from 4 to 42% in northern United States [15]. In our study, seed viability ranged from 8% to 31%.

**Pre-treatments:** Cool-moist stratification (1 to 5°C) for 60 days will improve germination success [14]. Pre-treatments can also include a 16 hour soaking of seed [15], however this can damage the seed if the soaking is prolonged.

**Germination protocols:** Seed provenance has a large influence on seed viability [15]. Alder seed germinates best with light and dark cycles of approximately equal proportions and temperatures between 20 to 27°C [14,15].

**Other propagation methods:** Unknown for speckled alder specifically, however, thin-leaf alder (*Alnus incana* ssp. *tenufolia*), a more western subspecies, has been propagated by cuttings from two year wood, taken in October when stems are dormant and treated with IBA [16]. Rooting success was high from 76 to 86%. However, it should be noted, vegetative propagation for this species of alder is not common practice.

**Field planting:** Seed can be broadcast in the fall or early spring when temperatures are still cool [10]. Speckled alder has been successfully established by direct seeding.

## Other

**Canadian commercial sources:** None found.

**Useful links and Further reading:**

https://www.fs.fed.us/database/feis/plants/tree/alninc/all.html

https://plants.usda.gov/core/profile?symbol=ALINR

http://www.wildflower.org/plants/result.php?id_plant=ALINR

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# mountain alder

Family: Betulaceae

Scientific name: *Alnus viridis ssp. crispa* (Aiton) Turrill

Cree Name: ___________

Synonyms: *Alnus crispa*, etc.

*Photo 1: Mountain alder and speckled alder thicket.*

## Quick Seed Guide

**When and what to collect**: Collect catkins from September to October. Use berry rakes or hand collect into buckets.

**Seed Processing**: Dry catkins. Shake seeds free, thresh catkins to separate remaining seed. Winnow.

**Storage:** Dry and cool (2 to 5°C) in sealed containers for 4 years.

**Pre-treatment of seed:**
14 days.

**How to Grow:** Seed; temperatures between 19 to 26°C, light improves germination.

## General

**Plant Description:** Mountain alder is a <u>deciduous</u> shrub with multiple stems (or trunks). Typically this shrub is under 3m in height but can exceed 4m [1]. Its bark is grayish-brown with white spots (<u>lenticels</u>). Leaves are dark green, 3.5 to 6cm long and 3 to 5 cm wide, finely toothed, singly serrate. This plant is <u>monoecious</u> (male a female flowers on a single plant). Male <u>catkins</u> are 2.5 to 9 cm long, female catkins that are round, hanging from stalks (1 to 5cm).

**Field Identification:** Alders are distinct from other shrubs because of the white spots on their bark and often have catkins that persist from the previous through the winter and into the following summer. **Similar species:** Speckled alder can be distinguished by the shorter stalk (0.1 to 0.5cm) on to female catkins and the leaf margins that are doubly toothed.

**Life Form:** Shrub; has a woody stem that persists through the winter season.

**Reproduction:** This plant is <u>monoecious</u> (separate male a female flowers on a single plant), it flowers in the spring [1]. Mountain alder reproduces by seed to colonize new sites and also reproduces by sprouting from the <u>root crown</u> [2].

*margins and stalked female catkins .*

**Continental Range:** Mountain alder is found throughout central and eastern Canada, absent in British Columbia, Northwest Territories and the Yukon. Populations in the United States are restricted to the most northeastern states and becomes critically imperiled south of Pennsylvania [3].

**HBL regional Range:** Widespread in Hudson Bay Lowlands, abundant to common [4].

**Habitat:** Mountain alder is tolerant of dry and moist sites ranging from rivers, lake and coastal shores, coasts, to sandy or gravelly slopes; 0-2000 m [1]. This species also tolerates some shading in forests [2].

## Reclamation value

Mountain alder has been used for revegetation at disturbed sites such as oil sands tailings, eroded slopes, gravel pits, and post clear-cutting (review in [5]). It fixes nitrogen, colonizes disturbed sites rapidly, and is tolerant to a variety of soil types.

**Nitrogen fixing:** Yes.

**Symbioses:** Forms both <u>ectomycorrhizal</u> and <u>arbuscular mycorrhizal</u> associations [6,7], this species can fix nitrogen due to an actinorhizal association with *Frankia* bacteria [8].

**Growth rate:** Moderate [9].

**Successional stage:** Early, mid and late (facultative). This species has the highest density and colonization on sites that are early in <u>succession</u>, but can be found in forest understories at lower densities [2].

## Seed and fruit properties

**Fruit description:** Female catkins contain numerous achenes which are the single-seeded fruits, treated as a seed. They are ovoid 1.2 to 2cm long and 0.5 to 1.2 cm in diameter. They change from green to tan then brown at maturity.
**Dispersal:** Wind [10], perhaps in part by water.
**Fruit weight:** (air dried) a single winged achene weighs approximately 0.62mg [11].
**Seeds/ fruit:** Likely over 100 seeds per catkin [12].
**Seed size and description:** Seed is winged, brown at maturity. With wings removed, seeds is approximately 2 to 3mm long and 1 to 1.5mm wide. Filled seeds are approximately 0.2mm thick.
**Average seed weight:** (cleaned, dried seed) 0.38mg [11].
**Seeds/kg:** 1 700 000/kg (seed with wings) or 2 600 000 seeds/kg (dewinged) [11].

*Photo 3: Mountain alder female catkin cut in half to check seed ripening. The white colour of some seeds suggests some seed development still needs to occur before collecting.*

## Seed Collection

**Timing collections:** Seeds are collected in the fall (September to November) depending on your region. The catkins will be closed and green, turning yellow to brown at which point the scales begin to open to release the seed. The best time to collect is when catkins are a yellow colour, before the scales begin to open. Confirm seed maturity by cutting open the catkins. They will be firm and brown. Some seeds will persist in the catkins until the spring.
**Collection protocols:** Catkins can be hand collected into buckets. Berry rakes with metal fingers are a useful collection tool. Collections can contain a great deal of leaves and branches. Seed viability varies between stands; it is important to monitor seed lot to track which populations have poor seed fill [5]. Lay material out to dry in thin layers following collection.
**Collection effort:** One person collected 114g pure dry seed in one hour.
**Potential density:** Approximate 2.4 to 9.5 million seeds/ ha from a study in Thunder Bay, ON [12].
**Cautions:** Wear gloves to make pulling catkins from the tree easier because it is rough on the collectors hands.

*Photo 4: Stepping on dry alder catkins to release trapped seed. (inset photo) cleaned mountain alder seed.*

## Propagule processing

**Processing protocols:** The catkins are laid out to dry following harvest, the seeds are released as the scales of the catkins open. 1. Shake the open catkins in a container (such as a garbage bin or tote with a lid) to release seed. 2. Pour the material over a coarse sieve (mesh #5). The catkins will remain in this sieve and the seed will fall through. 3. Return catkins to a threshing mat and cover them with a sheet. Step on catkins to further release seed, this also breaks the scales from the catkins and results in a mix of scales and seed. Scales are problematic for screening because they are a similar size to the seeds. 4. Winnow; seeds are winged and will separate from scales. 5. Seeds can be returned to the flat side of a rubber mat and threshed to break wings. 6. Winnow in front of a low air flow to remove wings and other chaff.
**Cautions:** None known.

## Storage

**Storage behaviour:** Orthodox [13].

**Storage requirements and longevity:** Air dry seed and store in a sealed container at 2 to 5°C, the seed longevity is not stated [14]. Seed dried to 5.7 to 7.2% seed moisture content can be stored for 4 years in sealed containers at 2 to 4°C [15].

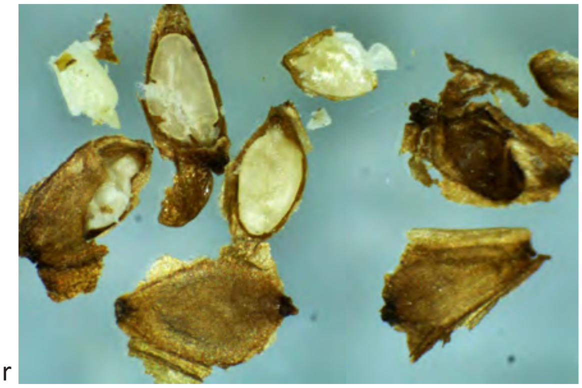

*Photo 5: Sectioned mountain alder seed. Seed to the left is viable and seed to the right is not viable.*

## Seed Propagation

**Dormancy classification:** Physiological dormancy [16].

**Potential viability:** Seed viability varies by year and location; the maximum viability found reported for one mountain alder population was 75% [5]. In our study seed viability ranged from 40 to 66%.

**Pre-treatments:** Cool-moist stratification at 3°C for over 14 days or soaking in gibberellic acid for 24 hours before germination [5]. Untreated seeds have lower germination rates.

**Germination protocols:** Germination was highest (75%) at a temperature range of 19 to 26°C, with light [5]. Seed lot and provenance may also affect germination success.

**Other propagation methods:** Uncertain. Other alders have been propagated by softwood cuttings taken in the spring, treated with rooting hormone [17].

**Field planting:** Seed can be sown in the fall, or if cool-stratified indoors can be planted in the spring.

## Other

**Canadian commercial sources:** None known.

**Useful links and Further reading:**

https://www.fs.fed.us/database/feis/plants/shrub/alnvirc/all.html
https://plants.usda.gov/core/profile?symbol=ALVIC
https://gobotany.newenglandwild.org/species/alnus/viridis/
https://www.acrre.ualberta.ca/Portals/14/ACRREDocuments/Alnus_viridis.pdf

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16. Baskin, J. & Baskin, C. *Seeds: Ecology, Biogeography, and Evolution of Dormancy and Germination*. (Academic Press, 1998). doi:10.2135/cropsci2000.0009br
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# roundleaf serviceberry

Family: Rosaceae

Scientific name: *Amelanchier sanguinea* (Pursh) DC.  Cree Name: ___________

Synonyms: *Amelanchier huronensis, etc*

## Quick Seed Guide

**When and what to collect**: Soft berries (red to dark purple) at the end of July, collect using berry rakes or by hand into buckets.

**Seed Processing**: 5:1; water:berry in a blender with dulled blades. Reserve sunken material, dry, thresh, then winnow.

**Storage:** Dry seed, place in sealed containers at 5°C.

**Pre-treatment of seed:**

germination percentages.

**How to Grow:** Seed: 20 to 30°C. Vegetative: Semi-hardwood cuttings taken in June.

## General

**Plant Description:** Roundleaf serviceberry is a deciduous shrub that is typically 1 to 3m tall; it can have one stem or up to 20 [1]. The branch and leaf pattern is alternate. The leaves are green but whitened on the lower surface and covered with small woolly hairs (tomentum), on a stalk 11-19mm long, generally egg shaped with a rounded tip and a base that is slightly heart-shaped. Leaf margins are toothed, about 1mm deep and are more dense on the upper half than the lower half. The flowers are grouped with 7 to 10 white flowers hanging from stalks. The flowers have five petals. This shrub produces berries that are dark purple at maturity.

**Field Identification:** Serviceberries (*Amelanchier* spp.) are difficult to distinguish from one another. A good reference for identification of serviceberries in Ontario is Shrubs of Ontario (see further reading). Roundleaf serviceberry has reddish young new branches, more than 4 teeth on the lower half of the leaf, and flowers on long stalk in groups of 7 to 10.

**Life Form:** Shrub; with a woody stem that lives through the winter season, buds are located above ground.

**Reproduction:** Roundleaf serviceberry, reproduces by seed and by suckering or by forming colonies with underground stolons [2]. Flowering occurs in May to June and fruit matures from July to August [1,2].

**Continental Range:** Canadian populations are mostly in central Canada (MB, ON, QC, and NB). Populations in the United states are limited to north-eastern states [3].

**HBL regional Range:** Widespread, occasional to infrequent in the Hudson Bay Lowlands [4].

**Habitat:** Common in upland, open habitats, on forest margins, shorelines, rocky slopes, river gorges, and sandy soils; 0-1000 m [1,2].

*Photo 2: Roundleaf serviceberry leaf. There are more than 4 teeth on the lower half of the leaf.*

## Reclamation value

**Nitrogen fixing:** No.

**Symbioses:** Endomycorrhizal and non-mycorrhizal [5].

**Growth rate:** Moderate**.**

**Successional stage:** Mid-successional.

## Seed and fruit properties

**Fruit description:** Berries are dark purple to blue when ripe [1].

**Dispersal:** Animal dispered [6].

**Propagule weight:** In our study, average fresh berry weight was 107mg.

**Seeds /propagule:** In our collections there were 5 to 10 seeds per berry.

**Seed size and description:** Seeds are brown, roughly crescent shaped, approximately 3 to 5mm long, 2 to 3mm wide.

**Average seed weight:** (cleaned air dried seed) 5.4mg [7].
**Seeds/kg:** 185 000 seeds/kg [7].


Photo 3: Collecting serviceberry using a berry rake.

## Seed collection

**Timing collections:** Fruits will ripen in July. Berries do not ripen all at the same time, so if the stand is prolific, it may be worthwhile to cover it with netting to avoid losses to wildlife. As soon as berries are soft, they can be collected, ranging in colour from red to purple to blue. Seeds are brown and hard when mature.
**Collection protocols:** Hand-collect berries by pulling them into plastic buckets or bags wrapped around the collector. If the berries do not detach easily from their stalk, they are likely unripe and not worth collecting because the seed will be underdeveloped. A berry rake is also effective, especially is all berries are ripe at one time. Some populations will have poor seed fill or seed deformities so collecting above your targets is recommended [8].
**Collection effort:** One person collects 13.5g per hour of pure dry seed. In our study, seed fill was poor for many berries and resulted in fairly low collection rates.
**Potential density:** Not determined.
**Cautions:** None known. Berries are edible.

## Propagule processing

**Processing protocols:** Berries can be processed in a blender with dulled blades. Do not remove leaves or stems before processing as they can be easily separated later. Place about 1 part berries to 5 parts water and run the blender in short pulses for 2 or 3 seconds. If left running the seed will be damaged. Seed sinks and pulp remains suspended in water. After several rinses most of the pulp and empty seed can be poured off. Pour sunked material into a sieve and place on paper towels for drying. Thresh, sieve and/or winnow materials to remove any remaining impurities. Full seed remains in mesh #10, empty seeds falls through. Seed purity was usually over 90% and improved if fewer unripe berries were included in the original collection.
**Cautions: None known.**


Photo 4: Sunken seed and unripe berries following blending. Unripe berries will sink, but can be sieved out easily after drying.


Photo 5: Service berry seed following drying. Our collections had many empty seeds.

## Storage

**Storage behaviour:** Likely orthodox [7].
**Storage requirements and longevity:** Seed can be dried and stored in sealed containers at 5°C [9]. Alternatively seed can be stored in conditions for cool-moist stratification in a plastic bag filled with vermiculite for up to 3 years [10].

## Seed propagation

**Dormancy classification:** Other species  of serviceberry (*Amelanchier*) exhibit a physiological dormancy [11].
**Potential viability:** Seed viability in our study ranged from 25% to 71% between populations.
**Pre-treatments:** Although not specified for roundleaf serviceberry, other serviceberries (*Amelanchier ssp.*) require cool-moist stratification for 90 to 120 days [6]. Mechanical scarification may further improve germination success.
**Germination protocols:** No information found for roundleaf serviceberry. Other serviceberries germinate at 20 to 30°C and light does not seem to improve germination success [6].
**Other propagation methods:** No information found for roundleaf serviceberry. Pacific serviceberry (*Amelanchier alnifolia*) had 22% rooting success with semi-hardwood cuttings taken in June and treated with rooting hormone.

**Field planting:** Untreated seed can be planted in the fall and covered by approximately 0.5cm of soil; seeds may not emerge until the second season [12]. Saskatoon serviceberry (*Amelanchier alnifolia*) seed sown on reclaimed tailings in Alberta had equal emergence when sown in spring or fall, cleaned seed emergence was higher than planting whole fruit [13].

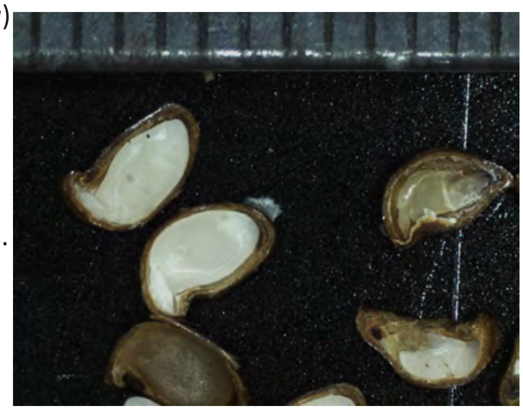

*Photo 6: Sectioned serviceberry seeds. Seeds to the left are viable, seeds to the right are not viable.*

## Other

**Canadian commercial sources:** Serviceberry seed is available from https://www.ontario.ca/page/buy-ontario-tree-seeds-or-cones, but is not identified to species.

**Useful links and Further reading:**

"Shrubs of Ontario" by Soper and Heimburger
https://gobotany.newenglandwild.org/species/amelanchier/sanguinea/
http://www.borealforest.org/shrubs/shrub6.htm
http://www.pfaf.org/user/Plant.aspx?LatinName=Amelanchier+sanguinea
http://www.wildflower.org/plants/result.php?id_plant=AMSA

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# canada anemone

Family: Ranunculaceae

Scientific name: *Anemone canadensis* L.

Cree Name: ___________

Synonyms : *Anemonidium canadense*

## Quick Seed Guide

**When and what to collect**: August. Seed heads turn from green to yellow. Collect using scissors or pulling off entire seed head.

**Seed Processing**: Thresh on a corrugated rubber mat, to break beaks and separate seed from one another. Winnow or sieve to remove chaff.

**Storage:** Dry and cool in sealed containers.

**Pre-treatment of seed:** Warm stratify (4+weeks) then cool stratify (12+ weeks).

**How to Grow:** Seed: Germinate at 20°C with equal light/dark cycles. Vegetative: Rhizome cuttings taken in spring.

## General

**Plant Description:** A perennial herb, ranging in height from 20 to 80cm [1]. It is rhizomatous and often forms colonies. It has 1 to 5 basal leaves 4 to 10cm long and 5 to 15 cm wide. The leaves have a long stalk, 8 to 22cm long. Typically there is one white flower per plant at the very tip. The flowers are white with 5 sepals and a dramatic yellow center from 80 to 100 stamens. The fruit are achenes, grouped into a tight round head, that looks spiked.

**Field Identification:** The anemones have distinct flower appearances and are attached to a long stalk, with lobed basal leaves. **Similar species**: Canada anemone, may be confused with wood anemone, but is distinguished because it does not have compound leaves and does not have woolly hairs on the achenes.

**Life Form:** Perennial forb; stems die back during winter and regenerates from underground rhizomes.

**Reproduction:** This species reproduces by seed and rhizomes. Flowering occurs in spring into the summer (May to August) [1].

**Continental Range:** Widespread throughout Canada, but less common in the Maritimes and in BC. Populations in the US are largely concentrated in northeastern states [2].

**HBL regional Range:** Widespread, abundant to frequent in the Hudson Bay Lowlands [3].

**Habitat:** Generally fond of moist sites, but tolerant of drier meadows or clearing, most common in meadows, wet prairies, lake shores, stream sides, clearings; 200-2800m [1].

## Reclamation value

**Nitrogen fixing:** No.

**Symbioses:** No reports found.

**Growth rate:** No information found. Likely moderate to rapid.

**Successional stage:** No information found. Likely early succesional.

## Seed and fruit properties

**Fruit description:** Fruits are achenes; they are clumped into a tight spherical head [1]. Achenes contain only one seed and are treated like seeds. Achenes have a 2 to 6mm beak, brown at maturity, round 3 to 6mm x 3.5 to 6 mm, and are flattened in one dimension.

**Dispersal:** Sectioning the seed reveals a spongy layer of tissue, in addition the broad wings likely assist in water dispersal for this species. Despite its curved beak, this species is not well dispersed by animals [4].

**Fruit weight:** (dried, whole achene) 2.35mg [5].

*Photo 2: Canada anemone, growing on a rocky soil.*

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**Seeds/ fruit:** Achenes have 1 seed per fruit, however there are up to 40 achenes per head [6].
**Seed size and description:** See fruit description above.
**Average seed weight:** See fruit weight above.
**Seeds/kg:** 245 000 seeds/kg [5].

*Photo 3: Canada anemone seed head turning yellow, ready to collect.*

## Seed Collection

**Timing collections:** Seed ripens about 6 weeks after flowering. Seed begins to ripen July until the beginning of September. In our region, most seed is ripe at the end of August. Seed will start to change from green to yellow and should be collected then. They do not persist for long after maturity and easily fall apart when touched if fully mature.
**Collection protocols:** Seed heads can be cut off using scissors or pulled off by hand. Place seed into a container that is harnessed to your body, so you can move quickly between stands and use both hands to collect. Place material to dry in thin layers following collection.
**Collection effort:** Our average collection rate was 53g cleaned, dry seed per hour.
**Potential density:** Not determined
**Cautions:** All parts of anemone plants are mildly poisonous when eaten.

## Propagule processing

**Processing protocols:** Canada anemone requires almost no seed cleaning. The achene (containing the seed) only has a small bur as a covering structure; at maturity seed easily detaches from the head. Place dried seed material on a corrugated rubber mat and gently thresh; this will break the beak and the seeds will separate from one another. Seed can be sieved or winnowed to remove any chaff.
**Cautions:** All parts of anemone plants are mildly poisonous when eaten.

## Storage

**Storage behaviour:** Probably orthodox [7].
**Storage requirements and longevity:** No information is available on the longevity of Canada anemone seed in storage, however the seed displays orthodox storage behaviour, so it is best to dry the seed and store it in sealed containers between 1 and 5°C.

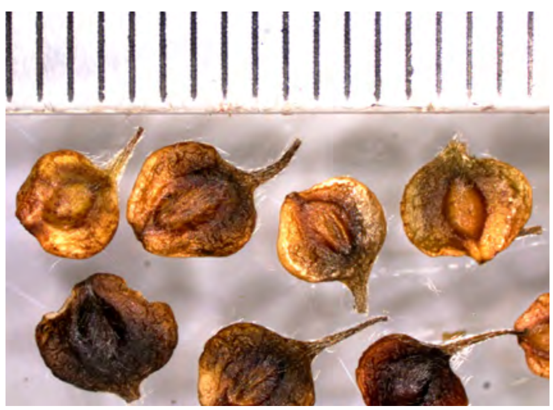

*Photo 4: Canada anemone whole seed.*

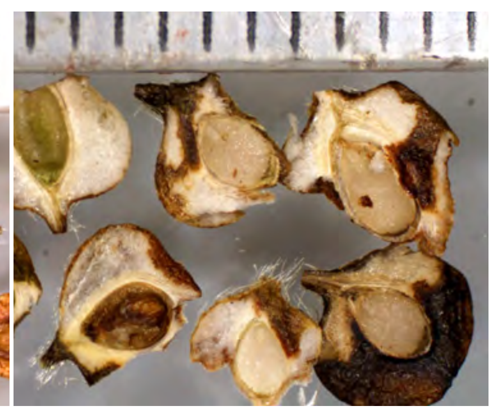

*Photo 5: Sectioned Canada anemone seed. The seeds to the left are not viable.*

## Seed Propagation

**Dormancy classification:** Uncertain, other species of *Anemone* have a morpho-physiological dormancy [8].
**Potential viability:** The range of seed viability in our study was from 45% to 89%.
**Pre-treatments:** Canada anemone requires several steps to pre-treat seed. Beginning with cool-moist stratification at 1 to 5°C, for 8 to 12 weeks, followed by warm-moist stratification for 8 to 12 weeks at 26°C and finally repeating the cool-moist stratification [9]. Alternatively seed may germinate well if the first cool-moist stratification period is skipped, beginning with warm stratification for 4 weeks at 20°C, followed by cool-moist stratification for 12 weeks at 5°C [7].
**Germination protocols:** Seed germinates at 20°C under light/dark cycles of 8/16 hours [7].

**Other propagation methods:** Canada anemone may be grown by rhizome cuttings taken in the spring [10].
**Field planting:** Seeds will take two years before they emerge in the field.

## Other

**Canadian commercial seed sources:** None found.
**Useful links and Further reading:**
http://ontariowildflowers.com/main/species.php?id=222=;
https://www.prairiemoon.com/seeds/wildflowers-forbs/anemone-canadensis-canada-anemone.html

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# cutleaf anemone

Family: Ranunculaceae

Scientific name: *Anemone multifida* Poir.

Cree Name: ___________

Synonyms: None found, however there are four recognized varieties.

seed heads developing.

## Quick Seed Guide

**When and what to collect**: August. Collect the entire seed head using scissors, before the seeds begin to

**Seed Processing**: Uncertain.
**Storage:** Dry seed, store in sealed containers at 3 to 5˚C for many years.
**Pre-treatment of seed:**
60 to 120 days.
**How to Grow:** Seed: germinate at temperatures between 15 to 26°C and roughly equal light/dark.

## General

**Plant Description:** Cutleaf anemone is an attractive perennial herb. It is 10 to 70 cm tall [1]. The leaves are compound with 3 leaflets on a long stalk, 4 to 10cm long. The leaf shape is unique; they are deeply divided into many thin lobes. The leaves along the stem have a similar appearance to the basal leaves but are mostly unstalked. The leaves can be covered in short or long hairs or sometimes are smooth. The flowers are eye-catching. The petals can be numerous colours, however in our region we found they were white and purple. The center of the flower is a dramatic yellow from over 50 stamens. Flowers are borne at the top of the stem. The mature fruits are found in a tightly packed, round and hairy flower head.
**Field Identification:** Recognize an anemone by their unique flower appearance borne at the tip of a long stalk and later by the spherical seed head. Once you become familiar with cutleaf anemone, you will also be able to recognize it by its distinctly shaped basal leaves. **Similar species:** This species may be confused with Canada anemone or wood anemone, long headed anemone, and tall anemone, but the leaves of cutleaf anemone are deeply 'cut' into many thin lobes.
**Life Form:** Perennial forb; stems die back during winter months, regenerating from buds at or below the soil surface [1].
**Reproduction:** This species reproduces by seed. This species is rhizomatous [2].

**Continental Range:** Cutleaf anemone is found across Canada, however east of Quebec populations are considered considered vulnerable [3]. It can be found in the western United States east to Nebraska and south to Arizona.
**HBL regional Range:** Widespread, abundant to frequent in the Hudson Bay Lowlands [4].
**Habitat:** Found in our region on exposed rocky areas and sandy hills, also occurs in open forests and grassy slopes; 0-3200 m [1].

*Photo 2: Cutleaf anemone growing on a rocky slope. Note the shape of the leaves.*

## Reclamation value

**Nitrogen fixing:** No.
**Symbioses:** Associated with arbuscular mycorrhiza [5].
**Growth rate:** Rapid [2].
**Successional stage:** No report found. Due to its tolerance of open and disturbed sites with exposed mineral soils, this species is likely tolerant of early successional conditions.

## Seed and fruit properties

**Fruit description:** Individual achenes have a small beak (1 to 6mm straight or hooked), flattened in one dimension, oval shaped: 3 to 4mm long and 1.5 to 2 mm wide. Brown at maturity, however the surface of the achene is covered by many wooly hairs. The achene is treated as a seed.
**Dispersal:** Wind [6]. The woolly hairs likely aid in dispersal by wind and water.
**Propagule weight:** (dried, whole achene with woolly hairs attached) 1.37mg [7].
**Seeds/ collection unit:** Not determined.
**Seed size and description:** See fruit description.
**Average seed weight:** (dried, cleaned) 0.98 mg [7].
**Seeds/kg:** Over one million seeds/ kg [7].

*Photo 3: Seeds dispersing from the head. Collect seed but before they begin separting.*

## Seed Collection

**Timing collections:** Seeds ripen in August. Seeds are ready to collect when they can be easily pulled from the head, but before they are separating naturally. Immature seeds are green and soft, becoming brown and firm at maturity. Seeds do not persist for long once mature.
**Collection protocols:** These plants are often tufted, with more than one flower stalk per plant. Collect using scissors by cutting just below the seed heads. Place into collection containers that are strapped to the collector. Scissors also prevent the collector from uprooting the plants if the collctor were to pull the seed heads by hand. Allow seed heads to dry in a thin layer.
**Collection effort:** One collector harvested approximately 110g of dry seed.
**Potential density:** Not determined.
**Cautions:** All parts of the plant are mildly poisonous if eaten.

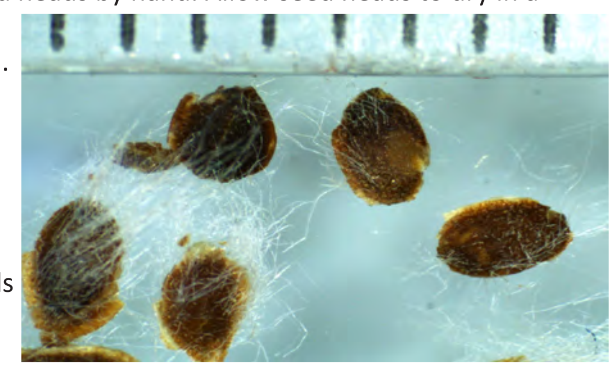

*Photo 4: Mature cutleaf anemone seeds with woolly hairs.*

## Propagule processing

**Processing protocols:** We were unable to clean seeds in our study. The woolly hairs are difficult to remove from the seeds. We tried rubbing seeds on a flat rubber mat, after much effort we were only able to free a few of the seeds. We also tried to dry blend seeds in a blender, without success. Seeds can be cleaned by a hammer mill but we did not test this [8].
**Cautions:** All parts of the plant are mildly poisonous if eaten.

## Storage

**Storage behaviour:** Orthodox [9].
**Storage requirements and longevity:** Seed that is dried can be stored up to 5 years in sealed containers at 3°C to 5°C [8]. Seed stored dried at -18°C maintained 91 to 100% viability after 18 years [9].

## Seed Propagation

**Dormancy classification:** Morpho-physiological dormancy [10].
**Potential viability:** Seed viability was approximately 86% in our study, but seed lots were uncleaned so we had not removed empty seeds from this sample.
**Pre-treatments:** Despite this species' dormancy, only cool-moist stratification is recommended for pre-treating seed. Seed may be stratified for 60 to 120 days [8,9].
**Germination protocols:** High germination rates (100%) are achieved at constant temperatures ranging from 15°C to 26°C and light/ dark cycles of 8/16 hours or 12/12 hours.
**Other propagation methods:** Uncertain.

**Field planting:** Seed emergence in the field was approximately 2.5% from seeds planted in sandy loam soils [11]. Seeds can be planted in the fall or spring.

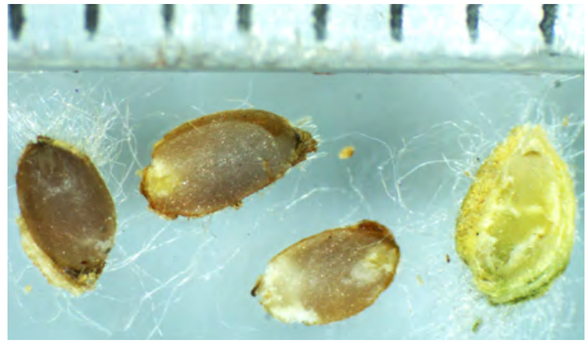

Photo 6: Cutleaf anemone seed, the seed to the right is not fully developed. Embryo growth will need to occur before this seed can germinate.

## Other

**Canadian commercial sources:**

http://www.alclanativeplants.com/section2/main.htm

http://www.wildaboutflowers.ca/plant_detail.php?Cut-Leaved-Anemone-11

**Useful links and Further reading:**

https://plants.usda.gov/core/profile?symbol=ANMU

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# sweetgrass

Family: Poaceae

Scientific name: *Anthoxanthum nitens* (Weber) Y. Schouten & Veldkamp

Cree Name: ________

Synonyms: *Hierochloe odorata*, etc.

*Photo 1: Sweet grass stand, growing on the Attawapiskat River shoreline*

## Quick Seed Guide

**When and what to collect**: Seeds ripen July to August, when the seed head turns tan in colour. Cut the entire seed head into large paper bags.
**Seed Processing**: Dry, thresh, winnow.
**Storage:** Dry, keep in sealed containers at 1 to 5°C for to 2 to 4 years.
**Pre-treatment of seed:**
8 weeks.
**How to Grow:** Seed: 23/9°C with equal amounts of light and dark. Rhizomes**:** Dig up rhizomes in spring or fall and plant where there is minimal competition.

## General

**Plant Description:** Sweet grass is a perennial grass with sweet smelling leaves and seed [1]. The stems of sweet grass are often spaced well apart (rather than in clumps), because it grows and reproduces by rhizomes. Stems are 15 to 50cm tall. Leaf blades are flat 10 to 30 cm long, ligules 0.5 to 6.5mm long. The flowering head has a triangular shape containing 8 to 100 spikelets. At maturity these spikelets are tan to golden. It appears as though each spikelet has 3 seeds (florets) but there are two male florets that do not contain seed and only the center floret is a seed (photo 2).
**Field Identification:** Identify sweetgrass by its sweet smelling leaves and the spikelet appearance that is unlike other grasses in the area.
**Life Form:** Perennial graminoid, stems die back during the winter months, regenerates from buds below the soil surface.
**Reproduction:** This species produces seeds, but it is strongly rhizomatous and produces new plants using these rhizomes.

**Continental Range:** This species is present in Nunavut and Ontario and in eastern Canada [2]. Populations in the United States are restricted to north eastern states.
**HBL regional Range:** Widespread and abundant in the Hudson Bay Lowlands [3].
**Habitat:** Grows in meadows, shores, coastal floodplain, roadsides, and fields [1].

## Reclamation value

Sweetgrass may be used for erosion control of slopes especially on seepage areas because of its rhizomatous growth [4]. This species may also be planted for its cultural use and importance. Tolerates some salinity.
**Nitrogen fixing:** No.
**Symbioses:** This species has been reported with arbuscular mycorrhiza [5].
**Growth rate:** Moderate [6].
**Successional stage:** Often early successional.

## Seed and propagule properties

**Dispersal:** ?Water [7].
**Seeds/ collection unit:** Only one seed per spike, and 80 to 100 seeds per stem [1].
**Seed size and description:** The seed it itself is approximately 3mm long x 1mm wide. However, typically the two sterile male florets will stay attached even after seed cleaning. The overall the size of the spikelet is about 4mm long x 2.5mm wide.
**Average seed weight:** (cleaned, dry seed) 0.45mg [8].

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**Seeds/kg:** Large variation in literature, may depend on the degree of seed cleaning: 242 000 [9] to 2.2million seeds/kg [10].

Photo 3: Collecting sweetgrass seed heads using scissors. Note seed heads are a brown colour.

## Seed Collection

**Timing collections:** Sweetgrass can be collected from mid-July to mid-August depending on the region. Check seed heads, if seeds can be pulled easily from spikelets and the seed heads are beginning to change colour from green to tan they are ready to collect. Seeds are fairly persistent (over 2 weeks).
**Collection protocols:** Cut the tops of seed heads using scissors into large paper bags or set out small sheets when populations are dense. Seed can be hand stripped when collections are sparse or widespread. Lay material out to dry following collection.
**Collection effort:** One person picks an average of 55g dried seed in one hour.
**Potential density:** Not determined.
**Cautions:** None known.

## Propagule processing

**Processing protocols:** Dried seed heads are gently threshed to detach the seed. Apply force cautiously to avoid damaging the seed. Winnow to remove glumes and other chaff. The two male florets stay intact.
**Cautions:** None known.

Photo 4: Threshing dry sweetgrass seed heads on a corrugated rubber mat.

## Storage

**Storage behaviour:** Orthodox [8].
**Storage requirements and longevity:** Dry seed and store in sealed containers at cool temperatures (1 to 5°C). Seed that was stored at room temperature for 10 years, still showed some viability and germinated to 15% [8,11]. Seed stored cool and dry for 2 to 4 years maintains most of its viability [12]. Seed stored dry at -18°C showed almost no loss in viability after 11 years [8].

## Seed Propagation

**Dormancy classification:** Physiological dormancy [10].
**Potential viability:** Seed viability from our cleaned seed lots ranged from 22 to 78%.
**Pre-treatments:** Most sources recommend cool-moist stratification of seed for 4 to 8 weeks [10,12,13]. Apparently fresh seed requires no pre-treatment as long as it has not been dried and is planted immediately after harvesting [12].
**Germination protocols:** Many practitioners report low germination rates for this species, however, it is hard to determine whether this is because they are beginning with low seed viability or because dormancy is not being broken with the pre-treatments. The highest reported germination was 100% following mechanical scarification. Germination temperatures were 23/9°C with equal amounts of light and dark [8].
**Other propagation methods:** Rhizome cuttings are the most common method for growing sweetgrass [4,10,14]. Cuttings are taken in the spring (June) or fall and planted immediately into a moist substrate. This method produces high survival rates (>70%) [14], but requires some disturbance to soils because rhizomes grow underground. Refer to further reading below for more information.
**Field planting:** Seeds can be planted in early spring when conditions are still cool or in the fall planted [15]. This species does not compete well with others while it is trying to be established, hairy vetch (*Vicia villosa*) was a helpful cover crop for this species, when it was field planted with rhizomes [14].

## Other

**Canadian commercial sources:**

http://www.wildaboutflowers.ca/plant_detail.php?Sweet-Grass-57

**Useful links and Further reading:**

http://www.wildflower.org/plants/result.php?id_plant=HIOD

https://plants.usda.gov/core/profile?symbol=HIOD

http://www.sixnationsfarmersmarket.com/gardening_growing_the_medicines.php

https://plants.usda.gov/plantguide/pdf/cs_hiod.pdf

https://npn.rngr.net/propagation/protocols)

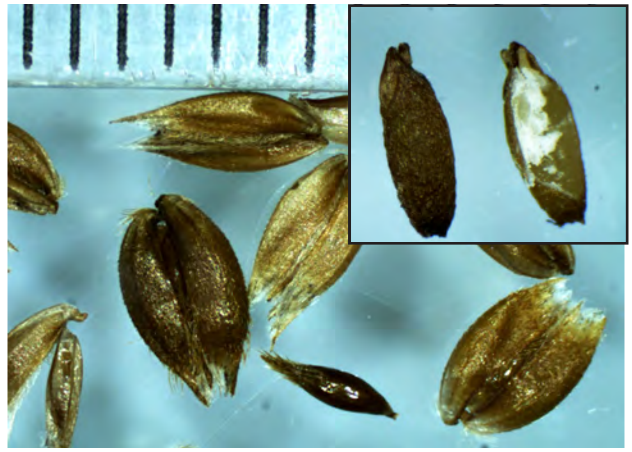

*Photo 6: Sweetgrass seed. (Inset photo) external view of seed and sectioned seed.*

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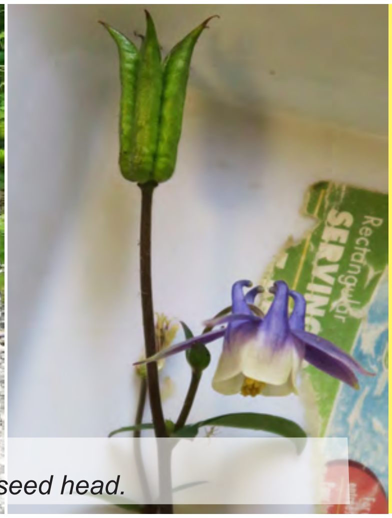
# smallflower columbine

Family: Ranuculaceae

Scientific name: *Aquilegia brevistyla* Hook.

Cree Name: ___________

Synonyms: *Aquilegia canadensis var. hybrida*




*with hooked spurs and mature seed head.*

## Quick Seed Guide

**When and what to collect**: Collect the entire seed head near the end of July, when the seeds inside follicles are black and hard.
**Seed Processing**: Dry, thresh, sieve and winnow if needed.
**Storage:** Dry, store in sealed containers at 1 to 5˚C.
**Pre-treatment of seed:** 60 to over 90 days cool-moist

**How to Grow:** Seed: germinate between 21 and 29°C, with 12/12 hours of light/dark. Vegetative: plants can be divided in the spring.

## General

**Plant Description:** Small flower columbine has an attractive flower and belongs to the columbines (*Aquilegia*) which are common garden plants. This plant can grow 20 to 80cm tall [1]. Early in the season, you will see the basal leaves, which are compound (3 lobes) and quite ornate. The flowers are the most distinct feature of this plant. The flower is borne at the tip of the stem. The flower is blue and light yellow, nodding, with hooked spurs (photo 1, right).
**Field Identification:** Small flower columbine is easy to identify, once you are familiar with its appearance. Early in the season, only the basal leaves are seen and may be confused with meadow rue leaves that have a similar ornate appearance, but the two are very different later is the season. **Similar species:** Other columbine species have different coloured flowers, or if blue, they will not have the hooked 'spurs' like this species.
**Life Form:** Forb; perennial, stems die back during winter months, regenerates from buds at or below the soil surface.
**Reproduction:** This species reproduces by seed, flowering is from June to August.

**Continental Range:** Smallflower columbine is present in northwestern and central Canada, east to Quebec [2]. Populations in the United States are restricted to northern states and Alaska.
**HBL regional Range:** Occasional in the Hudson Bay Lowlands, only located inland, at least 15km from the coast [3].
**Habitat:** In our region, found most commonly on rocky outcrops in exposed sites. Also found in open woods, meadows, or shores; 800-3500m [1].

## Reclamation value

**Nitrogen fixing:** No.
**Symbioses:** Unknown for this species. *Aquilegia vulgaris* has been reported with arbuscular mycorrhiza [4].
**Growth rate:** No information found.
**Successional stage:** Early to mid-successional**.**

## Seed and capsule properties

**Capsule description:** Seeds are contained within follicles that will open to release seed when mature.
**Dispersal:** ?Seed falls in the vicinity of the mother plant when mature.
**Propagule weight:** Refer to seed weight below.
**Seeds /propagule:** Numerous.
**Seed size and description:** Seeds are about 2mm long x 1mm wide. Plump, black and shiny at maturity.

*capsules.*

De Beers Canada Victor Mine · Laurentian University Université Laurentienne · NSERC CRSNG

**Average seed weight:** In our study, air-dried, cleaned seed was 0.81mg, another source reported an average seed weight of 0.93mg [5].
**Seeds/kg:** 1.1 million [5] to 1.24 million seeds/kg.

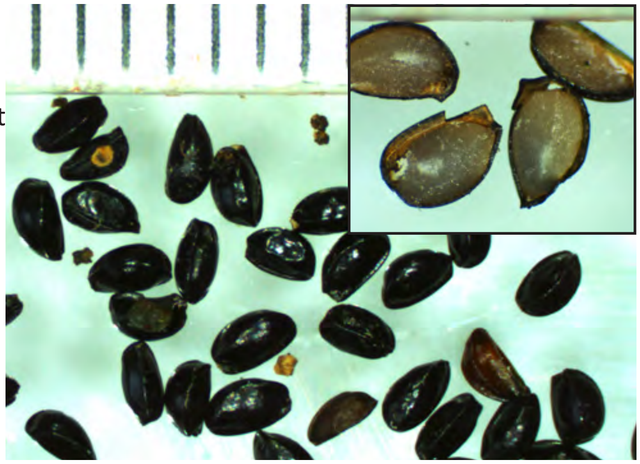
opened and released seed. Break off the stem to collect seed heads before they turn brown to avoid losses.

## Seed Collection

**Timing collections:** Seed matures in early August, when capsules are still green but hard and the seed inside is black. Seeds can persist in follicles even after they have opened, but they wind will shake the stem to help the seed to fall. The best time to collect seed is just before the follicles open.
**Collection protocols:** To collect columbine seed, simply break the stem just below the seed head; if the stem does not break easily, hand pruners may make harvesting easier. Allow material to dry before processing.
**Collection effort:** The collection rates in our study varied because of differences in the plant density, from 34g to 165g of pure, dry seed in one hour.
**Potential density:** Not determined.
**Cautions:** None known.

## Propagule processing

**Processing protocols:** Seeds of columbine are easy to clean by <u>thresh</u>ing and <u>winnow</u>ing. The dry capsules can be placed on a corrugated rubber mat and will open to release seed using the threshing paddle. This crushed material is sieved to separate capsules from seed and further cleaned by winnowing.
**Cautions**: None known.



Sectioned seed, note the embryo is not visible in fresh seed.

## Storage

**Storage behaviour:** The storage behaviour of this species is unknown, but 100% of the other columbines (*Aquilegia* spp.) studied, have <u>orthodox</u> storage behaviour.
**Storage requirements and longevity:** Seed from a related species, Canada columbine (*Aquilegia canadensis*) can be stored cool and dry for up to three years [6].

## Seed Propagation

**Dormancy classification:** Unknown, *Aquilegia pubescens* from temperate and arctic climates has a <u>morphological dormancy.</u> The embryo must grow before germination can occur.
**Potential viability:** In our study, seed viability was 95% on average.
**Pre-treatments:** More information is needed for this species. *Aquilegia canadensis* requires 60 days at 6°C [5]. This species, requires a period of <u>cool-moist stratification</u> for at least 90 days before germinating (Accessed: June 7th, 2017; http://www.naturatours.ca/blue-columbine.html).
**Germination protocols:** *Aquilegia canadensis*, germinated to 88% at 21°C and 12/12 hours of light/dark [5]. Seeds of two other alpine *Aquilegia* ssp. had peak germination rates at 27/23°C with equal light/dark cycles [7].
**Other propagation methods:** Canada columbine can be propagated by plant divisions [8].
**Field planting:** Seeds of Canada columbine require light to germinate [8]. Plant immediately after collecting into a soil that will hold moisture, such as peat or vermiculite. Seedlings will emerge the following spring. This species prefers well-drained soils.

## Other

**Canadian commercial sources:**

http://www.wildaboutflowers.ca/plant_detail.php?Blue-Columbine-13

http://www.naturatours.ca/blue-columbine.html

**Useful links and Further reading:**

http://www.saskwildflower.ca/nat_Aquilegia%20brevistyla.html

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# bearberry, kinnikinnick

Family: Ericaceae

Scientific name: *Arctostaphylos uva-ursi* (L.) Spreng.

Cree Name: ___________

Synonyms: *Arctostaphylos adenotricha,* etc

Photo 1: Bearberry with ripe fruit.

## Quick Seed Guide

**When and what to collect**: Collect berries when they turn red in late summer to fall.
**Seed Processing**: Thresh berries on corrugated rubber mat, apply a great deal of force to separate seed from one another. Rinse into bucket with water, reserving only sunken seed.
**Storage:** Dry, in sealed containers at 3 to 5°C for 20 years.
**Pre-treatment of seed:** 1. Acid scarify (4.5 hours) 2. Warm stratify 8 to 16 weeks, 3. Cold stratify 8 to 12 weeks.
**How to Grow:** Seed: standard conditions, expect about 50% germination success. Vegetative: take stem cuttings in May, treat with rooting hormone.

## General

**Plant Description:** This shrub grows low to the ground, forming mats. It has a trailing stem which can develop roots if it comes in contact with the soil. It can grow to a height of 50cm, but is usually under 15cm [1]. The leaves are dark green and shiny on the upper surface, "leathery" and usually stay green throughout the winter (evergreen). The leaf tip is round, narrowing to the base, leaf margins are smooth, 1 to 2.5cm long and 0.5 to 1.5 cm wide attached by a short stalk. The flowers are white to light pink, hanging like bells in clusters. The fruit of bear berry is red at maturity.
**Field Identification:** The fruit of bear berry and its horizontal growth make this species distinct. **Similar species:** Before this species has ripe fruit it may be confused for other ericoid shrubs because their leaves are similar and their flowers are also bell shaped. In our region lingonberry (*Vaccinium vitis-idaea*) is very similar in appearance to bearberry, and can overlap in their habitat in some cases. They also both have red fruit and grow low to the ground. At maturity their fruits are easily distinguished, because bearberry seeds are large stone seeds (up to 6), while mountain cranberry seeds are very small and numerous.
**Life Form:** Bearberry is considered a dwarf shrub; it has a woody stem that persists throughout the winter.
**Reproduction:** Bearberry spreads by its trailing stems that can develop adventitious roots and by seed. It flowers in May until June and produced berries by the summer [1].

**Continental Range:** Bearberry is widespread throughout Canada [2]. The status of this species is largely not ranked in the United States, but populations are concentrated in northern states.
**HBL regional Range:** Occasional in the Hudson Bay Lowlands [3].
**Habitat:** This species prefers open habitats, but can also be found in some forests. Bearberry prefers well-drained soils, rocky, sandy and tolerates a variety of soil pH from 5.5 to 8; 0-3100 m [1,4].

Photo 2: Bearberry growing on a rock outcrop, spreading onto exposed mineral soil.

## Reclamation value

Bearberry is commonly used in reclamation because of its tolerance to drought and a variety of soil conditions, including: a wide range of pH, calcium carbonates, and salt [4]. It has a horizontal growth so may be used to stabilize loose soils and protect against wind erosion.
**Nitrogen fixing:** No.

**Symbioses:** Forms symbioses with several types of mycorrhizae, including: arbutoid mycorrhiza, arbuscular mycorrhiza, ectomycorrhiza, ericoid mycorrhiza, and ectendomycorrhiza [5]. These relationships are diverse and critical for this species because it often grows in harsh, nutrient limited soils [1].

**Growth rate:** Moderate [6].

**Successional stage:** Bearberry succeeds in a variety of successional stages depending on the habitat and region, but due to its tolerance of fire, shade intolerance, and creeping growth, it is a successful pioneer [7].

*Photo 3: Collecting mature bearberry fruit. It is bright red and soft at maturity. It grows low to the ground so we collect onto a tray.*

## Seed and fruit properties

**Fruit description:** Berries are round, bright red at maturity, 6 to 12 mm in diameter [1].

**Dispersal:** Animal dispersed, not by bats [8].

**Fruit weight:** (dried, whole fruit) 81.4mg [9].

**Seeds /propagule:** Up to 5 per berry [1].

**Seed size and description:** Seeds are approximately 2.5 to 4mm by 1.5 to 2mm.

**Average seed weight:** (dried cleaned seed) 5.2mg [9].

**Seeds/kg:** 190 000 seeds/kg [9].

## Seed Collection

**Timing collections:** Berries will ripen from August to October depending on the region. They are ready to collect when the berries are bright red and soft and when seeds are tan [10]. We have found berries stay on the plant until the following spring, if not eaten by wildlife.

**Collection protocols:** Berries are hidden under leaves and are located low to the ground making their collection challenging. Harvest by hand collection. Use a berry basket or a tray that sits on the soil surface to allow both hands free for collection. Keep berries in the refrigerator until processing is possible.

**Collection effort:** We collected approximately 52g of pure dry seed in one hour.

**Potential density:** Plants are habitat specific and sparsely distributed throughout our region, however where plants occur, plant density and fruit production is often high.

**Cautions:** None known.

*Photo 4: Bearberry seed separated from fruits, ready to be cleaned by winnowing.*

## Propagule processing

**Processing protocols:** Fruit must be processed because they contain multiple seeds. The seeds are often grouped together into a round stone that requires some force to separate. Thresh berries on a corrugated rubber mat, seeds are very hard and can handle a great deal of force. Rinse seeds into a bucket of water, pour off the floating pulp and seed, reserve only sunken seeds.

**Cautions:** None known.

## Storage

**Storage behaviour:** Likely orthodox [11].

**Storage requirements and longevity:** Dry, store in sealed containers at 3 to 5°C. Seeds stored in sealed containers at 3 to 5°C were viable for up to 20 years [12]. Other members of *Arctostaphylos* maintain viability for up to 18 months kept in moist soil [13].

# bearberry, kinnikinnick

## Seed Propagation

**Dormancy classification:** Physiological dormancy [14].
**Potential viability:** Cleaned seed batches had nearly 100% viability.
**Pre-treatments:** Cool-moist stratification for at least 17 weeks is the minimum requirement to break dormancy, however it is unclear if warm stratification is also required before or after cool stratification [8,14,15]. The highest germination rates are reported by the following pre-treatments: 1. seed is soaked in concentrated sulphuric acid for 4.5 hours. 2. Warm-stratified for 8 to 16 weeks. 3. Cool-stratified for 8 to 12 weeks [16]. Acid scarification is required to remove a “plug” that blocks the channel from which the radicle emerges, however soaking for too long will damage the seed [8].
**Germination protocols:** Germination rates tend to be low for bearberry seeds. The highest germination percent reported was 50 to 56%, following the complex of treatments listed above. However germination medium and temperatures were not specified [16].

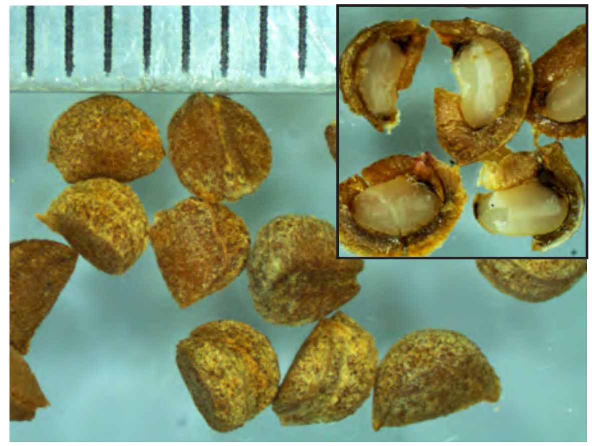

*Photo 6: Whole bearberry seed. (inset photo) Sectioned, viable bearberry seeds.*

**Other propagation methods:** Softwood cuttings (10 to 20cm long) taken in May can be successfully rooted (+/- 50%). Treat cuttings with a rooting hormone, such as IBA[16].
**Field planting:** Bearberry seeds planted in the fall had over 3% emergence by the 4th season, but only about 1.5% emergence by the 2nd season [17]. Fall planted seed had significantly higher emergence than spring planted seeds or fall planted fruit.

## Other

**Canadian commercial sources:**
Available in small quantities from: http://www.wildaboutflowers.ca/plant_detail.php?Kinnikinnick-115
**Useful links and Further reading:** http://www.nativeseednetwork.org/viewtaxon?taxon_code=ARUV&release_name=
http://library.cemaonline.ca/dataset/2008-0019
http://www.missouribotanicalgarden.org/PlantFinder/PlantFinderDetails.aspx?kempercode=j380
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# resin birch

Family: Betulaceae

Scientific name: *Betula glandulosa* Michx.

Cree Name: ___________

Synonyms: None found

*Photo 1: Resin birch branch and female catkins.*

## Quick Seed Guide

**When and what to collect**: Seeds ripen in September. Catkins change from green to tan or yellow. Collect before catkin scales open.

**Seed Processing**: Dry, thresh, sieve. To break wings off

**Storage:** Dried seed kept at 5°C remains viable up to 6 years.

**Pre-treatment of seed:** Soak seed for 24 hours, cool stratify for 8 weeks.

**How to Grow: Seed:** Germinates at a range of temperatures, some light is required.

## General

**Plant Description:** Resin birch is a deciduous shrub that grows up to 3m tall [1]. Each plant can have multiple stems. This species will often be in dense stands with other resin birch. The twigs are covered with resin glands that look like raised white spots. The leaves are also covered in resin glands, alternate leaf pattern, dark green and shiny on the upper surface, 0.5 to 3cm and 1 to 2.5 cm. The leaf edges are characteristic with their rounded teeth. The seeds are inside erect catkins that look like small cones. Separate male and female catkins are found on a single plant.

**Field Identification:** The small round tooth leaves, 'warty' branches, and catkins can be used to identify this species from other plants. **Similar species:** There are several similar species including *Betula pumila*, *Betula nana*, and *Betula occidentalis*. However resin birch can be distinguished by its shrub size and the new branch growth is covered in white spots (rather than yellow or red). Its leaves are green on both sides, rather than whitened beneath. Identifying this species can cause some confusion because the birches hybridize regularly [1].

**Life Form:** Resin birch is a perennial shrub; stems persist through the winter.

**Reproduction:** This plant is monoecious (separate male and female catkins on one plant). This species reproduces by seed and by branch layering [2]. At the southern part of this species range, seed production is the most common, however in the northern parts of its range this species reproduces mainly by branch layering and although plants may produce seed, they often have low viability at the northern limit.

**Continental Range:** Resin birch is found throughout Canada, but is much less common in the Maritime provinces [3]. Populations in the United States are primarily in the northern states.

**HBL regional Range:** Occasional, restricted to the northern portion of the Hudson Bay Lowlands [4].

**Habitat:** Primarily an upland birch but can also be found in moist habitats like muskegs and stream banks. Primary upland habitats are tundra, rocky slopes, open subalpine summits, river shores; 0-3400m [1].

*Photo 2: Resin birch branch, note the white spots on the branches and the green underside of the leaf.*

## Reclamation value

Resin birch grows slowly so it is not considered a valuable species for establishing a quick vegetation cover, however, it may have value as a nurse crop, providing shade to planted conifer trees and has shown potential for erosion control of stream banks (cited in [5]).

**Nitrogen fixing:** No.
**Symbioses:** Unknown for this species, however *Betula pumila*, forms an ectomycorrhizal association as does *Betula papyrifera* [6].
**Growth rate:** Slow (cited in [5]).
**Successional stage:** Early, mid, and into late [5]. This plant regenerates from the root crown after disturbances such as fire, and is tolerant of early succession conditions, but resin birch also persists into mid-succession and late succession up to 50 years post fire.

Photo 3: Resin birch female catkins are almost ready for collecting, note the brown seed is visible between the scales.

## Seed and fruit properties

**Fruit description:** Fruits are called catkins that look like small cones [1]. They are round, 1 to 2.5 and 0.5 to 1.2 cm. They change colour from green to light brown to dark brown when ripening and will fall apart (shatter) when touched.
**Dispersal:** Wind, seeds have wings [7].
**Seeds/ catkin:** 30 to 100 (potential) [2], typically 30 to 50 [8].
**Seed size and description:** Seeds are called samaras, they are winged. Seeds are about 3mm long by 3mm wide (with wings) and about 1.5mm wide (without wings). Filled seed is plump and firm, brown at maturity.
**Average seed weight:** (cleaned, dried seed) 0.18mg [9].
**Seeds/kg:** 5.56 million seeds/kg [9].

## Seed Collection

**Timing collections:** Seeds are mature in early September, when the catkins are green to yellow and the seed is brown. Collect them before the scales of the catkins open to avoid seed loss.
**Collection protocols:** Collect entire catkins by hand into buckets strapped to the collector. The catkins are easy to collect because they separate easily from the plant and are located at chest height. If seeds are very ripe they will fall apart when touched. If the stand is very dense and seeds are very ripe, place a sheet below the branches and shake the branch vigorously to free the seed (only if it is not a windy day). Place catkins on trays to dry following collection.
**Collection effort:** One person collected 67g of pure, dry seed in one hour. In our region, resin birch stands were not very dense and seed fill was low, therefore collection rates of cleaned dried seed were fairly low.
**Potential density:** In high density plots, maximum seed rain was over 2000 seed/m$^2$.
**Cautions:** None known.

Photo 4: Dried female catkins ready to be threshed.

Photo 5: Catkins following threshing, the seed and scales easily separate.

## Propagule processing

**Processing protocols:** The seed and scales easily fall apart. 1. Place dry material on the corrugated side of a rubber threshing mat and use the paddle to break apart the catkins. The seeds and scales are a different size. 2. Pour material into a sieve, seed remains in sieves with mesh # 10 or #18. If you wish to further clean seed by removing the wings, return the seed to a rubber corrugated mat and gently thresh the seed with the paddle. Avoid using too much force as this can damage the seed. Finally winnow this material in front of a low air stream to remove broken wings and empty seeds.
**Cautions:** None known.

## Storage

**Storage behaviour:** Orthodox? [9].
**Storage requirements and longevity:** Dried seed from resin birch can be stored at 5°C for up to 6 years and maintain germination levels similar to fresh seed [10].

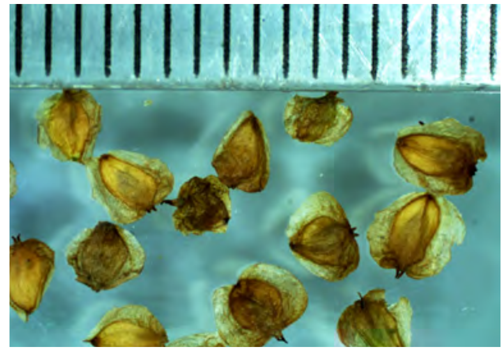

*Photo 6: Resin birch seed. Wings are still attached.*

## Seed Propagation

**Dormancy classification:** Other birches (*Betula ssp*.) have seeds that are non-dormant or exhibit a physiological dormancy [11].
**Potential viability:** In our study seed viability was low, on average 14%, but ranging from 11.5% to 20%. More southern sourced seed has higher viability (up to 70%) than resin birch at its northern limit (approx. 0.8% viable) [8].
**Pre-treatments:** Resin birch likely exhibits physiological dormancy because cool-stratification is a typical pre-treatment recommendation. One author soaked seed for 24hrs and then cool stratified seed for 8 weeks [12]. Another author, cool stratified seed for 4 weeks at 0 to 4°C, then froze seed at -20°C for 16 weeks [8]. Both authors reported high seed germination rates, for filled seeds.
**Germination protocols:** Germination rates of 91% were achieved in a greenhouse at 25°C/18°C. Some light is necessary for germination of birches [11]. Seeds will germinate at higher and lower temperatures.
**Other propagation methods:** No information found.
**Field planting:** No information found.

## Other

**Canadian commercial sources:** None found.
**Useful links and Further reading:**
https://www.fs.fed.us/database/feis/plants/shrub/betgla/all.html#166
http://www.flora.dempstercountry.org/0.Site.Folder/Species.Program/Species.php?species_id=Betu.glandu
https://gobotany.newenglandwild.org/species/betula/glandulosa/

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# paper birch

Family: Betulaceae

Scientific name: *Betula papyrifera* Marshall

Cree Name: ___________

Synonyms: *Betula papyrifera var. papyrifera*


Photo 1: Paper birch tree.

## Quick Seed Guide

**When and what to collect**: Collect catkins in the later summer to fall, before the catkins turn brown, but when brown plump seed is seen.
**Seed Processing**: Dry
winnow to remove broken wings.
**Storage:** Dry, in sealed containers at 1 to 5°C.
**Pre-treatment of seed:** Cool-moist stratify for 45 days.
**How to Grow:** Seed: Germinate at 24°C to 30°C, at least 16 hours of light a day.
Vegetative: Semi-hardwood stem cuttings, see below.

## General

**Plant Description:** Paper birch is a deciduous tree that can reach 30m, but more often is less than 20m [1]. A plant can have a single trunk or multiple. The bark of a mature tree is white and peels off the trunk in horizontal strips. Twigs are alternate and newer growth is covered in raised white bumps. Leaves are generally 5 to 9cm long by 4 to 7cm wide, have a pointed tip, and irregularly toothed margins. Monoecious, so one tree has both male and female flowers but on separate fruits. The female catkins hang from a slender stalk, male catkins are up to 10cm long and also hang.
**Field Identification:** Paper birch can be recognized by it leaves, hanging female catkins, papery bark (at maturity), and by the raised dots (glands) on the new branches. **Similar species**: Yellow birch (*B. alleghaniensis*) and river birch (*B. ocidentalis*) are also trees or large shrubs similar to paper birch. Paper birch twigs do not have a wintergreen smell like yellow birch and its bark is white unlike river birch. Be aware that many birches can hybridize with one another, making their identification challenging in some cases.
**Life Form:** Tree; has woody stems that persist year-round, buds are usually over 3m above ground.
**Reproduction:** This species will begin to produce seed after 15 years [2]. Seeds are produced annually but good seed crops may occur every two years. The most abundant seed production years are when trees are 40 to 70 years old. Paper birch can reproduce from sprouts following a fire [2].


Photo 2: Paper birch young branch, covered in raised dots (glands) and irregularly toothed leaf.

**Continental Range:** Widespread throughout Canada, becoming less common in northern provinces. This species is also present through most of the United States [3].
**HBL regional Range:** Occasional in the Hudson Bay Lowlands, but only located inland, at least 15km from the coast [4].
**Habitat:** Ranges from moist to open sites, upland forest, especially on rocky slopes; 300-900 m [1].

## Reclamation value

Paper birch is a good colonizer of severally burned sites [5]. It is known as a good pioneer following disturbance from fire and mining impacts [6].
**Nitrogen fixing:** No.
**Symbioses:** Ectomycorrhizal [7].
**Growth rate:** Rapid [8].

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**Successional stage:** Early, however it can coexist in forest openings once it is replaced by later successional species [2].

Photo 3: Birch catkins with open scales after drying. These are ready for processing.

## Seed and fruit properties

**Fruit description:** Female catkins contain many seeds, they are long and slender, 2.5-5cm long and 0.6-1.2cm in diameter [1].
**Dispersal:** Primarily dispersed by wind, seeds are winged [9].
**Seeds/ catkin:** Not determined.
**Seed size and description:** Seeds are winged, round and flattened, about 3mm long and 1.5mm wide (without wings).
**Average seed weight:** (cleaned air-dried seed) 0.3mg [10].
**Seeds/kg:** Three million seeds/kg [2].

## Seed Collection

**Timing collections:** Catkins ripen in the first week of September when they change colour from green to yellow, but the seeds inside are brown and firm. The majority of seed (80% or more) is dispersed from September to November, but some can persist until the spring [9].
**Collection protocols:** Paper birch can be collected using pole pruners, by trimming highly productive branches. If the tree is shorter, a pole with a hook at the end can be used to pull branches into reach. The collector can hold the pole between their legs and collect individual catkins into buckets. Attach collection buckets to your body so both hands are free to collect. Be cautious because ripe catkins will fall apart and result in lost seed. Place catkins in thin layers to dry following collection.
**Collection effort:** One collector harvests an average of 230g (100g to 400g) dried pure seed in one hour.
**Potential density:** 2.5 to 25 million seeds/ha [9].
**Cautions:** None known.

Photo 4: Collecting paper birch branches and catkins using pole pruners.

Photo 5: Using a pole with a hook to bring branches into reach.

## Propagule processing

**Processing protocols:** Dry catkins at room temperature, 15 to 25°C. Crush catkins using a paddle so they fall apart. Remove large pieces such as twigs and leaves, or sieve this material out. Thresh on a flat rubber mat to break wings. Sieve to remove seeds from chaff using a sieve with a 2mm opening, test this sieve size because regional seed sizes may vary [11]. Winnow to remove broken wing pieces.
**Cautions:** None known.

## Storage

**Storage behaviour:** Orthodox [10].
**Storage requirements and longevity:** For short term storage of paper birch seed, store in sealed containers at cool temperatures (1 to 5°C) [12]. For long term storage, well dried seed can be stored at freezing temperatures, below -10°C [10].

## Seed Propagation

**Dormancy classification:** Physiological dormancy [13].
**Potential viability**: Highly variable, 47 to 100% seed fill in one study [14] and 11% to 31% from our collections.
**Pre-treatments:** Cool-moist stratification is likely to enhance germination success. Cool-moist stratify seed at approximately 3°C for 14 to 75 days [11,13]. Optimal stratification time is approximately 45 days, after which germination success may decline [14].

**Germination protocols:** Optimal germination temperatures range from 24°C to 30°C under continuous light (optimal 24 hours, minimum of 16 hours) [14]. Germination was over 90% after 5 days in these conditions. The germination medium is non-specific.

**Other propagation methods:** Paper birch may be grown by semi-hardwood stem cuttings. The cuttings are taken before the last bud on the branch has developed. Apparently this timing is critical. Cuttings that are 10 to 20cm in length, treated with 8000 ppm IBA and kept heated in a moist medium have had high rooting percentages. For more information refer to further reading below.

**Field planting:** Field planting in the fall requires no seed pre-treatment.

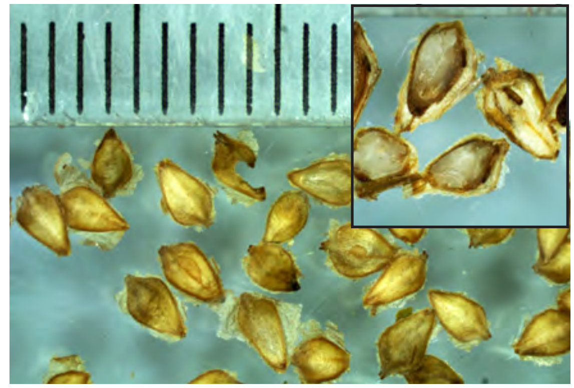

*Photo 6: Whole paperbirch seed, has been mostly-dewinged. (inset photo) Sectioned paper birch seed. Seed to the left is viable, seed to the right is not.*

## Other

**Canadian commercial sources:**

https://www.oscseeds.com/ecommerce/-tree--seeds-/-deciduous--trees-/White-Birch-Betula-papyifera.htm

**Useful links and Further reading:**

https://www.na.fs.fed.us/pubs/silvics_manual/volume_2/betula/papyrifera.htm

http://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=betulaceae-betula-42

https://gobotany.newenglandwild.org/species/betula/papyrifera/

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# fringed brome

Family: Poaceae

Scientific name: *Bromus ciliatus* L.

Cree Name: ___________

Synonyms: *Bromus dudleyi*

Photo 1: Fringed brome grass with mature seeds.

## Quick Seed Guide

**When and what to collect**: Collect entire seed head in

colour has changed from green to brown.

**Seed Processing**: Dry, thresh gently, winnow.

**Storage:** Dry and cool (1 to 5°C)

**Pre-treatment of seed:** None required.

**How to Grow:** Seed: Germinates well at 30/20°C and 16/8 hours of light/dark.

## General

**Plant Description:** A tufted perennial grass, 0.5 to 2m tall [1]. Stems are covered in fine hairs. Leaf blades are flat, 15 to 25cm long and 3 to 15mm wide. The flowering head is drooping at maturity. Spikelets have more than one seed, seeds have many fine hairs around the margins [1,2].

**Field Identification:** Fringed brome is recognized by its drooping seed head, hairy seeds, tufted growth, and wide leaves.

**Similar species:** There are both native and introduced brome grasses in Ontario. Smooth brome (*Bromus inermis*) is similar but its seed head is mostly erect rather than drooping and the seeds and stems are usually not hairy like fringed brome. Japanese brome (*B. japonicus*) is another introduced grass that can be distinguished by its very hairy leaf sheaths and longer spikelets compared to fringed brome.

**Life Form:** Perennial grass; stems die back during the winter months regenerates from buds below or at the soil surface [1].

**Reproduction:** Reproduces by seeds, this species is not rhizomatous [1]. Also reproduces by tillers, forming tufts [3].

**Continental Range:** Present in all Canadian provinces except in Nunavut. Widespread in the United States, absent in the southeastern states.

**HBL regional Range:** Widespread and abundant in the Hudson Bay Lowlands [4].

**Habitat:** A variety of habitats, often associated with some moisture, but tolerant of seasonally dry, exposed sites (cited in [1]). Woodlands, thickets, meadows, prairies, fens, lake shores, along streams. Tolerant of all soil textural classes and a pH range of 4.8 to 7.9.

## Reclamation value

A species used for erosion control on moist sites [5]. It provides a valuable food source for wildlife and persists as succession advances [1,5].

**Nitrogen fixing:** No.

**Symbioses:** Arbuscular mycorrhiza, vesicular mycorrhiza, and dark septate endophytes [6].

**Growth rate:** Moderate [7].

**Successional stage:** Present in early successional site and late successional or climax sites [1].

Photo 2: Fringed brome seed head. Note large spikelets and slender branches.

# fringed brome

## Seed properties

**Dispersal:** Seeds fall from the mother plants at maturity.
**Seeds/ collection unit: Not determined.**
**Seed size and description:** Seeds are covered by a papery layer, tan at maturity, hard with a visible dark-brown or purple seed coat. Long and wide, flattened, about 20mm long and 2mm wide.
**Average seed weight:** 1.03mg (cleaned, dry seed) to 1.71mg (with seed coverings) [8].
**Seeds/kg:** 585 000 to 971 000 seeds/kg.

## Seed collection

**Timing collections:** Collect seed from late August to September when flowering heads chang from green to tan. Seed will disperse quickly after maturity and should be collected as soon a colour change is visible.
**Collection protocols:** Strip seed heads by hand into a collection container that is harnessed to the collector to free up both hands. Entire seed heads can be collected using scissors. This species regenerates almost entirely by seed, so some seed should be left behind to allow the stand to regenerate in futre years. Place seed materials out to dry following collection.
**Collection effort:** One collector picks 160g pure dry seed in one hour from wild stands.
**Potential density:** 120 to 2792 kg seed/ha, from one year old plants in cultivation [9].
**Cautions:** None known.

*Photo 3: Fringed brome spikelets. The spikelets to the far right do not contain any seed, they are the glumes.*

## Propagule processing

**Processing protocols:** Seeds are covered by a papery layer; this does not need to be removed during seed cleaning and may damage seed if attempted. The goal of seed processing is to separate seed from the plant. 1. Place dried seed heads on a corrugated rubber mat and gently thresh seed using a paddle in order to separate seeds. 2. Winnow material in front of a light airflow to remove chaff.
**Cautions:** None known.

## Storage

**Storage behaviour:** Orthodox [10].
**Storage requirements and longevity:** Seed stored cool and dry (temperature not specified) can maintain its viability for at least two years [5].

*Photo 4: Fringed brome whole seed.*

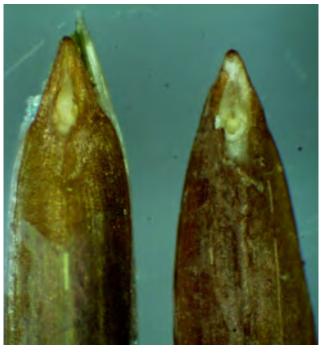

*Photo 5: Fringed brome seed, with a sectioned embryo.*

## Seed Propagation

**Dormancy classification:** Non-dormant [11].
**Potential viability:** Seed viability ranged from 60 to 100% from our collections. The reason for some lower seed viability was due to predation from insects.
**Pre-treatments:** None required, seed germinates equally well without or without cool stratification [11].
**Germination protocols:** Seed germinates well at a range of temperatures, in the range of 30/20°C [5] and 24/10°C with 16/8 hours of light/dark [11].
**Other propagation methods:** None known [7].
**Field planting:** Seeds can be sown in the spring or fall and will emerge well [3]. Seeds sown at a rate of 1.9kg/ha will provide approximately 10% cover. Seed should be planted to a depth of 1.2cm or broadcast [3,5].

## Other

**Canadian commercial sources:**

https://www.brettyoung.ca/professional-turf-and-reclamation/seed/native-grasses

http://www.silverplains.ca/flora/grasses/fringed-brome.html (contains several links to Canadian sources)

**Useful links and Further reading:**

http://michiganflora.net/species.aspx?id=2029

https://era.library.ualberta.ca/files/cf95jc369/Bromus%20ciliatus.pdf

https://gobotany.newenglandwild.org/species/bromus/ciliatus/

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# bluejoint

Family: Poaceae

Scientific name: *Calamagrostis canadensis* (Michx.) P. Beauv. Cree Name: ___________

Synonyms: *Calamagrostis cinnoides*

*Photo 1: Bluejoint stem. Note the swollen purple nodes.*

## Quick Seed Guide

**When and what to collect**: Seeds ripen in the late summer, seed disperses quickly. Seed heads turn tan at maturity. Using scissors or shears, cut the entire seed head off.

**Seed Processing**: Thresh plant material, discard empty stalks.
separate seed from covering structures, sieve.

**Storage:** Seed is not sensitive, dry and store at room temperature or cool for several years.

**Pre-treatment of seed:** None required.

**How to Grow:** Seed: Germinate at 30/20°C.

## General

**Plant Description:** Bluejoint is a perennial grass, often found in large dense stands. In the proper conditions this species can be 65 to 112cm tall [1]. The stem has 3 to 7 nodes that are purplish in colour. The leaves are flat, 16 to 31cm long, 2 to 8mm wide, ligules (3 to 8mm, looks like it has been shredded). The seed head is tight when developing like a paint brush, but large and spreading when ripe, changing from greenish purple to straw coloured. Each spikelet has only one seed.
**Field Identification:** Bluejoint is often recognizable because it is a large grass, with large purple nodes. It can also be recognized by its seeds that have many stiff long hairs (2 to 3.5mm). **Similar species:** Many species of grasses will form large colonies like bluejoint. The invasive common reed (*Phragmites australis*) it much larger than bluejoint and reed canary (*Phalaris arundinacea*) has smooth seeds, unlike the notably hairy seeds of bluejoint. Slimstem reedgrass (*Calamagrostis stricta*) has a seed head that does not spread open at maturity like bluejoint. Purple reedgrass (*Calamagrostis purpurascens*) has a long awn and hairy leaves. If you are unfamiliar with this species, refer to useful links below for more detailed descriptions on this plant and more photographs.
**Life Form:** Perennial graminoid, stems die back during winter months and plants regenerate from buds at or below the soil surface.
**Reproduction:** Bluejoint reproduces by seeds and rhizomes.

**Continental Range:** This species is present in every Canadian province [2]. Populations in the United States are largely unranked, however bluejoint is present west to east, south to New Mexico.
**HBL regional Range:** Widespread and abundant in the Hudson Bay Lowlands [3].
**Habitat:** Grows in many different habitats. Forms dense stands on lake or river shores, moist meadows, bog edges, but is tolerant of upland environments such as forest openings; 0 - 3400m [1].

## Reclamation value

Canada bluejoint is an aggressive grass once established and had been reported as a pioneer at many disturbed sites[4,5]. It may be useful for erosion control and is very cold tolerant [6]. For a more thorough review of this species use in revegetation refer to literature cited.
**Nitrogen fixing:** No.
**Symbioses:** Vesicular arbuscular mycorrhiza (VAM) [7,8].
**Growth rate:** Moderate [9].
**Successional stage:** This species is a good colonizer after fire or on disturbed sites.

## Seed and propagule properties

**Propagule description:** Each spikelet is 2 to 4.5mm long and contains one seed (floret)[1].
**Dispersal:** Wind.
**Seeds /propagule**: One seed per spikelet, numerous seeds per plant.
**Seed size and description:** Seeds are contained within glumes on the spikelet and within a lemma (thin papery covering). The floret has many straight hairs that make seed cleaning difficult.
**Average seed weight:** **highly variable 0.09mg to 0.9mg; mean of 0.3mg [10]. In our study, we cleaned seeds so all seed coverings were removed. Seed weight for dried seed, cleaned to this degree is approximately 0.1mg.
**Seeds/kg:** 3.3 million seeds/kg [10]. With fully cleaned seed, there is upwards of 8.5 million seeds per kg [6,11].

*Photo 2: Collecting ripe bluejoint seed heads.*

## Seed Collection

**Timing collections:** Seeds ripen at the end of August to the first week of September, when the seed head begins to spread open and the colour begins to fade, seeds are ready to collect. To confirm seed readiness pinch the spikelets to check for developed seed, if you can feel a firm and plump (but small) seed, they are mature. Seeds dispersed quickly, seed heads were all empty by mid-September in our region.
**Collection protocols:** This species often grows in pure stands and can be easily collected using scissors or pruning shears into large paper bags. We did not test vacuum harvesting for this species, but if you find spikelets just beginning to open, this may be an effective collection method.
**Collection effort:** One person collected 15 to 36g pure, dry seed in one hour. *Our cleaned seed included only naked seed and not covering structures.
**Potential density:** In cultivation 20 to 50 lbs of seed per acre [5].
**Cautions:** None known.

*Photo 3: Seed material following threshing. Material can be kept like this, or threshed further and sieved for a cleaner product.*

## Propagule processing

**Processing protocols:** Place plant materials in thin layers on sheets to dry. Bluejoint seed is very challenging and time consuming to clean using non-mechanized equipment, due to the seed hairs, however we were able to clean seed to high purities (99%) using simple equipment. 1. Thresh seed heads on a corrugated rubber mat to remove seed from the spikelets. Discarded the empty seed heads. 2. Thresh the separated material again, but on the flat side of a rubber mat to further separate seed. 3. Place this material into a stacked sieve. Shake the sieve vigorously back and forth and nearly pure seed will fall in sieves with mesh size #40 and #60.
**Cautions:** Processing this seed produced a lot of fine dust from the hair bristles. Wear a mask while processing.

## Storage

**Storage behaviour:** Likely orthodox. The reedgrasses (*Calamagrostis* ssp.) with known storage behaviour are all orthodox [10].
**Storage requirements and longevity:** Seed can remain viable for up to 7 years in the soil seed bank [4,12]. Seed viability can be maintained, dry at room temperature for up to two years, however, best practices are to dry seed and store cool between 1 and 5°C, this will improve seed longevity (cited in [5]).

## Seed Propagation

**Dormancy classification:** Seeds do not appear to be dormant [13].
**Potential viability**: In our study seed viability was approximately 75%, ranging from 54% to 95% between populations.
**Pre-treatments:** Seed does not require pre-treatment and seed treatment may actually reduce germination success [5,11].
**Germination protocols:** Germination percentages were low (2%) for seeds that were stratified in BC [5]. In the same study, the highest germination rates were 42.5% at 30/20°C for untreated seed, compared to 17.6% for untreated seed germinated at 25/15°C.
**Other propagation methods:** Some U.S. populations have low seed viability therefore rhizome cuttings or plugs are also used for plant establishment [11].
**Field planting:** Seeds can be sown in either spring or fall [11]. Seeding rates for purely bluejoint establishment is approximately 2.2kg per hectare, or in a mix with other species reduce to 14 to 27g per hectare, due to the high cost of seed. Rhizomes can be planted 15 to 45cm apart.

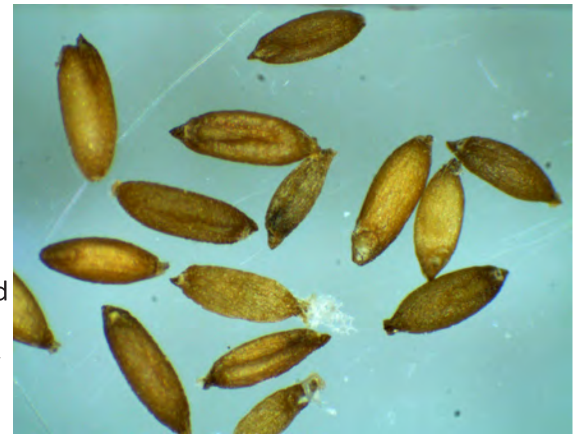

*Photo 4: Whole bluejoint seed folowing cleaning.*

## Other

**Canadian commercial sources:**
https://www.brettyoung.ca/professional-turf-and-reclamation/seed/native-grasses
**Useful links and Further reading:**
https://plants.usda.gov/plantguide/pdf/pg_caca4.pdf
http://illinoiswildflowers.info/grasses/plants/bluejoint.html
http://www.wildflower.org/plants/result.php?id_plant=CACA4
https://gobotany.newenglandwild.org/species/calamagrostis/canadensis/

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# golden sedge

Family: Cyperaceae

Scientific name: *Carex aurea* Nutt.

Cree Name: ___________

Synonyms: None found


Photo 1: Golden sedge plant with ripe seed.

## Quick Seed Guide

**When and what to collect**: Collect entire seed head using scissors when the fruits turn a vibrant orange.
**Seed Processing**: Thresh when fresh, winnow, dry.
**Storage:** Dry, cool in sealed containers.
**Pre-treatment of seed:**
weeks at 4°C.
**How to Grow: Seed:** Germinates to 56% after 10 days at 20/16°C and full light.

## General

**Plant Description:** Golden sedge is a short perennial graminoid, typically about 5 to 20cm tall [1]. Its leaves are grass-like, long (3 to 20cm) and narrow (1.4 to 3mm). Their seeds are grouped into a seed head that contains one or more spikes. Each plant has about 4 or 5 spikes each with 4 to 20 fruit. The tallest spike appears different from the rest, this is the 'male' portion of the plant and does not have any seed, in some cases the tallest spike is half male and half female. At maturity the fruit are bright orange, round, resembling a small berry.
**Field Identification:** Golden sedge is easy to recognize when its fruits are ripe, because they are a vibrant orange. **Similar species:** Elk sedge (*Carex garberi*) is a similar species, except its fruit is not as plump and round as golden sedge and does not turn bright orange at maturity.
**Life Form:** Perennial graminoid; stems die back during the winter months, regenerating from rhizomes in the spring [2].
**Reproduction:** This plant grows vegetatively by rhizomes and produces seeds annually.

**Continental Range:** This species is present in every Canadian province. Populations in the US are mostly in northern and north-eastern states [3].
**HBL regional Range:** Widespread and abundant in the Hudson Bay Lowlands [4].
**Habitat:** Found in open or partially shaded habitats, moist uplands, meadows, and seepage slopes. Tolerant of alkaline soils; 0-3000 m [1].

## Reclamation value

Useful for small-scale erosion along pond banks (Littley; personal comunication) and seepage slopes.
**Nitrogen fixing:** No.
**Symbioses:** No information found for this species. Some *Carex* have an association with arbuscular mycorrhiza, however many species are non-mycorrhizal [5].
**Growth rate:** Slow [6].
**Successional stage:** Early successional vegetation.


Photo 2: Golden sedge plant, with immature fruit.

# golden sedge

## Seed and fruit properties

*Photo 3: Winnowing golden sedge seed to remove any chaff.*

**Fruit description:** The orange fruit portion is called the perigynium, it holds a single achene, which holds a single seed. For cleaning and growing purposes the whole fruit can be considered as a seed unit.
**Dispersal:** Seeds fall off the plant at maturity. They may be further dispersed by water.
**Seeds/ fruit:** One seed per fruit.
**Seed size and description:** Achene: circular, flattened in one dimension, 2.3 to 3.2mm and 1.2 to 1.8 mm [1].
**Average seed weight:** Seed dried with perigynium intact 1.5mg, achene dried without perigynium 1.1mg [7].
**Seeds/kg:** 650 000 seeds per kg (with perigynium intact).

## Seed Collection

**Timing collections:** End of July to early August, fruit turns from a light green to an orange colour and are plump. Seeds fall off the plant easily when touched. Seeds persist on the plant for less than 14 days.
**Collection protocols:** Seeds can be collected by hand. This species grows very low to the ground, in addition seeds will easily fall off the plant when touched at maturity. Place a tray with a short lip below the plants and pull the seeds off. If plants are abundant, cut the seed heads off using scissors. This species is often found in clumps because of rhizome spreading.
**Collection effort:** An average of 26g (7g to 51g) of pure, dried seed in one hour, for one person.
**Potential density:** Not determined.
**Cautions:** None known.

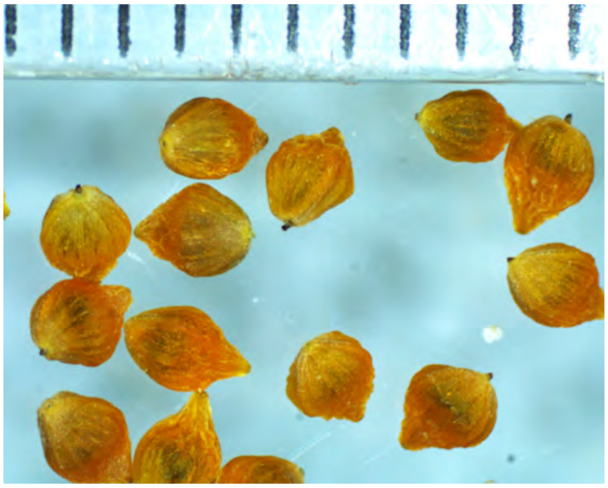

*Photo 4: Golden sedge whole fruit.*

## Propagule processing

**Processing protocols:** Thresh material when fresh if possible, to avoid creating chaff from leaf material. 1. Thresh material on the corrugated rubber mat to separate seeds from the plant. 2. Sieve seeds through a stacked sieve, mesh sizes (top to bottom) #10, #18, #35, bottom pan, the seed will be in #18 and #35 sieves. 3. Winnow to remove any final impurities. Allow seed to dry. If you are unable to clean material immediately, allow it to dry; winnowing will remove much of the leafy chaff that is created.
**Cautions:** None known.

## Storage

**Storage behaviour:** Unknown for this species, likely orthodox. Over 95% of *Carex* species with a known storage behaviour were orthodox [2].
**Storage requirements and longevity:** No information for this species. Other species of *Carex* have maintained seed viability after 2 years in dry/ cool storage [8], although germination rates may show a slight decline. For short-term storage (<6months), seeds can be placed immediately into pre-treatments, see pre-treatments below.

## Seed Propagation

**Dormancy classification:** Uncertain, probably physiological like the majority of *Carex* ssp. growing in cool climates [9].
**Potential viability:** Seed viability was 100% for cleaned seed in our study.
**Pre-treatments:** The highest reported germination percentage for golden sedge was 56% following 16 weeks of cool-moist stratification at 4°C [10].

**Germination protocols:** Germination percentages were 56% at temperatures of 20/16°C, day/night and 24 hours of light [10]. Seeds germinated to 34% in total darkness. Emergence begins approximately 10 to 12 days after planting.
**Other propagation methods:** Plants can be divided (Littley; personal communication).
**Field planting:** Plant in the spring into a moist soil medium.

## Other

**Canadian commercial seed sources:** None known.
**Useful links and Further reading:**
http://ontariograsses.com/main/species.php?id=3027
http://www.michiganflora.net/species.aspx?id=914
http://www.bluestem.ca/carex-aurea.htm

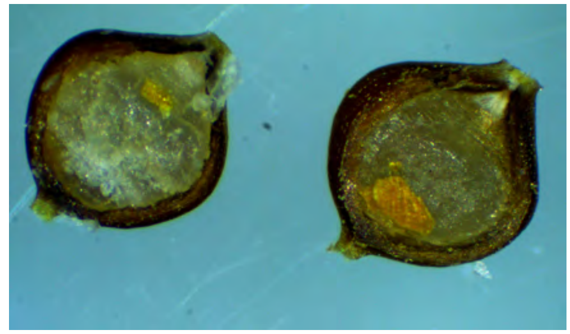

*Photo 5: Golden sedge achene sectioned (peryginium removed).*

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# Labrador Indian paintbrush

Family: Orobanchaceae

Scientific name: *Castilleja septentrionalis* Lindl.

Cree Name: ___________

Synonyms: *Castilleja acuminata*

*Photo 1: Small stand of Labrador Indian paintbrush.*

## Quick Seed Guide

**When and what to collect**: August to September, collect entire spike when the petals deteriorate and the capsules are yellow to brown.

**Seed Processing**: Dry, thresh to open capsules and release seed. Sieve to clean.

**Storage:** Dry, keep cool in sealed containers.

**Pre-treatment of seed:**

90+days.

**How to Grow:** Seed: Germinate at 21 to 25°C for day temperatures and 10 to 16°C for night, plants will require a host plant because they are hemi-parasitic.

## General

**Plant Description:** A perennial wild flower, 20 to 60 cm tall [1]. The stems can be branched or not. The leaves have an alternate pattern along the stem. The leaves are 3 to 10cm long with smooth edges. The flower head is a spike, borne at the top of the stem and each stem branch. Overall the spike colour fades from creamy-white to yellow to a pale pink. This colour is from the leaf bracts along the spike that have 3 lobes at the tips and enclose the flowers. There are several flowers on one spike. Flowers are tubular shaped.

**Field Identification:** Recognize Labrador Indian paintbrush by its unusually shaped flowers and creamy-white flowering spike that has a pinkish colour at the base. The green stem leaves are not lobed.

**Life Form:** Perennial forb; stems die back during winter months, regenerates from buds at or below the soil surface.

**Reproduction:** Reproduces by seed and probably by underground rhizomes [2,3].

**Continental Range:** Found mostly in central to eastern Canada [4]. Any populations in the north-eastern United States are considered vulnerable to critically imperiled.

**HBL regional range**: Widespread and abundant in the Hudson Bay Lowlands [5].

**Habitat:** Found in damp to dry rocky soils, seepage slopes, gravel, sand, or silty soils [1]. From exposed to moderately shaded sites [6].

*Photo 2: Labrador Indian paint brush spikes. From left to right, mature and dispering capsule, mature capsule,*

*.*

## Reclamation value

**Nitrogen fixing:** No.

**Symbioses:** Indian paintbrush (*Castilleja* ssp.) are often non-mycorrhizal. However Indian paintbrushes are hemi-parasitic and will infect the roots of other plants to obtain nutrients [7].

**Growth rate:** No information found.

**Successional stage:** Found on early to mid-successional sites.

## Seed and fruit properties

**Fruit description:** There are several seeds contained within one capsule. This capsule will split open to release the seeds when they are mature [3]. Capsules are 7 to 12 mm long and 4 to 6 mm wide.

**Dispersal:** Capsules split open to release seed [3]. Seeds floated in our tests, but we did not test the duration of floating time. Due to the small size of the seed and the netting surrounding the seed, they may be carried for short distances by the wind.

# Labrador Indian paintbrush

**Seeds /propagule:** Numerous.
**Seed size and description:** Seeds are contained inside a seed coat that looks like fish netting. About 2mm long and 1mm diameter (with outer netting intact).
**Average seed weight:** (cleaned dry seed) 0.09 mg [2].
**Seeds/kg:** 11.4 million seeds/kg [2].

Photo 3: Dried spikes, ready to be threshed on a corrugated rubber mat.

## Seed Collection

**Timing collections:** Seed ripens beginning in early August.Seed is ready to collect when the spike loses its colour and the leaf bracts have disintegrated. The capsules with be yellow turning brown. Once mature the pods will split open to release seed; if weather conditions are hot and dry the seed will not persist for long.
**Collection protocols:** Cut off the entire spike by hand or using scissors. The height of the stems are at about waist level and are often in small clumps with many plants. It is helpful to have a collection container harnessed to your body because you will be moving regularly from patch to patch to collect.
**Collection effort:** One person collected approximately 24g of dried cleaned seed in one hour.
**Potential density:** Not determined.
**Cautions:** This species is considered vulnerable in parts of its range and should not be collected if that is the case. To find out more about the status of this species in your province visit: http://explorer.natureserve.org.

## Propagule processing

**Processing protocols:** Allowed plant materials to dry in paper bags or on trays. Many of the capsules will open themselves. Thresh the dried pods on a corrugated rubber mat to free the seed. Sieve the plant material through a stack of sieves (largest to smallest); most seed stays in sieves with mesh size #35. Winnowing is not effective for further seed cleaning. Our seed purity was approximately 91% using these methods.
**Cautions:** None known.

Photo 4: Cleaned Indian paintbrush seed.

## Storage

**Storage behaviour:** No data available for this species, however seed is likely orthodox [8].
**Storage requirements and longevity:** No information available for this species. Following best practices for orthodox seed, dry seed following collections and keep in cold conditions (1 to 5°C) for short term storage (up to 2 years) or dry to moisture contents between 5% and 10% and freeze at -18°C to store for longer periods. If seeds will be planted the following spring, place it immediately into pre-treatments conditions described below.

## Seed propagation

**Dormancy classification:** Uncertain, related paintbrush (*Castilleja* ssp.) species have seeds with a physiological dormancy.
**Potential viability:** In our study, one population had a very low seed viability of 5%, however if we excluded this population, the mean viability was 84%.
**Pre-treatments:** No information exists for Labrador Indian paintbrush, however the Indian paintbrushes are a popular horticultural species. They require a cool-moist stratification period (minimum 30 days at 1 to 2°C), upwards of 90 days for northern seed sources for the highest success [9].

# Labrador Indian paintbrush

**Germination protocols:** Germination temperatures should alternate from 21 to 25°C for day temperatures and 10 to 16°C for night. Germination percentages for some alpine species of *Castilleja* are typically <40%, despite stratification [9]. After 4 weeks of growth a host plant should also be introduced because plants are beginning to seek host roots.

**Other propagation methods:** None known, only seed propagation methods found in our review.

**Field planting:** Seed germinates in the spring [9]. Plant fresh seed in the fall or pre-treat seeds over winter, before planting in the spring.

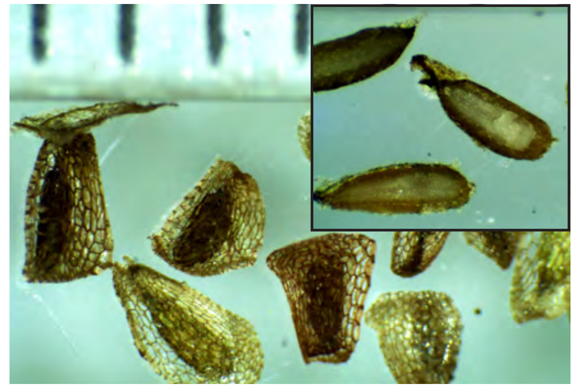

*Photo 5: Whole seed of Labrador Indian paintbrush. (inset photo) sectioned viable seed.*

## Other

**Canadian commercial sources:** None known.

**Useful links and Further reading:**

plant identification: https://mnfi.anr.msu.edu/abstracts/botany/Castilleja_septentrionalis.pdf

https://nature.ca/aaflora/data/www/sccase.htm

https://gobotany.newenglandwild.org/species/castilleja/septentrionalis/

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# fireweed

Family: Onagraceae

Scientific name: *Chamerion angustifolium* ssp. *angustifolium* (L.) Holub

Cree Name: ____

Synonyms: *Epilobium angustifolium, Chamaenerion angustifolium, etc.*

## Quick Seed Guide

**When and what to collect**: Collect plump capsules just before they open to release seed. Open capsule and check for small orangish-brown seed.

**Seed Processing**: Shop vacuum technique, refer to seed processing below.

**Storage:** Dry seed kept in sealed containers in cold temperatures can remain viable for 1.5 to 2 years.

**Pre-treatment of seed:** None required, Cool-moist

**How to Grow:** Seed: Germinates well between 20-30°C and 8/16 hours of light/dark. Fertilizer may improve germination percentages. Vegetative: Rhizome cuttings.

## General

**Plant Description:** Fireweed is a common perennial wildflower that can form vast stands after a disturbance. It is typically about 1m tall, but can grow up to 3m in height [1]. The stems are often reddish in colour, with leaves alternating along the stem, but become opposite as they reach the plant base. The leaves are up to 20cm long. The leaf margins are not toothed. The flowering head is made up of many pink flowers attached by a long stalk [2]. The flowers themselves have 4 petals. Mature seed capsules are long and slender.

**Field Identification: Similar species:** Willow herbs (*Epilobium* ssp.) resemble fireweed but are usually much shorter, with stouter leaves and much smaller flowers. The invasive plant purple loosestrife may resemble fireweed and also grows in dense stands, but its seed capsules are very different, short and stout, compared to the long slender capsules of fireweed.

**Life Form:** Perennial forb. The stems dies back during the winter months and new stems grow from the underground rhizome in the spring [3].

**Reproduction:** This species spreads by rhizomes to form vast colonies and is often a prolific seeder [1]. Flowering may begin in early summer. The lower flowers open first, progressively upwards, so flowering lasts from June until September in some regions. Plants as young as one year old may produce flowers [4].

**Continental Range:** Fireweed is present and secure in all Canadian provinces [5]. This species spans west to east in the United States, south to New Mexico and is present in Alaska. The species is not found in south-eastern states and is considered critically imperiled in Tennessee. The naming of this species was recently changed (previously *Epilobium angustifolium*) and the full extent of the range may not be reflected.

**HBL regional Range:** Widespread and abundant in the Hudson Bay Lowlands [6].

**Habitat:** Fireweed is known for its invasion of sites following a fire [1]. Otherwise it is found in a range of sites, from moist rich soils to disturbed upland habitats, such as roadsides and waste lands. Tolerant of a range of moisture regimes except waterlogged soils and tolerant of a large range in soil pH from 3.7 to 9 [3].

*from the plant.*

## Reclamation value

Photo 3: Fireweed seed dispersing.

Fireweed naturally invades many newly disturbed sites, such as following fire or mining disturbance [1,7]. This species colonizes roadsides, coal spoils, oil spills in the arctic, and other mine waste sites [3]. Fireweed may promote the growth of conifers by delaying the growth of dense shrubs and because they store nutrients in plant tissues that are released to trees as they die (cited in [4]).
**Nitrogen fixing:** No.
**Symbioses:** Forms a relationship with arbuscular mycorrhiza and can be non-mycorrhizal [8].
**Growth rate:** Rapid [9].
**Successional stage:** Most common and abundant as a pioneer, early successional sites, but can persist into later successional stages with fewer plants [3].

## Seed and fruit properties

**Fruit description:** Many small seeds are contained in long pink capsules. These capsules split open to release seeds at maturity.
**Dispersal:** Wind.
**Seeds/ capsules:** 300 to 400 seeds per capsule, up to 80 000 per plant (cited in [3]).
**Seed size and description:** Each seed is attached to several long hairs. Seeds are about 1mm long and 0.2mm in diameter.
**Average seed weight:** (clean dry seed) 0.028mg [10].
**Seeds/kg:** 35.6 million seeds/kg [10].

## Seed Collection

**Timing collections:** Seed ripening will begin with lower capsules from mid to late August and it may take several weeks until the upper capsules are fully mature. The first flowers on a plant to open, tend to have higher seed viabilities [11] and should be prioritized over the upper most capsules that will contain fewer seed and potentially have seed qith lower viability. Collect capsules whan they are plump. Break them open to check for mature seed which are orangish brown at maturity (very small) and seed hairs are well developed.
**Collection protocols:** We collected the entire flower head by stripping capsules with our hands, beginning from the bottom to the top. The entire seed head can be clipped using hand pruners or scissors, both methods are efficient. If the stand is dense, collect into large paper bags, or have a container strapped to your body that you can easily empty once it is full. Allow capsules to dry in a breathable but enclosed container because capsules will burst open and seed will be airborne. Your drying space should be draft free.

covered with a mesh cloth.

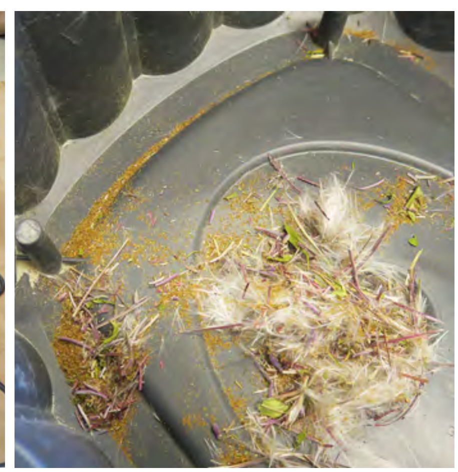
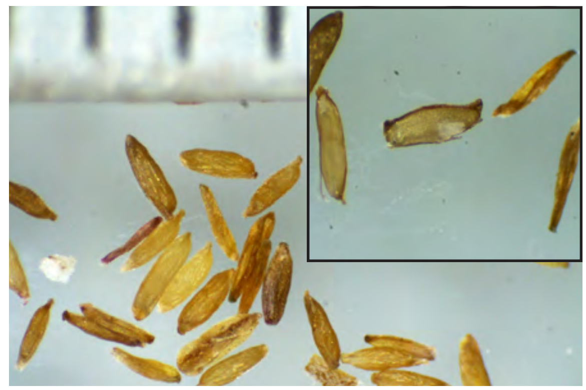


Photo 5: Fireweed seed separated from hairs during the vacuuming have settled to the bottom of the vacuum.

**Collection effort:** We collected an average of 77g/hr, ranging from 25g/hr to 155g/hr of clean, dry seed for one person by hand.
**Potential density:** Often found in dense stands where it occurs and produces large quantities of seed.
**Cautions:** If stripping capsules from the plant by hand, wear gloves.

## Propagule processing

**Processing protocols:** Seeds can be cleaned using a shop vacuum and sieves. 1. Place a screen cloth over the filter (2mm or less opening). 2. Suck capsules into the shop vacuum once they are dried and have burst open. This helps to 'tame' the seed and will separate some seeds from their hairs. 3. Open the vacuum and transfer materials into a mesh #20 sieve. Stack sieves (top to bottom), mesh #240, 20, 40, 60, 140, and the bottom pan. The 240 mesh on top will stop seeds from escaping as you blow air through. 4. Blow air into the top sieve using the vacuum for about 20 seconds or less, this separates seeds from their hairs. Seeds falls into #60 and #140 sieves and is mostly pure, but may contain some pieces from broken capsules. Our seed purity was over 98% using these methods.
**Cautions:** Wear a mask, seed hairs become airborne and can be irritating.



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## Storage

**Storage behaviour:** Orthodox [12].
**Storage requirements and longevity:** Seed of fireweed is short-lived. Seed may remain viable if dried and stored in sealed containers at 1 to 3°C, but the longevity is not specific [13]. Seed that is dried and placed in cold storage inside sealed plastic bags, can remain viable for 18 to 24 months [14].

## Seed Propagation

**Dormancy classification:** Physiological dormancy [15].
**Potential viability:** In our study, seed fill was approximately 65%, ranging from 51% to 67% between populations.

*distinguish the seed embryo from endosperm due to the small size. Instead we determine the*

**Pre-treatments:** Fireweed seeds may germinate without cool-moist stratification [3], however some sources say cool-moist stratification for 30 to 60 days will improve germination [13,15].
**Germination protocols:** Seed germinates well (89 to 98%) on a moist medium, with temperatures between 15 to 25°C with light/dark cycles of 8/16 hours respectively, no pre-treatments were reported [12]. Germination percentages improve as temperatures increase above 20°C up to 30°C [3]. Fertilizing the growing medium may also improve initial germination percentages [3,13].
**Other propagation methods:** Rhizome cuttings from young or old plants have had good emergence [3]. Rhizome sections 8 to 16cm long will fully emerge after two years. Rhizome sections 32cm long will have a high rates of shoot emergence in the first year of transplanting (cited in [3]).
**Field planting:** Fireweed may not compete well when planted with other herbaceous plants. This species established better on soil surfaces that contain organic matter [16].

## Other

**Canadian commercial sources:**
http://www.wildaboutflowers.ca/plant_detail.php?Fireweed-105
https://www.growwildflowers.ca/collections/canadian-wildflower-collection/products/fireweed-epilobium-angustifolium?variant=201328372
**Useful links and Further reading:**
For more photos: https://plants.usda.gov/core/profile?symbol=CHANA2
https://www.prairiemoon.com/seeds/wildflowers-forbs/epilobium-angustifolium-fireweed.html
https://www.minnesotawildflowers.info/flower/fireweed
http://www.pfaf.org/user/plant.aspx?LatinName=Epilobium+angustifolium

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# Canadian bunchberry

Family: Cornaceae

Scientific name: *Cornus canadensis* L.

Cree Name: ___________

Synonyms: *Chamaepericlymenum canadense*

. *Note the whorled leaves.*

## Quick Seed Guide

**When and what to collect**: Fruits ripen in August when berries turn orange-red and soften. Collect by hand into a short basket or tray.

**Seed Processing**: Thresh on corrugated ruber mat, rinse, reserve sunken material. Dry. Thresh and winnow.

**Storage:** Store dry seed in sealed containers at 3 to 5°C for 2 to 4 years.

**Pre-treatment of seed:** Cool-moist stratify for 150 days or acid scarify then cool-moist stratify for 90 days.

**How to Grow:** Seed: Germinate in moist-medium at 21 to 25°C (daytime) and 13 to 18°C (nightime); seed germinates after 10 days. Vegetative: Rhizome cuttings.

## General

**Plant Description:** This herbaceous shrub grows low to the ground and often creates dense ground covers [1]. Plants are typically 10 to 20 cm tall. The leaves are whorled in a set of 4 or 6 leaves. The leaves are strongly veined, pointed at base and tip of the leaf, 4 to 7cm long. Each plant appears to have one large white flower with 4 white petals at the top. This is actually many small flowers and the 'petals' are just showy leaf bracts. This one cluster of flowers will produce many berries. Berries are vibrant red-orange when mature.

**Field Identification:** Bunchberry can be recognized by its unique leaves early in the season; they are whorled and strongly veined. Later the white flowering head and bright orange berries make this species distinct.

**Life Form:** Perennial herb; in the winter months the leaves and stems die-back, regenerating from buds at or below the soil surface [2].

**Reproduction:** Spreads underground by rhizomes to produce large dense colonies and also reproduces by seed.

**Continental Range:** Widespread in all Canadian provinces and Alaska [3]. This species is mostly restricted to northern states in the United States, spanning west to east, populations become vulnerable south of Montana.

**HBL regional Range:** Widespread and abundant in the Hudson Bay Lowlands [4].

**Habitat:** In our region, we found bunchberry in a variety of habitats, including forest understories, and forest openings, also growing in dense patches on trail sides with intermediate shade.

## Reclamation value

Canadian bunchberry, can overlap through successional stages [5], and may be a useful species for planting once soil conditions are suitable and a moderate canopy is established. Seeds directly sown into exposed mine waste soils showed low emergence [6]. Plants are highly tolerant to fire and recover quickly [7].

**Nitrogen fixing:** No.

**Symbioses:** Can be arbuscular mycorrhizal or non-mycorrhizal [8].

**Growth rate:** Slow [9].

**Successional stage:** Ranging from early to late, but more common in late successional forested sites[5].

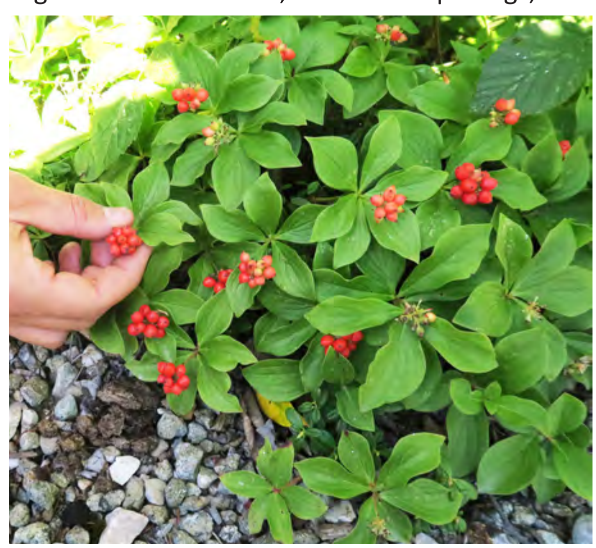

*Photo 2: Bunchberry plants with ripe fruit. Growing along a trailside.*

# Canadian bunchberry

## Seed and fruit properties

**Fruit description:** Berry, bright red-orange and soft fleshed at maturity, 8mm diameter, round [1].
**Dispersal:** Animal, berries are eaten[10].
**Fruit weight:** (dried whole fruit) 15.1mg [11].
**Seeds/ fruit:** One seed per berry.
**Seed size and description:** Seeds are round, about 3mm long and 2mm in diameter. One seed can contain up to two embryos, but usually only one is viable.
**Average seed weight:** (dried whole seed) 5.94mg [11].
**Seeds/kg:** 168 000 seeds/ kg [11].

*Photo 3: Thresh bunchberry seeds. A corrugated rubber mat is more effective than a smooth surface.*

## Seed Collection

**Timing collections:** In early August berries will change from a green colour to a bright orange and the flesh will soften. Berries should be collected at this time. Berries will persist until they are eaten by animals.
**Collection protocols:** Hand collect berries onto a tray or basket with a short lip. Berry scoops are ineffective, because they uproot plants and require too much precision to effectively be used. Place berries in the refrigerator until they can be processed.
**Collection effort:** One collector picks an average of 25g (17g to 46g) of dried pure seed in one hour.
**Potential density:** Bunchberry stands are often quite dense. Our collections had an average density of 168 seeds/m$^2$.
**Cautions:** None known.

## Propagule processing

**Processing protocols:** Crush berries on a corrugated rubber mat using a rubber paddle. Seed will get stuck in the grooves but are easily removed by flipping the mat and rinsing the seeds into a large plastic bucket. Pour out floating seeds and pulp and reserve the sunken material. Lay this material out to dry on paper towels. Once dry, thresh the material and winnow to remove any impurities. Because there is only one seed per berry, berries can be dried with the fruit intact. There was no difference in the field emergence of planted seed versus planted whole fruit in field trials [6].
**Cautions:** None known.

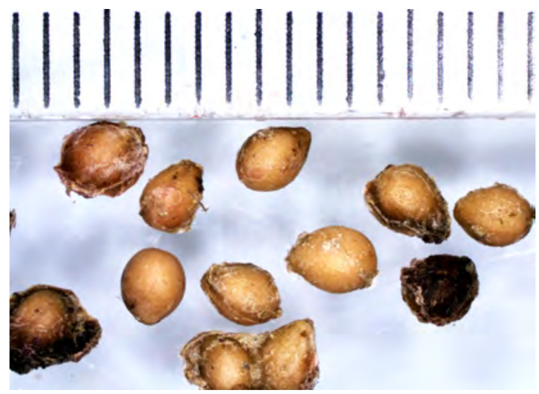

*Photo 4: Whole bunchberry seed. The black seed is not viable.*

## Storage

**Storage behaviour:** Orthodox [2].
**Storage requirements and longevity:** Seed stored in sealed containers at 3 to 5°C can stay viable for 2 to 4 years [12].

## Seed Propagation

**Dormancy classification:** Physiological dormancy [13].
**Potential viability:** In our study seed viability was 88% on average, ranging from 77 to 96% between populations.
**Pre-treatments:** Germination percentages were the same for the following two pre-treatments. 1. Seed was cool-moist stratified for 150 days or 2. Seed was treated in sulphuric acid and then placed in a 90 day cool-moist stratification[12]. Another author recommended warm-moist stratification in sand at 25°C for 60 days followed by a cool-moist stratification for 120 days, but their germination success with these pre-treatments was not reported [10].
**Germination protocols:** Up to 90% germination achieved with seeds grown in peat-perlite-vermiculite at 21°C to 25°C daytime temperatures and 13°C to 18°C for night temperatures [12]. Seeds germinated after 10 to 15 days.
**Other propagation methods:** Rhizome divisions [12].

**Field planting:** Freshly collected seed can be planted in the fall [10]. A field trial in northern Alberta, found very low emergence rates (0 to 0.2%) for seed directly sown onto exposed mineral soils in spring and/or fall [6]. There was also no differences in emergence rates from planting whole fruit and cleaned seed.

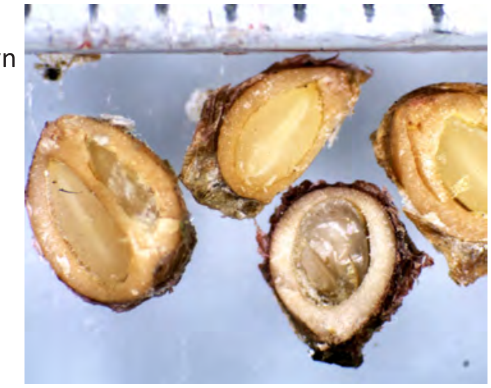

*Photo 5: Sectioned bunchberry seed. Note the seed to the far left has two chambers with developing embyros. The dark seed is not viable.*

## Other

**Canadian commercial sources:**
http://www.wildaboutflowers.ca/plant_detail.php?Bunchberry-30
**Useful links and Further reading:**
https://plants.usda.gov/core/profile?symbol=COCA13
http://www.pfaf.org/user/plant.aspx?latinname=Cornus+canadensis
http://plantwatch.naturealberta.ca/choose-your-plants/bunchberry/

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# redosier dogwood

Family: Cornaceae

Scientific name: *Cornus sericea* ssp. *sericea*

Cree Name: ___________

Synonyms: *Cornus stolonifera*, etc.

## Quick Seed Guide

**When and what to collect**: Collect white berries using a berry rake or by hand into a bucket.

**Seed Processing**: Crush berries on a corrugated rubber mat. Rinse, dry, thresh, then winnow.

**Storage:** Dry, keep in sealed containers at 1 to 4°C for 5 to 7 years.

**Pre-treatment of seed:** Acid scarify then cool-moist stratify for 90 days.

**How to Grow: Seed:** Germinate under standard greenhouse conditions. Field emergence up to 15% on a loamy soil from seed planted in the spring. **Vegetative:** Hardwood stem cuttings taken in the spring.

## General

**Plant Description:** Redosier dogwood is a common deciduous shrub. It is typically 1 to 3m in height, has multiple stems and forms thickets [1,2]. Its bark is shiny and red with white spots. The bark colour changes intensity with the season, brightest red in the winter months, dulling during the summer. The branches and leaves are opposite. The leaves are large, 5 to 10cm long and strongly veined, smooth margins, and pointed at the tip. The flower head is called a cyme, made up of many small white flowers. The berries are green when immature, turning white at maturity.

**Field Identification:** Red osier dogwood is a very distinct plant because of its red bark. During the summer months the bark appears browner than it does red, but the plant can be recognized by the opposite branching pattern, large leaves with strong venation, and by the large clusters of white fruit. **Similar species:** Round leaf dogwood (*Cornus rugosa*) is very similar, but its leaves are rounded at the tip and its fruit is a pale blue. Alternate leaf dogwood (*Cornus alternifolia*) has very similar leaves, but its branching pattern is alternate and its fruit is blue. Snowberry (*Symphoricarpus albus*) has white berries and alternate leaves, but this shrub is generally under 1m tall and does not have the prominent leaf veins like redosier dogwood.

**Life Form:** Perennial shrub; has a woody stem that persists throughout the winter, buds are above ground.

**Reproduction:** Reproduces by seed and vegetatively by layering, stolons, and from the root crown (reviewed in [3]). Flowering occurs in June, fruits start to ripen in early August to October [1].

*Photo 2: Redosier dogwood stem. This photo was taken in the summer when the redness of the stem has lost some vibrancy.*

**Continental Range:** Widespread in all Canadian provinces and Alaska. This species is present in most of the United States except in southeastern states, east of New Mexico, and south of Illinois [4].

**HBL regional range:** Abundant to common in the Hudson Bay Lowlands [5].

**Habitat:** Commonly growing in moist soils such as lake edges and river shorelines, tolerating seasonal flooding [1]. This species is also found along forest edges and in forest understories [3].

## Reclamation value

**Nitrogen fixing:** No.

**Symbioses:** Commonly associated with arbuscular mycorrhiza, can be non- mycorrhizal [6].

**Growth rate:** Moderate [7].

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# redosier dogwood

**Successional stage:** Found in disturbed, early successional sites in our region [8]. This species are persists into a forest understory into late successional sites, but is most abundant in open areas [3].

Photo 3: Using a berry rake to collect redosier dogwood berries.

## Seed and fruit properties

**Fruit description**: Fruit is a round white berry at maturity, 7 to 9mm in diameter[2].
**Dispersal:** Animal dispersed, mammals and birds [9].
**Fruit weight:** (dried, pulp intact) 48.5mg [10].
**Seeds/ fruit:** One seed per berry.
**Seed size and description:** Seed is hard, round, dark brown and striped, about 5mm long by 3.5mm in diameter.
**Average seed weight:** (dried seed) 28.1mg [10].
**Seeds/kg:** 35 500 seeds/kg [10].

## Seed Collection

**Timing collections:** Berries ripen from July to August. Berries will change colour from green to white and the berry will soften.
**Collection protocols:** Plants and berries were so abundant in our region that it was not worthwhile protecting plants with netting. The berries also ripen all at once. Collect using berry rakes or by hand into a bucket that is wrapped around the collector so they can use both hands. Do not waste time picking 'cleanly'; leaves and stems are easily removed in the cleaning process. Place berries in the refrigerator until cleaning is possible.
**Collection effort:** One collector picked approximately 160g of pure dry seed in one hour. Collection rates did not differ for berry rakes or hand collection.
**Potential density:** Not determined, but plants are often found in thickets and highly productive.
**Cautions:** None known.

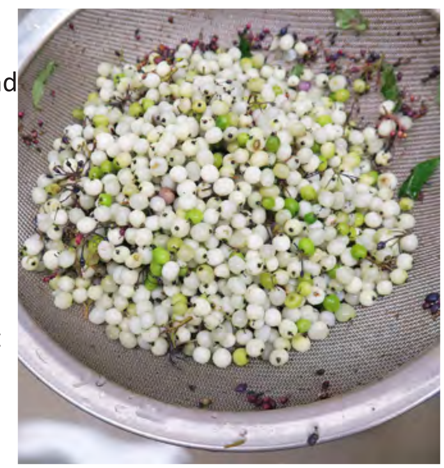

Photo 4: Uncleaned redosier dogwood fruit.

Photo 5: Redosier dogwood berries threshed on a corrugated rubber mat.

## Propagule processing

**Processing protocols:** Use a corrugated rubber mat and paddles to crush the berries. Rinse the mat into a 5 gallon bucket. Some of the pulp and empty seed can be floated off. Pour the seed and sunken materials into a sieve and place onto a paper towel to dry. Thresh the dry material and winnowed to further remove any chaff. Seeds are large and are easily damaged by blender blades, even when the blades are dulled.
**Cautions:** None known

## Storage

**Storage behaviour:** Probably orthodox [11].
**Storage requirements and longevity:** Dried seed can be stored for 5 to 7 years at 1 to 4°C [12]. Seeds were viable for 2 to 4 years in sealed containers at 3° to 5°C [13].

## Seed Propagation

**Dormancy classification:** Physiological dormancy [14].
**Potential viability:** Seed viability for processed seed was on average 98% in our study. Seed viability ranged from 88% to 100%.

**Pre-treatments:** Cool-moist stratification for 90 to 160 days is a required [9,14]. Acid scarification for 30 minutes, prior to a 90 day cold moist stratification may also improve germination rates [15].

**Germination protocols:** Seeds germinated to 80% following acid scarification and cool stratification [15]. Seeds were germinated in a mix of peat-perlite-vermiculite, and emerged after approximately 14 days. Optimal germination temperatures are 25°C to 30°C for daytime and 10°C to 20°C for nighttime [9,14], fluctuating light and dark.

**Other propagation methods:** Redosier dogwood is commonly propagated by hardwood cuttings, layering, and root divisions [1]. Cuttings can be taken in the spring, before leaf buds open. A detailed review on vegetative propagation is provided at the Plants database (https://plants.usda.gov/plantguide/pdf/cs_coses.pdf) and the Native Plant Network (https://npn.rngr.net/propagation/protocols).

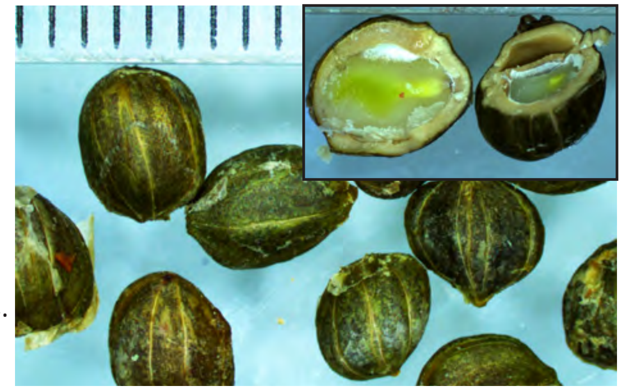

*Photo 6: Whole redosier dogwood seed. (inset photo) sectioned viable seeds.*

**Field planting:** Field emergence rates for seed planted in the spring was fairly high on mine waste soils in Alberta [16]. Seed emergence was over 15% at one site with loamy sand soiland a pH of 7.2 to 7.4. Seed planted in the spring showed better emergence than fall planted seed [16]. In the same study, cleaned seed had a much higher emergence than whole fruit.

## Other

**Canadian commercial sources:**

https://www.ontario.ca/page/buy-ontario-tree-seeds-or-cones

**Useful links and Further reading:**

https://gobotany.newenglandwild.org/species/swida/sericea/

https://www.prairiemoon.com/plants/bare-root/trees-shrubs-vines/cornus-stolonifera-red-osier-dogwood.html

http://www.wildflower.org/plants/result.php?id_plant=COSE16

http://ontariotrees.com/main/species.php?id=2036

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# shrubby cinquefoil

Family: Rosaceae

Scientific name: *Dasiphora fruticosa* (L.) Rydb.

Cree Name: ___________

Synonyms: *Potentilla fruticosa, Dasiphora floribunda, etc.*

## Quick Seed Guide

**When and what to collect**: Collect plump capsules, when they are light brown in colour and seeds inside are yellow to brown and are easy to rub free from capsules.
**Seed Processing**: Thresh dry capsules to remove seed.

winnow to clean.
**Storage:** Dry, store cool (1 to 5°C); seed may remain viable for up to 5 years.
**Pre-treatment of seed:** None required.
**How to Grow:** Seed: Germinate at 26°C and 12/12hr,
Vegetative: Stem cuttings taken in the summer root well.

## General

**Plant Description:** Shrubby cinquefoil is a small deciduous shrub, typically 1m tall or less [1]. This shrub may grow upright or horizontally along the ground. The leaves are lobed into 5 leaflets. The leaves are stalked, often hairy and whitened beneath. The flowers are yellow with 5 petals, singly or in clumps. The flowers become brown capsules at maturity.
**Field Identification:** Shrubby cinquefoil is a unique plant recognized by its 5 part leaves and yellow, 5-part flowers.
**Similar species:** The cinquefoils (*Potentilla* spp.) are primarily herbaceous rather than woody plants.
**Life Form:** Perennial shrub; has a woody stem that persists throughout the winter and buds are above the ground.
**Reproduction:** Shrubby cinquefoil reproduces by seeds and from the root crown [2]. It can reproduce by adventitious roots, when the stems come into contact with the ground and can spread by underground creeping stems [3]. It flowers throughout the summer; seed matures mostly in the early fall. According to one author this species is dioecious (separate male and female plants) with a 2:1 female to male occurrence in Britain and Sweden. Female flowers can have stamens but they produce no good pollen [3].

**Continental Range:** Widespread in all Canadian provinces and Alaska [4]. Populations in the United Stated extend west to east in the northern states and are absent in south eastern states, east of New Mexico and south to Illinois [4].
**HBL regional Range**: Widespread and abundant in the Hudson Bay Lowlands [5].
**Habitat:** Tolerates dry conditions, common on sandy to gravelly shores, rocky slopes, and in meadows; 0-3600m [1]. Tolerates a wide range of soil pH and soil textures from clay to sand; also found in moist sites such as calcareous fens [2]. This species prefers open sites, but can tolerate moderate amounts of shade.

*Photo 2: Shrubby cinquefoil growing horizontally on a hard packed soil.*

## Reclamation value

A species tolerant of disturbance and open conditions. Shrubby cinquefoil has been successfully used to revegetate cold-climate sites such as mine-tailings, dry roadside slopes and even moist streambanks [2]. Growth and establishment of plants using seeds has been less successful than using cuttings or nursery stock.
**Nitrogen fixing:** No.
**Symbioses:** Arbuscular mycorrhiza [6].

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**Growth rate**: Slow from seedlings, rapid from root crowns or stem cuttings (cited in [2]).
**Successional stage:** Found in early to late successional sites (cited in [2]). Shrubby cinquefoil was found to colonize sites with regular disturbance from annual ice scouring, flooding and erosion (cited in [2]). This species is common in a similar environment in our region along the Attawapiskat river shoreline [7]. This species may represent a dominant species in mid-successional to climax communities such as the Montana grasslands (cited in [2]).

is immature, shiny yellowish green and hairy at the base.

## Seed and fruit properties

**Fruit description:** Capsules developed from the flower, will close and turn brown at maturity. They will open to release numerous seeds.
**Dispersal:** Wind [3]. Ring of hairs at the base of the seed likely helps in wind dispersal.
**Seeds/ fruit:** Highly variable. The number of seed per capsule ranges from a mean of 18 seed per capsule to 70 between populations [3].
**Seed size and description:** Seeds are pear shaped. They are tan to brown at maturity. They have a ring of basal hairs that make seed cleaning difficult. Seeds are approximately 1.2mm long and 0.5mm in diameter.
**Average seed weight:** (dried cleaned seed) 0.16mg [8].
**Seeds/kg:** 625 000 seeds/ kg [8].

## Seed Collection

**Timing collections:** Flowering spans from the spring to summer, but the majority of seeds will ripen in the late summer to early fall. Once mature, seeds do not stay on the plant for long, because they are often growing in highly exposed environments where the wind and sun increase the rate of seed maturation. Collect the capsules that are light to dark brown and closed. Open up some of the capsules to ensure they contain several plump light brown seed. If they are all empty, move onto another plant; it may be a male and have no viable seed. The seed should separate easily from the capsule if rubbed gently.
**Collection protocols:** Hand collect entire capsules by clipping to tops using scissors into a bucket, or by pulling capsules off in clumps by hand. Place capsules on trays in a warm room to dry.
**Collection effort:** Our collection rates for cleaned dry seed were very low, because seed fill in many of the capsules was very poor. It is very important to examine the plant to ensure it contains a worthwhile quantity before collecting.
**Potential density:** No information found.
**Cautions:** None known.

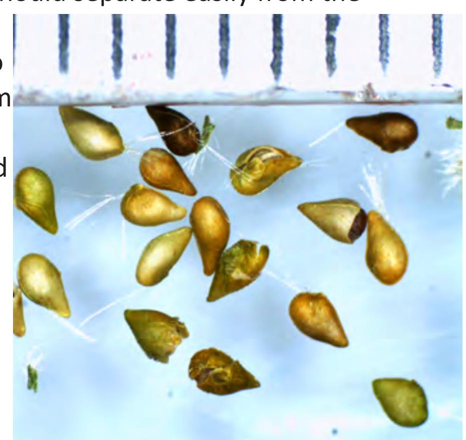

*Photo 4: Shrubby cinquefoil whole seed. Some seeds were damaged by threshing.*

## Propagule processing

**Processing protocols:** Once capsules are dried, thresh them gently to dislodge the seed. 2. Sieve the material and return the seed to the flat side of the threshing mat. 3. Re-thresh this material to remove the hair from the seeds. Threshing crushes empty seed, but can also cause some seed damage to viable seeds; be cautious of the amount of force you are applying. 4. Finally sieve again, and winnow material for a final cleaning. Seed purity was approximately 61% using these methods.
**Cautions**: Seeds are not hard and will be damaged if applying too much force during the threshing process.

## Storage

**Storage behaviour:** Orthodox [9].

**Storage requirements and longevity:** Dried seed, stored cool (1 to 5°C) can remain viable for up to 5 years [10]. For long term storage, ensure seed is dried to 6 to 10% moisture content and freeze at -18°C [9].

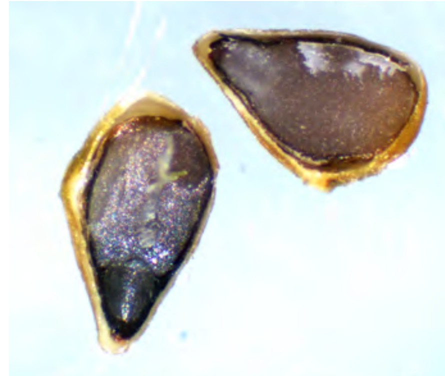

*Photo 5: Sectioned shrubby cinquefoil seed. Both seeds are viable.*

## Seed Propagation

**Dormancy classification:** Non-dormant [11].

**Potential viability:** In our study, cleaned seed had a viability of 83%, however many empty seeds were produced by the plants but were removed in the cleaning process.

**Pre-treatments:** None required [11].

**Germination protocols:** Untreated seed germinates to 90% on a moist medium at 26°C and 12/12 hours of light/dark [9]. Light is not required for successful germination, but does not inhibit germination [12], yielding 79% and 81% germination in complete light and dark respectively at 25°C. Germination is largely complete after 10 days [12].

**Other propagation methods:** This species is easily propagated by stem cuttings. Cuttings 10 to 15cm long, taken in July and August, have up to 100% successful root formation and survival after one year [13].

**Field planting:** Seeds sown in the fall had up to 4% emergence on treated mine soils in northern Alberta [14]. Fall sown seed had much higher emergence rates than spring sown seed.

## Other

**Canadian commercial sources:**

Seed sources found in Canada were for ornamental cultivars.

**Useful links and Further reading:**

https://www.fs.fed.us/database/feis/plants/shrub/dasflo/all.html#189
https://www.prairiemoon.com/plants/bare-root/trees-shrubs-vines/potentilla-fruticosa-bush-cinquefoil.html
https://gobotany.newenglandwild.org/species/dasiphora/floribunda/

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# parasol whitetop

Family: Asteraceae

Scientific name: *Doellingeria umbellata* (Mill.) Nees

Cree Name: ___________

Synonyms: *Aster umbellatus*

## Quick Seed Guide

**When and what to collect**: September to October.

seed hairs are visible.

**Seed Processing**:1.Vacuum the seed from the plant.

.

Repeat 2 and 3 if needed.

**Storage:** Dry and cool (1 to 5°C) in sealed containers.

**Pre-treatment of seed:** Cool-moist stratify 60+ days.

**How to Grow: Seed:** Germinate at 25/15°C and 8/16 hours of light/dark.

## General

**Plant Description:** A large aster, 50 to 200cm tall [1]. Commonly found in stands due to its rhizomatous growth. The stems are smooth or lightly hairy. The stem leaves are 60 to 110cm long and 13 to 25mm wide. Leaf edges are smooth, the leaf surfaces can be either smooth or slightly hairy with prominent veins. The overall shape of the inflorescence has a flat top. Flowers are white, on a short stalk, typically 20 to 100 per flowering head. One flower has 5 to 10 rays, and yellowish disk flowers in the center, that fade to white with age.

**Field Identification:** Parasol whitetop is one of the more distinct asters, recognized by its large size, flat-topped inflorescence, smooth leaf margins and prominent leaf veins. **Similar species**: Upland whitetop (*Solidago ptarmicoides*) is a much smaller plant (under 40cm) and has more rays (10 to 20) on a flower than parasol whitetop [1].

**Life Form:** Perennial forb; stems die back during winter months, regenerating from buds below the ground surface.

**Reproduction:** Reproduces by seeds and spreads vegetatively by rhizomes sometimes forming colonies [1]. Flowering late summer to the fall.

**Continental Range:** Present in eastern and central Canada [2]. Absent in the Yukon, Northwest Territories, Nunavut, and British Columbia, becoming vulnerable in Manitoba and westward. In the United States this plant is present in all eastern states, westward to North Dakota and south to Florida.

**HBL regional Range:** Abundant in the southern portion of the Hudson Bay Lowlands [3].

**Habitat:** Moist soils, clearings, thickets, margins of forests and near streams, prairies, ditches and rock shores; 100–700 m [1,4].

## Reclamation value

Parasol whitetop is an aggressive competitor that may be suitable for planting in sites with a moderate amount of moisture [5].

**Nitrogen fixing:** No.

**Symbioses:** Vesicular and arbuscular mycorrhiza and dark septate endophytes [6].

**Growth rate:** No information found.

**Successional stage:** No information found.

## Seed and propagule properties

**Propagule description:** Seeds are inside achenes, tightly clustered in a flower head. There are several stiff bristles attached to achenes that help them to disperse.
**Dispersal:** Wind.
**Seeds/ collection unit:** There are approximately 11 to 26 seeds per flower head and 20 to 100 flower heads per plant. One plant may produce 220 to over 2600 seeds [1].
**Seed size and description:** Seeds are within achenes. Tan at maturity, 1.4mm to 3.2mm long, 4 to 6 ribs on the surface [1].
**Average seed weight:** (cleaned, dry seed) 0.7mg [7].
**Seeds/kg:** Approximately 1.4 million seeds/kg [7].

## Seed Collection

**Timing collections:** Seeds ripen from September to October. Collect when at least half the flower heads on a plant have turned to seed. Seeds will persist for about a week or more after maturity, but will disperse more quickly if the weather is hot and dry.
**Collection protocols:** Using scissors; collect the entire flowering head. Plants are often found in dense stands and are bulky so collect into a large paper bag. At the brink of dispersal, seeds may be vacuum harvested; this will make seed cleaning easier, but you may risk losing seed to the wind. If seed sources are bountiful and nearby for frequent visitation, vacuum harvesting may be a useful collection method. Place materials in thin layers to dry immediately following collection.
**Collection effort:** One person collects an average of 152g pure dried seed in one hour.
**Potential density:** Not determined.
**Cautions:** None known.

*Photo 3: Winnowing aster seed material after it was threshed. Seeds are reserved in the pan.*

*Photo 4: Cleaned parasol whitetop seed.*

## Propagule processing

**Processing protocols:** 1. Once dry, separate the seeds from plant stalks by vacuuming into a shop vacuum or shaking vigorously in paper bags. 2. Place seed materials on the flat side of a rubber mat in thin layers. Having leaves in with this material will result in poorer seed purity. 3. Thresh and rub seed forcefully using a threshing paddle, until bristles have broken off the seeds. Reserve this material for later winnowing. Continue to thresh remaining materials. 4. Winnow seed material in front of a moderate air flow. Sieve if larger pieces of material remain. If seeds still have bristles they may need to be returned to the threshing mat and steps 3 to 4 repeated.
**Cautions:** Processing this seed creates a lot of dust during the threshing and winnowing steps, wear and mask and work in a ventilated space.

## Storage

**Storage behaviour:** Orthodox [7].
**Storage requirements and longevity:** No information found for this species. Following best practices, this seed should be well dried following collection. Store seed in sealed containers at 1 to 5°C.

## Seed Propagation

**Dormancy classification:** Uncertain, probably physiological. Related species from temperate and arctic climates exhibit a physiological dormancy [8].
**Potential viability:** Seed viability in our collections was on average 65%.
**Pre-treatments:** Uncertain, may germinate without pre-treatments [7,9], but may benefit from a period of cool-moist stratification for about 60 days [10].
**Germination protocols:** Under lab conditions, seed germinates to 78% without pre-treatment on a moist medium at 25°C/15°C and 8/16 hours of light/dark [7]. Seed collected in Maine that was untreated and germinated at approximately 21°C had only 15% germination success [9].
**Other propagation methods:** None found. Other species of asters (*Symphyotrichum* and *Solidago)* can be propagated by stem cuttings taken in the late spring to a length of 20cm, treated with rooting hormone and kept moist [11,12].
**Field planting:** No information found.

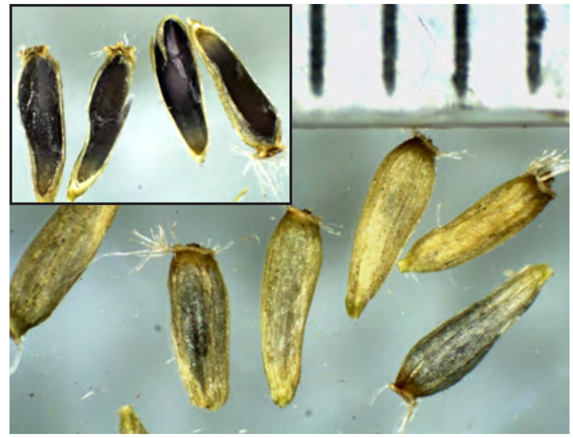

*Photo 6: Whole parasol whitetop seed after cleaning (inset photo) sectioned, viable seed of parasol whitetop*

## Other

**Canadian commercial seed sources:** None found.
**Useful links and Further reading:**
http://www.illinoiswildflowers.info/wetland/plants/fltp_aster.html
https://gobotany.newenglandwild.org/species/doellingeria/umbellata/
http://ontariowildflowers.com/main/species.php?id=7
https://www.minnesotawildflowers.info/flower/flat-topped-white-aster
https://shop.wildseedproject.net/products/tall-white-aster?variant=1046013913
https://www.prairiemoon.com/seeds/wildflowers-forbs/aster-umbellatus-flat-topped-aster.html

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# silverberry

Family: Elaeagnaceae

Scientific name: *Elaeagnus commutata* Bernh. ex Rydb.

Cree Name: ___________

Synonyms: *Eleaegnus argentea*

Photo 1: Silverberry branch and developing fruits.

## Quick Seed Guide

**When and what to collect**: August to October, collect fruit when they are soft and contain a hard brown seed.
**Seed Processing**: Thresh, rinse, dry and winnow for nearly pure seed.
**Storage:** Not sensitve; best to dry seed and store cool in sealed containers.
**Pre-treatment of seed:** Cool-stratify for 6 months, then soak seed in hot water (50°C) for 48 hours.
**How to Grow:** Seed: Germinate at 20 to 30°C; seeds may react negetively to light. Vegetative: Winter stem cuttings.

## General

**Plant Description:** Silverberry is a deciduous shrub, 1 to 4m tall, often growing in colonies [1]. Its branches are covered in silver scales, giving the branch a silver appearance from a distance. The branches are alternate. Leaves are 2 to 10cm long on a short stalk and covered in silvery scales. The lower leaf surface is covered with brown and silver scales. The flowers are not showy, typically occurring in clusters of 1 to 3. The fruits are silver, large and egg-shaped.
**Field Identification:** This plant is easy to spot from a distance. It can be identified by its silver leaves that are covered in small brown spots on the lower half. **Similar species:** There is a non-native silverberry called Russian olive (*Elaeagnus angustifolia*) that does not have brown spots on the lower leaves. This species is unlikely to be found in remote or wild environments but is sometimes cultivated.
**Life Form:** A perennial deciduous shrub; has a woody stem that persists through all seasons.
**Reproduction:** Forms colonies through rhizomes, also reproduces sexually by seed production [1].

**Continental Range:** Occurs from western to central Canada and Alaska, becoming vulnerable in Quebec. Populations in the United States are scattered, but concentrated mostly in the north-western states [2].
**HBL regional Range:** Widespread and abundant in the Hudson Bay Lowlands [3]**.**
**Habitat:** Commonly found in disturbed sites[1]. Tolerates various substrates including loamy soils, sandy, gravel, slopes, open, dry uplands. Silverberry is also common in boreal forests, shrublands, prairies, and upper river floodplains[4].

Photo 2: Silverberry plants stand out from the surrounding vegetation at a distance.

## Reclamation value

Silverberry is highly valued in reclamation for its tolerance to disturbance, nitrogen fixing capacity and rhizomatous growth [4]. It was planted in British Columbia and Alberta mine sites for erosion control and had high survival and spread [4]. It is moderately tolerant of saline soils [5].
**Nitrogen fixing:** Yes.
**Symbioses:** Arbuscular endomycorrhiza [7]. Forms a symbiosis with nitrogen-fixing bacteria *Frankia* [7].
**Growth rate:** Rapid [8].

De Beers Canada Victor Mine
LaurentianUniversity UniversitéLaurentienne
NSERC CRSNG

**Successional stage:** This species prefers open, recently disturbed habitats, but it also dominates in sites that are up to 19 years old and is present in forest openings [4]. Tolerant of early, mid, to late successional sites.

*Photo 3: Mature silverberry fruit.*

## Seed and fruit properties

**Fruit description:** Silverberry fruits are silver, large (8 to 10mm long) and egg shaped. The flesh is dry and mealy.
**Dispersal:** Animals eat the fruit, likely birds [9].
**Fruit weight:** (fresh whole berries) 628.5mg.
**Seeds /propagule:** One seed per berry.
**Seed size and description:** Seeds are large and hard, **about** 20mm long and 7mm in diameter. They are dark brown at maturity and striped.
**Average seed weight:** (cleaned dry seed) 107.65mg [10].
**Seeds/kg:** 9300 seeds/kg [10].

## Seed Collection

**Timing collections:** Berries ripen at the end of August. The berry flesh is soft and the seeds inside should be hard and light brown. The seed changes colour to a dark brown when it comes into contact with the air. Berries are somewhat persistent and collection may continue into the fall for some regions [11].
**Collection protocols:** The fruit of silverberry does not grow at the tip of the branch, but along the stem and branches so berry rakes are not effective for this species. The berries are well camouflaged. To collect seed run your hands along the branches to feel for seeds rather than searching visually. Do not waste time picking cleanly for silverberry. Use a hands free collection container such as a bucket that can be strapped around your neck. Place berries in the fridge until processing.
**Collection effort:** One person collected an average of 89g of clean, dry seed in one hour. The range in collection rates was 50g/hr to 120g/hr. Berry production was absent in some stands.
**Potential density:** No information found.
**Cautions:** None known.

*Photo 4: Threshing silverberry fruit on a corrugated rubber mat.*

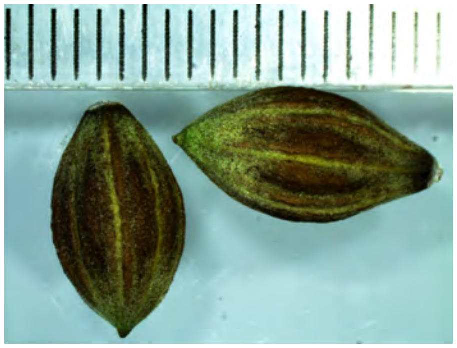

*Photo 5: Whole silverberry seed.*

## Propagule processing

**Processing protocols:** Seeds have inhibitory chemicals in the seed coat and should be cleaned then pre-treated before planting. 1. Berries and any leafy material are placed on a corrugated rubber mat and threshed. Rinse seed into a 5 gallon bucket. Empty seeds, leaf and pulp will float and can be poured off. 2. Reserve the sunken material in a sieve. 3. Allow material to dry. 4. Finish cleaning by winnowing.
**Cautions:** None known.

## Storage

**Storage behaviour:** Probably orthodox [10].
**Storage requirements and longevity:** Seed can be stored cool and dry (to 6% moisture content) for over 2 years. Seeds that were dried but kept in open storage at room temperature were viable for up to for up to 2 years [12].

## Seed Propagation

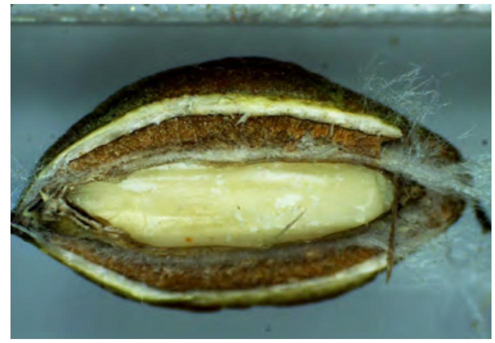

*Photo 6: A sectioned silverberry fruit. The seed is contained within this thick hard outer covering.*

**Dormancy classification:** Physiological dormancy [13].

**Potential viability:** Cleaned seed in our study were 91% viable on average, ranging from 71% to 100% between populations.

**Pre-treatments:** Removing the hard outer part of the seed (endocarp) can result in up to 100% germination, however is incredibly labour intensive [14]. The pretreatment resulting in the second highest germination percentage (85%) required cool-moist stratification at 4°C for up to 6 months, followed by a hot water rinse [15]. For the hot water rinse, the seeds were soaked in 50°C water for 48 hours, and the water was changed every 24 hours. Longer soaking periods resulted in reduced germination rates. The water rinse is required to remove germination inhibitors from the endocarp.

**Germination protocols:** Silverberry seeds may react negatively to germination in light [15]. Seeds can be germinated in a soil medium in the dark at temperatures of 20 to 30°C (85% germination). Silverberry seeds germinated to 78% on agar at 30/20°C and 8/16hours light/dark [10]. Seed germinated to 75% after 20 days at 20°C [14].

**Other propagation methods:** Stem cuttings, may be used to propagate silverberry. Cuttings 20cm or longer taken in December to February or in May had over 75% rooting [16,17].

**Field planting:** Sow seeds in the fall to a 2cm depth at a rate of 180 to 270 seeds/$m^2$ and surface mulch [5].

## Other

**Canadian commercial sources:**

None known.

**Useful links and Further reading:**

https://www.fs.fed.us/database/feis/plants/shrub/elacom/all.html#59
https://plants.usda.gov/plantguide/pdf/pg_elco.pdf

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# slender wheatgrass

Family: Poaceae

Scientific name: *Elymus trachycaulus* (Link) Gould ex Shinners

Cree Name: ___________

Synonyms: *Agropyron trachycaulum, etc*

*Photo 1: Slender wheatgrass tuft.*

## Quick Seed Guide

**When and what to collect**: Collect in August when the grass turns tan in colour and the seeds can easily be pulled off the plant. Cut entire seed head using scissors.
**Seed Processing**: Dry, thresh, sieve. Winnow for further cleaning.
**Storage:** Dry, cool for several years.
**Pre-treatment of seed:**
germination rates but may not be required for all seed lots.
**How to Grow:** Seed: Germinate at 25/15°C and 8/16hr of light/dark.

## General

**Plant Description:** This tall slender grass often grows in tufts with many stems, 30 to 150cm tall [1]. Its leaves are mostly found at the base of the plant, 2 to 5mm wide. The flowering head is a spike, tall and slender, 8-30cm long by 0.5-0.8cm wide. Each spikelet has 3-9 florets (seed), green to purplish when immature becoming straw coloured with age. The glumes are shorter than spikelets and can have an awn or not.
**Field Identification:** Slender wheatgrass is recognized by its tall slender spike (over 30 long), its tufted growth and by looking closely at the spikelets. There is only one spikelet at each node of the stem and the glumes that enclose the spikelets are over 4mm long. Visit: http://michiganflora.net/species.aspx?id=2103 for photos of the different appearances of this grass. **Similar species**: There are several grasses in the genus *Elymus* and *Agropyron* that resemble slender wheatgrass. See further reading for identification keys.
**Life Form:** Perennial graminoid; stems die back during winter months, overwintering by buds at or below the soil surface.
**Reproduction:** Predominantly by seed but also by tillering (the production of new shoots from existing stems) [2]. Seeds are produced annually.

**Continental Range:** Widespread in all Canadian provinces and Alaska [3]. Populations in the United States extend west to east in the northern states. This plant is not found in southeastern states, east of Texas, and south of Missouri.
**HBL regional Range:** Widespread and abundant in the Hudson Bay Lowlands [4].
**Habitat:** Most common in open sites, but sometimes found in forests; 0-3300m [1]. Tolerates a range of soil conditions and moisture regimes from dry to moist sites [5].

## Reclamation value

This grass is highly valued in reclamation on disturbed sites, such as mine spoils, roadsides, and in the oil sands [6]. It tolerates saline and alkaline soils and is moderately drought tolerant [5]. This species is a valuable food source for wildlife. It is short lived but will persist while conditions are suitable by self-seeding and will decline as canopy cover and organic litter increases, making it a valuable species early in the reclamation process.
**Nitrogen fixing:** No.
**Symbioses:** Arbuscular mycorrhiza [7].
**Growth rate:** Rapid [8].

*Photo 2: Slender wheatgrass naturally recolonizing an old mine exploration site.*

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**Successional stage:** Early to middle succession [5]. This species is one of the first to colonize disturbed sites and declines in abundance after a few years. It may be found in small numbers it late successional sites.

Photo 3: Collecting slender wheatgrass seed using scissors. Note the yellow colour of the seed head.

## Seed properties

**Dispersal:** Seeds detach from the stem when ripe, they may be distributed further distances by animals [5].
**Propagule weight:** (whole floret, dried) 2.2mg [9].
**Seeds/ propagule:** There is only one seed per floret. There may be over 100 seeds per spike.
**Seed size and description:** Floret (no awn) about 9mm long by 2mm wide.
**Average seed weight:** (clean, dry seed) 1.6mg [9].
**Seeds/kg:** 445 000 to 625000 seeds/kg [9].

## Seed Collection

**Timing collections:** Seeds are ripe in early August when plants change colour from green to yellow. Check the spike and seeds to ensure they are firm and plump. Seed may persist on the spike for a couple weeks after maturity. However to avoid losses, collected seed as soon as it becomes mature.
**Collection protocols:** The seeds do not easily attach from this plant making vacuum harvesting unsuitable for this species [10]. In our wild collections, this grass did not occur in large stands but rather in clumps, commonly scattered throughout sites. Collect using scissors, cutting just below the spikes. Collect into large paper bags because collections are bulky. This grass is tall and tufted making collection easier because multiple stems can be harvested at once. If the stand is dense, use long grass clippers to cut spikes. Lay seed out to dry following harvesting.
**Collection effort:** We collected an average of 444g of cleaned, dry seed in one hour.
**Potential density:** No information found.
**Cautions:** None known.

## Propagule processing

**Processing protocols:** 1. Thresh entire dry stalks on a corrugated rubber mat. This detaches seeds from the stalk. The shape of this seed (long and flat) makes it vulnerable to damage from threshing, so apply only as much force as is required to detach seed from the stem. 2. Sieve to separate seed from stems. 3. Winnow to remove any glumes that attached during the threshing process. Our seed was cleaned to 98% purity using these methods.
**Cautions:** None known.

Photo 4: Threshing slender wheatgrass stalks to remove seed.

Photo 5: Cleaned slender wheatgrass seed.

## Storage

**Storage behaviour:** Orthodox [11].
**Storage requirements and longevity:** Seed maintains its viability for 3 to 6 years in the soil [5]. Following best practices, dry seed and store cold at 1 to 5°C.

## Seed Propagation

**Dormancy classification:** Physiological dormancy [12].
**Potential viability:** Average seed viability for cleaned seed was 98% in our study.
**Pre-treatments:** Seed germination percentages improve with cool stratification but germination will still occur for untreated seed [10]. In our germination trials, seeds germinated to 77% following a cold-dry storage for 12 weeks in a refrigerator (1°C to 5°C).
**Germination protocols:** Optimal germination conditions are using fluctuating temperatures of 25/15°C for 8/16 hours of light/dark [5,10]. Seed can also germinate at a constant temperature of 15°C [11].
**Other propagation methods:** None known, reproduces well by seed.
**Field planting:** Seed planted in the fall shows better emergence than spring planted seed [5]. Mulching is also recommended. For reclamation purposes, this species is planted in a mix at a rate of 1.12 to 2.25kg per hectare to a depth of approximately 1 to 2cm [6].

*Photo 6: Sectioned slender wheatgrass seed. Note the starchy endosperm and the embryo at the tip of the seed.*

## Other

**Canadian commercial sources:**
https://www.brettyoung.ca/professional-turf-and-reclamation/seed/native-grasses
**Useful links and Further reading:**
https://www.fs.fed.us/database/feis/plants/graminoid/elytra/all.html
https://plants.usda.gov/core/profile?symbol=ELTRT
For grass id (this resource contains many of the grass species found in Ontario, but is not complete): For this plant go to "KEY TO GENERA OF GROUP 2" http://michiganflora.net/family.aspx?id=POACEAE

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# hyssopleaf fleabane

Family: Asteraceae

Scientific name: *Erigeron hyssopifolius* Michx. Cree Name: ___________

Synonyms: *Erigeron hyssopifolius var. hyssopifolius*

## Quick Seed Guide

**When and what to collect**: Seeds ripen July to August, resembling a dandelion seed head when ripe. Cut multiple seed heads off using scissors.

**Seed Processing**: Dry, thresh, sieve, winnow.

**Storage:** Dry seed, store cool in sealed containers.

**Pre-treatment of seed:** None-required, however may

**How to Grow:** Seed: Germinated at 20 to 22°C, seeds will germinate with or without light.

## General

**Plant Description:** A perennial flower that looks like a small daisy. Hyssopleaf fleabane is between 5 to 35cm tall, spreading by underground rhizomes, often found in small stands [1]. The stems can be branched or not and are often covered with small stiff hairs. The leaves along the stem are 1 to 3cm long by 1 to 5mm wide. The largest leaves are at the center of the stem. The edges of the leaves are smooth, but may be covered in small hairs. The flowers (ray florets) are white, becoming pink with age.

**Field Identification:** The fleabanes resemble many other asters, which is large group of flowering herbs. Hyssopleaf fleabane is a much smaller plant in general; it has usually only 1 to 4 flowers per stem and the leaves are more slender than many other asters. Most of the fleabanes have small hairs with glands on the green parts under the flower head (phyllaries). **Similar species**: *Erigeron strigosus* (introduced) has larger leaves and more flowers per stem than our species. *Erigeron acris* has wider leaves and is much hairier than our species. For a key to the fleabanes: http://michiganflora.net/genus.aspx?id=Erigeron

**Life Form:** Perennial forb; stems die back during winter months, overwintering by underground buds.

**Reproduction:** This species reproduces by seed and likely by underground rhizomes [1]. Flowering begins in June and continues through the summer until August.

**Continental Range:** Hyssopleaf fleabane is most common in central Canada in Manitoba, Ontario and Quebec, populations east and west of these provinces are considered vulnerable or imperiled [2]. Its distribution is limited to north eastern states in the U.S., but these populations are considered imperiled.

**HBL regional range:** Widespread and abundant in the Hudson Bay Lowlands [3].

**Habitat:** Open woods, rock ledges and crevices, gravel barrens, roadsides; 0-500 m [1]. Found on seepage slopes and meadows.

## Reclamation value

**Nitrogen fixing:** No.

**Symbioses:** Some species of the fleabanes (*Erigeron* ssp.) associate with vesicular arbuscular mycorrhiza (VAM) [4].

**Growth rate:** No information found.

**Successional stage:** No information found.

*note uneven seed ripening within the tuft,*

# hyssopleaf fleabane

## Seed and propagule properties

**Propagule description:** One flower head will produce numerous seeds attached to stiff hairs. They will resemble a very small dandelion flower gone to seed.
**Dispersal:** Wind, the hairs attached to the seed help the seed be carried by the wind.
**Propagule weight:** (dried seed with hairs attached) 0.08mg [5].
**Seeds/ propagule:** Numerous seeds per flower head.
**Seed size and description:** Brown at maturity about 1.5mm x 0.4mm.
**Average seed weight:** (cleaned dry seed, hairs removed) 0.08mg [5].
**Seeds/kg:** 13.2 million seeds/kg [5].

*night of drying.*

## Seed Collection

**Timing collections:** Seeds ripen in the middle of July on exposed shorelines and almost a month later in shaded locations. With hot dry weather, this seed ripens quickly after flowering. Plants do not produce ripe seed all at once so in order to avoid losses we collected this seed when 50% of the stand or plants had gone to seed.
**Collection protocols:** Cut the flower heads using scissors into paper bags. If some of the flower heads are not fully mature in your collection, they may still produce seed but may have lower viability. Place plant material on a tray or in thin layers for drying.
**Collection effort:** We collected up to 7g of cleaned, dry seed in one hour.
**Potential density:** No information found.
**Cautions:** None known.

## Propagule processing

**Processing protocols:** For a cleaner final product, separate seed heads first, by shaking in a paper bag and then removing the stems. 1. Thresh the dried plant materials on the flat side of a rubber mat. The purpose of this is to detach the hairs from the seeds. 2. Sieve material. 3. Winnow in front of a low air flow.
**Cautions**: Seed processing creates dust. Wear a mask and ensure adequate ventilation.

*Photo 4: Fleabane seed separated from plant by shaking seeds free in a paper bag. Ready to be threshed.*

*Photo 5: Seed material following threshing is ready to be sieved and winnowed.*

## Storage

**Storage behaviour:** Probably orthodox. No information was available for this species, however of the known fleabane species 100% have orthodox seed [6].
**Storage requirements and longevity:** Best practices for short term storage of orthodox seed is to dry seed and store cool (1 to 5°C) in sealed containers.

## Seed Propagation

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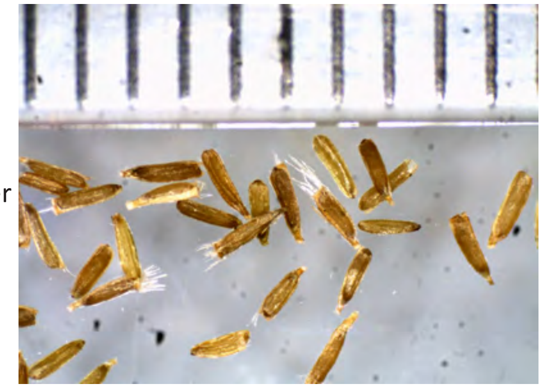
# hyssopleaf fleabane

**Dormancy classification:** Probably non-dormant; many arctic and temperate fleabanes (*Erigeron*) are not dormant [7].
**Potential viability**: Seed viability of cleaned seed ranged from 88% to 98% in our collections.
**Pre-treatments:** None required if seed is non-dormant [7]. One author pre-treated cut-leaf daisy seed with 8 weeks cool-moist stratification and had higher germination rates compared to untreated seed [8].
**Germination protocols:** Germination temperatures for other fleabane species are continuous between 20 to 22°C [7]. One author reported 90% germination from cut-leaf daisy seed grown at 22°C on a soil medium of peat, sand, vermiculite, perlite and fertilizer [8]. Seed germinates well in light or darkness [9].
**Other propagation methods:** None found.
**Field planting:** No information found.



*after processing.*

## Other

**Canadian commercial sources:** None known.
**Useful links and Further reading:**
https://gobotany.newenglandwild.org/species/erigeron/hyssopifolius/
http://www.saskwildflower.ca/nat_Erigeron%20hyssopifolius.html

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# wild strawberry

Family: Rosaceae

Scientific name: *Fragaria virginiana* Duchesne

Cree Name: ___________

Synonyms: Four recognized varieties.

Photo 1: Wild strawberry plant growing on rocky outcrop. The red berry is ready to be collected.

## Quick Seed Guide

**When and what to collect**: Berries ripen rom June to August, depending on the region. Collect red strawberries by hand.

**Seed Processing**: Blend with 2:1 water to berries. Reserve sunken material, dry, quickly thresh and winnow for pure seed.

**Storage:** Dry seed stored in cool conditions (4.5°C) can remain viable for 20 years.

**Pre-treatment of seed:** Cool-moist stratify for 85 days.

**How to Grow:** Seed: Germinate at 20°C under 8/16hr light/dark.

## General

**Plant Description:** Wild strawberry is a common wild flower, well known for its delicious berries. It is short (5 to 20cm tall) and grows horizontally, producing a groundcover [1]. The leaves are 3-lobed, each leaflet is round and has toothed margins. Flowers are white with 5-petals, hanging from a stalk in groups of 3 to 5. These flowers become small egg-shaped strawberries.

**Field Identification:** Wild strawberry can be recognized by its 3-lobed, rounded leaves and by the berries it produces.

**Similar species:** Woodland strawberry is also a common species. Woodland strawberry is more common in forested habitats and has rounder berries than wild strawberry. The tooth at the tip of a woodland strawberry leaf is as tall or taller than the surrounding teeth, whereas the tooth at the tip of the leaf in wild strawberry is shorter than surrounding teeth (photo 1).

**Life Form:** Perennial herb; leaves and stems die back during winter-months, regenerating from buds at or below the soil surface.

**Reproduction:** Reproduces vegetatively by stolons and by seeds [1]. Flowers open in May and June and fruit develops about a month afterwards, from June to July. Flowers may be male, female or both.

**Continental Range:** Found in all Canadian provinces and Alaska [2]. Present in throughout the United States, except Hawaii.

**HBL regional range:** Widespread and abundant in the Hudson Bay Lowlands [3].

**Habitat:** This species tolerates a variety of habitats from disturbed areas such as roadsides and fields to open forests and forest edges [1]. Often considered a weedy species. Tolerant of moist to dry sites; 0-1000m.

Photo 2: Wild strawberry plant, growing on exposed mineral soil.

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# wild strawberry

## Reclamation value

Wild strawberry tolerates disturbed, highly exposed habitats and may be useful as a pioneer species on bare mineral soil. It produces a dense ground cover and may spread quickly from surface stolons, this may be beneficial for the prevention of wind erosion and creating soil microclimates, such as shading and reducing evapotranspiration.
**Nitrogen fixing:** No.
**Symbioses:** Vesicular-arbuscular mycorrhiza [4].
**Growth rate:** No information found.
**Successional stage:** early to mid-successional.

Photo 3: Collecting low growing wild strawberry. Collection buckets are wrapped around the collector so she can move quickly from patch to patch and use both hands to collect.

## Seed and fruit properties

**Fruit description:** Berries are egg-shaped, red and soft at maturity. The berry surface is pitted and the seeds are on the outer surface of the berry inside the sunken pits.
**Dispersal:** Animals consume berries and disperse seeds.
**Propagule weight:** (whole fresh berry) 200mg from our collections; (whole dried berry) 52.9mg [5].
**Seeds/fruit:** In our collections, there were 10 to 64 seeds per fruit, with an average of 27 seeds per fruit.
**Seed size and description:** Seeds are contained within an achene. Yellow-green, turning brown when mature, generally round or tear shaped, 1.2 to 1.8mm in diameter [1].
**Average seed weight:** (cleaned dry seed) 0.39mg [5].
**Seeds/kg:** 2.56 million seeds/kg [5].

## Seed Collection

**Timing collections:** In northern regions, berries are ripe near the end of July and earlier further south. This species produces a berry that turns red at maturity. To avoid losing all the berries to animals, check plants regularly. Collect fruit when the majority is red and has softened. If the berry is still white, it may still be collected as long as the seeds appear plump and dark.
**Collection protocols:** Hand-collect berries onto a tray or a short basket. Having a basket strapped to your body, that sits at the hip level is useful for moving quickly between patches and allowing you to have both hands free to collect. Do not waste time picking cleanly, some berries may contain stems or leaves, but the cleaning regime is successful even when collections contain vegetative material. Place fruit in the refrigerator until processing is possible.
**Collection effort:** One collector picked 7 to 8g of pure dried seed in one hour. This plant grows low to the ground and may require the collector to be bent over for long periods.
**Potential density:** No information found.
**Cautions:** No part of this plant is toxic.

Photo 4: Strawberry fruits crushed in the blender mixed with water. Full seeds have settled to the bottom of the blender.

## Propagule processing

**Processing protocols:** 1. Blend berries with a ratio of 2:1 (or higher) water:berry. 2. Pour all material into a fine sieve lined with a paper towel or coffee filter and lay it out to dry. 3. Once dry, thresh the material on the flat side of a rubber mat to break apart. 4. Winnow the material at a moderate airflow to remove berry pulp and any leaves or stems.
**Cautions:** None.

## Storage

**Storage behaviour:** Orthodox [6].

**Storage requirements and longevity:** Strawberry seeds can be stored dry and cool (about 4.5°C), for long periods (up to 20 years) without losing viability [7].

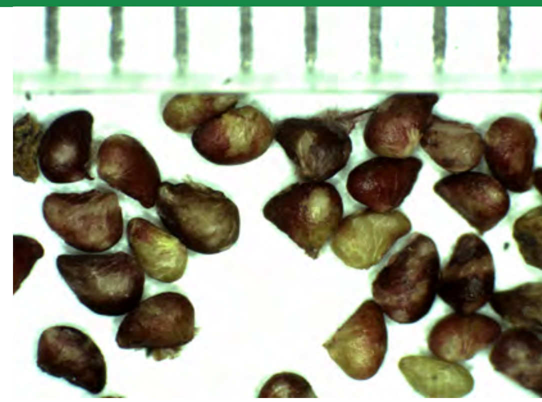

Photo 6: Wild strawberry seed.

## Seed Propagation

**Dormancy classification:** Physiological dormancy [8].

**Potential viability:** Seed viability for cleaned seed was 94% to 100% in our collections.

**Pre-treatments:** Cool-moist stratify for at least 85 days [8].

**Germination protocols:** Germination rates of 75% to 95% were achieved for seeds grown on agar under 8/16hr of light/dark and temperatures of 20°C, 25°C or 25/10°C [6], with no listed pre-treatment.

**Other propagation methods:** Plants may be transplanted in the spring or fall [8].

**Field planting:** Plant seeds in the fall. The emergence and survival of fall sown seed was as high as 7% after 3 seasons on amended mine soils in northern Alberta [9]. Fall-planted seeds performed better than spring-planted seeds.

## Other

**Canadian commercial sources:**

http://www.wildaboutflowers.ca/plant_detail.php?Wild-Strawberry-44

**Useful links and Further reading:**

http://plantwatch.naturealberta.ca/choose-your-plants/wild-strawberry/

https://gobotany.newenglandwild.org/species/fragaria/virginiana/

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# northern bedstraw

Family: Rubiaceae

Scientific name: *Galium boreale* L.

Cree Name: ___________

Synonyms: *Galium hyssopifolium, etc*


*Photo 1: Northern bedstraw plant in .*

## Quick Seed Guide

**When and what to collect**: Seeds ripen near the end of August. Collect the entire seed head using scissors when the seed is turning dark brown to black.

**Seed Processing**: Dry, thresh, sieve and winnow.

**Storage:** Seed does not tolerate freezing. Seed dried and kept at room temperature for 5 months maintains viability.

**Pre-treatment of seed:** Uncertain. Cool-moist stratify for 12 weeks.

**How to Grow:** Seed: Low germination rates (40%) at 20/10°C with light and dark. Vegetative: Rhizome cuttings or plant divisions.

## General

**Plant Description:** Northern bedstraw is a perennial flower, 30 to 100cm tall [1]. The stem is smooth, leaves are whorled in groups of 4. The leaflets are thin, 2 to 5cm long by 2 to 8mm wide, pointed at the tip with three distinct veins. The flower head is made up of many small white flowers with 4 petals.

**Field Identification:** There are several native and non-native bedstraws. Northern bedstraw is unique because it has narrow leaves (more than 4 times as long as wide) in whorls of 4 and its leaves have 3 mid ribs. **Similar species:** *Galium asprellum* has shorter rounded leaflets in whorls of 6, *Galium trifidum* and *Galium labradoricum* are more common in wetland environments and have fewer flowers. For an online identification key and more information on similar species refer to further reading below.

**Life Form:** Perennial forb; the stems die back during winter months, but the plant survives by from rhizomes below the surface [2].

**Reproduction:** Seeds and rhizomes [2].

**Continental Range:** Found in all Canadian provinces except Nunavut, New Brunswick and is rare in Prince Edward Island [3]. In the United States northern bedstraw is widespread, except east of Texas and south of Tennessee.

**HBL regional range:** Widespread and abundant in the Hudson Bay Lowlands [4].

**Habitat:** Found in a variety of habitats, from coniferous to deciduous-mixed forests, grasslands and riparian shores [2]. Prefers southeastern exposure to northeastern exposures [2]. Roadsides, open to mixed forests [5].


*Photo 2: Northern bedstraw growing on an exposed river shoreline.*

## Reclamation value

This species is not commonly included in a reclamation seed mix, but has been found colonizing old coal mine sites and has been used for prairie habitat restoration in Alberta with success [2]. It produces many seeds and spreads by rhizomes, tolerating shading or full sun exposure [2]. Has a high tolerance to calcium carbonates, and moderate drought tolerance [6].

**Nitrogen fixing:** No.

**Symbioses:** Arbuscular mycorrhiza [7,8].

**Growth rate:** Moderate [6].

**Successional stage:** Tolerant of a range of successional stages and disturbances [2]; early, mid-and late, but may not persist into climax communities. In our region, northern bedstraw occurs on rocky outcrops and upper river shores that receive at least some annual disturbance.

# northern bedstraw

## Seed and propagule properties

Photo 3: A cleaned seed lot of northern bedstraw. Some leaves and stems could not be removed.

**Propagule description:** Each flower has a two-celled ovary and will produce 2 fruit, each containing one seed. Fruits are small and round about 2mm in diameter, brown to black at maturity. The fruit in our collections were covered in short stout hairs, but they can also be smooth. We found seed size for this species highly variable, but the small seeds still contained viable embryos.
**Dispersal:** Uncertain; seed bristles may help this seed disperse by catching onto animal fur [2].
**Propagule weight:** (whole dried fruit) 0.44mg [9].
**Seeds /propagule:** One seed per fruit, numerous seeds per plant. One author reported a maximum of 1300 seeds on one plant [10].
**Seed size and description:** Seed does not separate from fruit; see propagule description.
**Average seed weight:** (cleaned, dry seed) 0.21mg [9], bristles removed?.
**Seeds/kg:** 2.27 million to 4.76 million seeds/ kg, depending on the degree of seed cleaning [9].

## Seed Collection

**Timing collections:** Seeds ripen near the end of August when they turn brown to black in colour. Seeds do not ripen all at once on a single plant. Collect when over 50% of the plant has fully ripe seeds.
**Collection protocols:** Collect entire seed heads using scissors, collect into large paper bags. Set the material out to dry following collection.
**Collection effort:** One collector picked 23g/ hour of pure, dried seed, ranging from 18g to 30g.
**Potential density:** No information found.
**Cautions:** None known.

## Propagule processing

**Processing protocols:** 1. Thresh plant materials on a corrugated rubber mat to separate seed from the plant. 2. Sieve this material, seeds will be trapped in mesh size #18 and #35.
3. Winnow material using a low air stream to remove leaf pieces and empty seed.
**Cautions:** None known.

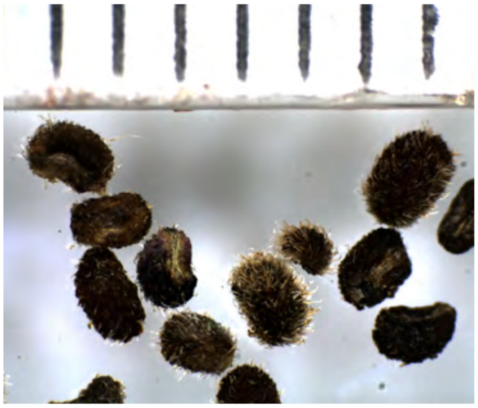

Photo 4: Northern bedstraw seed.

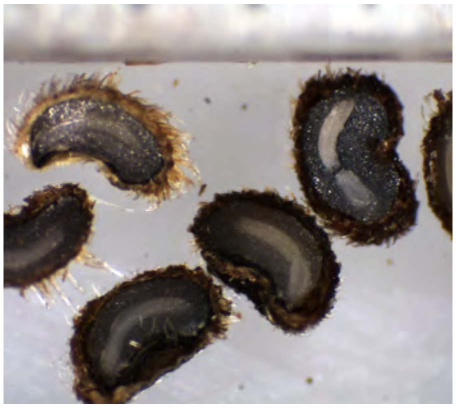

Photo 5: Sectioned, viable northern bedstraw seed.

## Storage

**Storage behaviour:** Uncertain [11].
**Storage requirements and longevity:**
Uncertain. This species loses most viability after less than 1 year in storage at -20°C [11].
Seeds had 89% viability following drying and storage at room temperature for 3 to 5 months [12].

## Seed Propagation

**Dormancy classification**: No information for this species. Other bedstraws (*Galium* ssp.) have a physiological dormancy[13].
**Potential viability:** Seed viability in our collections was 89% on average, ranging from 85% to 100% for cleaned fresh seed.
**Pre-treatments:** Pre-germination treatments for this species are unclear and are not thoroughly researched. Germination percentages tend to be low (less than 30%) even with over 12 weeks of cool-moist stratification [12,14].
**Germination protocols:** Germination success for this species is variable in literature. Maximum reported germination is between 30% and 40% at temperatures of 15/5°C and 20/10°C after one month with natural light and dark cycles [12,14].

**Other propagation methods:** It may be possible to propagate northern bedstraw by rhizome cuttings or division [15].
**Field planting:** No information found.

## Other

**Canadian commercial sources:**
http://www.wildaboutflowers.ca/plant_detail.php?Northern-Bedstraw-46
**Useful links and Further reading:**
Identification: http://michiganflora.net/genus.aspx?id=Galium
https://gobotany.newenglandwild.org/species/galium/boreale/
http://www.pfaf.org/user/Plant.aspx?LatinName=Galium+boreale
https://www.fs.fed.us/database/feis/plants/forb/galspp/all.html#LIFE FORM
https://www.prairiemoon.com/seeds/wildflowers-forbs/galium-boreale-northern-bedstraw.html

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# foxtail barley

Family: Poaceae

Scientific name: *Hordeum jubatum* L.

Cree Name: ___________

Synonyms: *Critesion jubatum, etc*

*Photo 1: Foxtail barley stand on Victor mine stockpile.*

## Quick Seed Guide

**When and what to collect**: August; clip entire spike once top of spike begins to turn straw coloured.
**Seed Processing**: Let seeds after-ripen on stem. Thresh seeds on corrugated mat to break awns off of seed. Winnow to remove chaff.
**Storage:** Cool dry.
**Pre-treatment of seed:** Cool stratify up to 6 months.
**How to Grow:** Seed: germination 25/15°C, alternating light/dark.

## General

**Plant Description:** Foxtail barley is a perennial grass that grows in dense clumps [1,2]. It is an attractive grass due to its showy, iridescent spike. Ranging in height from 20 to 80cm tall at maturity. It produces seeds after only one year of growth and increases the number of stems per plant annually, up to 188 spikes per plant by year four [3]. The spike which contains the seed is 3 to 15cm tall, nodding, appearing greenish to purplish until maturity, then becomes straw coloured. Each seed has very characteristic awns (1 to 9cm long) that helps the seed to spread. There is no rachilla (a stem that seeds attach to), the seeds attach to the base of one another. The leaf sheaths can be smooth or lightly hairy, ligules are up to 0.8mm. Leaf blades are scabrous, 15cm long x 5mm wide.

**Field Identification:** Foxtail barley is distinguished because it is a tufted grass, with characteristic long awns and no rachilla. **Similar species** include *Elymus elymyoides*, *E. canadensis*, *E. virginicus*, *E. glaucus*. Foxtail barle can be distinguished because it does not have auricles on the leaf blades, is not rhizomatous, and has leaf blades less than 10mm wide [3]. It is distinguished from *Hordeum vulgare* (cultivated barley), *H. brachyantherum*, and *H. pusillum* by its flattened seed and length of awns.

**Life Form:** Graminoid; perennial [1,4]. Produces new shoots every spring.

**Reproduction:** This species reproduces predominantly by seed, that can germinate in the fall [3]. Each spike has male and female parts and is self-compatible. It also develops vegetatively by buds that overwinter on the root crown.

**Continental Range:** Present in all Canadian provinces and Alaska [5]. It is also present in most of the United States except the most south eastern states including LA, AL, GA, and FL.

**HBL regional Range:** Widespread and abundant [6].

**Habitat:** Grows in meadows, along roadsides and other disturbed areas, highly tolerate of saline conditions [1]. Occurs in a wide range of climates, including sub-alpine environments [3]. Tolerant of slightly alkaline soils with a range of textures [3].

*Photo 2: Ripe foxtail barley spike and seeds.*

## Reclamation value

**Nitrogen fixing:** No.

**Symbioses:** Arbuscular mycorrhizal [7].

**Growth rate:** Apparently rapid.

**Successional stage:** Early [3].

# foxtail barley

## Seed and propagule properties

Photo 3: Foxtail barley in August, nearing harvest time.

**Dispersal:** The long awns of the seed roll like tumble weed, or can become attached to animal fur [3].
**Propagule weight:** (dry mass, with awns) 2.9 mg [8].
**Seeds/ collection unit**: Several seeds per spike, over 100 spikes per plant [3].
**Seed size and description:** Seed is 5.0 to 7.5 mm long by 1.0 to 1.5 mm wide and flattened, tan at maturity [3].
**Average seed weight:** (cleaned, dry seed) 0.98 mg [8].
**Seeds/kg:** One million.

## Seed Collection

**Timing collections:** Late August [2]. In our region, seed collection begins in early August. Once ripe, the seed will only persist on the plant for approximately a week depending on weather conditions, however seeds can likely be harvested earlier if clipping the entire head of the spike, once the colour begins to change from purple-green to straw at the tip.
**Collection protocols:** This species has long awns and usually occurs in dense stands. We do not recommend vaccuum harvesting for this species; vacuum harvesting is effective when the seed is falling away from the plant, but not earlier and does not increase collection volumes in our experience. Because this species is tufted in its growth, hand collection can produce fairly high seed volumes. Seed can be harvested using scissors, for each tuft, or if growing in a monocultural can be harvested by grass cutting shears. Place spikes into large paper bags, avoid cloth since the awns will cling to the sides. Allow materials to dry on the stem, this will allow for after-ripening of seed.
**Collection effort:** (cleaned seed; air-dried) 695g/hour using scissors.
**Potential density:** Not determined.
**Cautions:** Awns stick to clothing and can be irritating to touch.

## Propagule processing

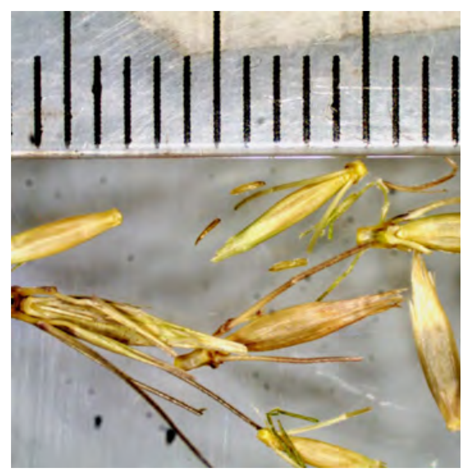

Photo 4: Foxtail barley seed.

**Processing protocols:** Seeds separates easily from stems. To separate awns from the seed, we used a corrugated rubber mat and a threshing paddle. Place seeds into a box with edges about 5 to 10 cm height to keep seed contained. Rub against the grain to break the awns. Transfer the seeds to a container and clean the final lot by winnowing at a moderate air flow. The final material is workable, but some seed will still have some short bristles attached to the seed using this method.
**Cautions:** Work in a ventilated area, and wear a mask. Broken awn pieces can become airborne and irritating to breath.

## Storage

**Storage behaviour:** Orthodox (probably) [4].
**Storage requirements and longevity:** Seed viability remains high for this species after 5 years, even when dried and stored in open conditions at room temperature [9]. Seeds do not emerge if buried over 7.5 cm deep [3].

## Seed Propagation

**Dormancy classification:** Physiological dormancy [10].
**Potential viability:** In our study, viability of fresh seed was high 100%, after seed cleaning.
**Pre-treatments:** Fresh seed won't germinate, however after 6 months at 5°C, germination was high [11].

**Germination protocols:** High germination percentages achievable. In the lab, fluctuating temperatures had higher germination rates than constant temperatures [11]. Fluctuating temperatures of 25/15 °C and 25/5 °C, achieved nearly 100% germination by about 2 weeks. Seeds germinated to 89% grown at 5°C, 8/16 hours of light/ dark. Germination was dratimically reduced under continuous light and warmer alternating temperatures were preffered to cooler temperatures [2]. This species tolerates salinity of 0 to 1% [11].

**Other propagation methods:** None known.

**Field planting:** Plant seed in the fall on the soil surface, if encorporated too deeply into soil (approximately 7.5cm or more) emergence is low [2]. As high as 35% of seeds emerged in less than a year when field planted in North Dakota [3].

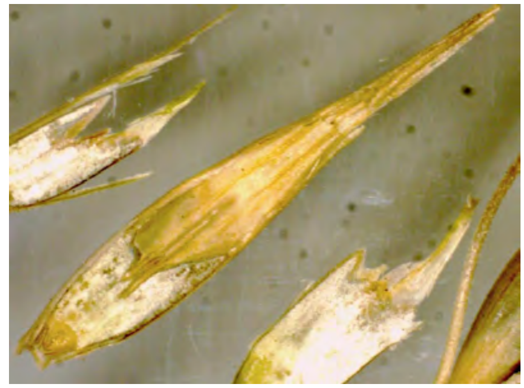

*Photo 5: Viable foxtail barley, exposed embryo and part of starchy endosperm.*

**Canadian commercial sources:**

http://www.stoverseed.com/; http://www.ssseeds.com/plant-database/hordeum-jubatum/

**Useful links and Further reading:**

https://www.prairiemoon.com/seeds/grasses-sedges-rushes/hordeum-jubatum-squirrel-tail-grass.html

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De Beers Canada Victor Mine
Laurentian University Université Laurentienne
NSERC CRSNG

# Dudley's rush

Family: Juncaceae

Scientific name: *Juncus dudleyi* Wiegand

Cree Name: ___________

Synonyms: *Juncus tenuis* var. *dudleyi, etc.*

Photo 1: Dudley's rush.

## Quick Seed Guide

**When and what to collect**: Seeds ripen from July to August. Collect seed heads using scissors when the plant becomes tan in colour.

**Seed Processing**: Thresh dry capsules, sieve.

**Storage:** Store seed dry and cool in sealed containers.

**Pre-treatment of seed:** Cool-moist stratify for 60 days.

**How to Grow:** Seed: Germinate between 15 and 30°C, do not plant seed more than 1cm deep, they require light to germinate.

## General

**Plant Description:** A perennial rush, with 1 to 20 stems, 20 to 100 cm tall [1]. It has 2 to 3 basal leaves with yellowish auricles (ear-like flaps at the junction of the stem and leaf). Leaf blades are flat (sometimes rolling inwards). Flowering heads are at the top of the plant, typically only a few flowers per stem, turning to tan capsules at maturity.

**Field Identification:** Rushes are grass-like plants, with rounded stems and few leaves along the main stem, forming seed capsules holding numerous tiny seeds. Dudley's rush has only basal leaves and can be recognized by its yellowish, shiny auricles (ear-like flaps) at the base of the leaf and smooth stems (rather than ribbed stems). When ripe, this species has tan or golden capsules, with pointed bracts just slightly taller than the capsule. **Similar species:** Too many to list. If you are unfamiliar with the rushes, many species will be diificult to distinguish from each other. Refer to an online identification key at http://michiganflora.net/genus.aspx?id=Juncus and for more photos of Dudleyi's rush.

**Life Form:** Perennial graminoid; stems die back during the winter months, regenerating from buds at or below the soil surface.

**Reproduction:** Reproduces by seeds, flowering in the spring [1].

**Continental Range:** Found in all Canadian provinces except Yukon and Nunavut [2]. Secure in western and central Canada, considered imperiled in the Maritime Provinces. Absent in Alaska. Present throughout the United States, except the most southeastern states.

**HBL regional Range:** Occasional and only in the southern portion of the Hudson Bay Lowlands [3].

**Habitat:** Exposed or shaded sites in sandy to clayey soils, in moist areas such as, river shores, stream banks, rock crevices, moist disturbed areas such as roadsides, ditches [1,4].

*Photo 2: Dudley's rush. The capsules are opening to release mature seed.*

## Reclamation value

Large seed outputs. Where established, this species may serve as a nurse species for the natural recruitment of trees [5]. Small seeded, however seedlings of other rushes (*Juncus* spp.) have rapid root growth to help them establish and survive on bare soil in cold climates [6].

**Nitrogen fixing:** No.

**Symbioses:** Arbuscular mycorrhizal [7].

**Growth rate:** Other rushes (*Juncus* ssp.) have a rapid growth rate [8].

**Successional stage:** Likely tolerant of early successional conditions. Based on habitat preferences and where we found Dudleyi's rush growing, it may be moderately tolerant to disturbance. This species may also persist into later successional stages and is tolerant of shade [1].

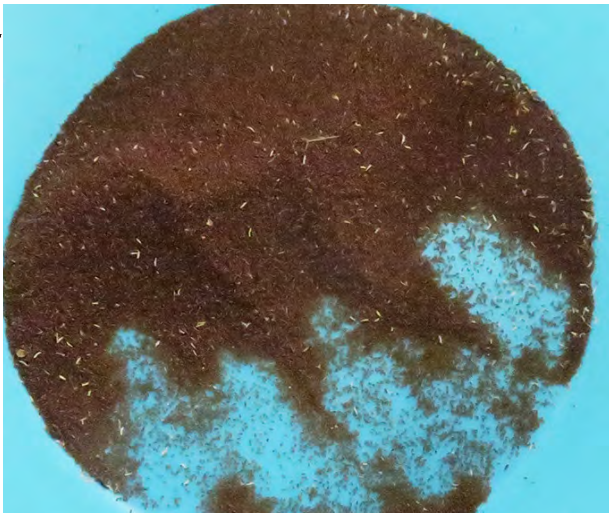

*Photo 3: Cleaned seed from Dudley's rush*

## Seed and capsule properties

**Capsule description:** Capsules are tan at maturity, small.
**Dispersal:** Capsules burst open to release very small seeds. Seeds may be carried for short distances by the wind due to their small size.
**Seeds/ capsule:** Numerous, probably hundreds.
**Seed size and description:** Seeds are tan to amber, 0.4 to 0.67mm long, not tailed [1].
**Average seed weight:** (cleaned seed) 0.01mg [9].
**Seeds/kg:** 100 million seeds/kg [9].

## Seed Collection

**Timing collections:** Capsules were fully ripe by the first week of July in our region. Plant stems change colour from green to tan. Collect capsules before they open.
**Collection protocols:** Use scissors to cut the tops of plants, just below the seed heads. Plant are often clumped and can be harvested by the handful. Harvest plants into a large paper bag, or if capsules are starting to open, collect into plastic buckets to avoid losing the very small seed through any holes in the bag. Place materials in thin layers to dry in a warm, sheltered room.
**Collection effort:** One person can collect approximately 216 to 250g of pure dried seed in one hour, from wild stands.
**Potential density:** No information found.
**Cautions:** None known.

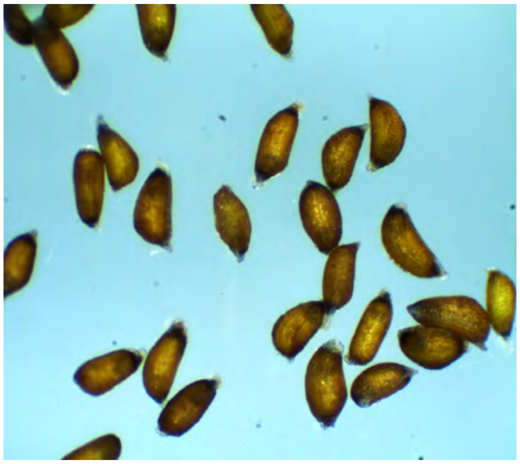

*Photo 4: Dudleys rush whole seed.*

## Propagule processing

**Processing protocols:** Place plant materials on a corrugated rubber mat. Thresh capsules using a paddle to open capsules and release seed. After all capsules have been opened, pour materials into a stacked sieve set with mesh sizes: #18, #35, #140, bottom pan, seeds will stay in the #140 sieve and the capsules will be trapped in the upper sieves.
**Cautions:** None known.

## Storage

**Storage behaviour:** No information available for this species, however the majority of rushes (*Juncus* ssp.) are orthodox. Likely orthodox.
**Storage requirements and longevity:** Dry seed and store cool (1 to 5°C) in sealed containers, uncertain on longevity.

## Seed Propagation

**Dormancy classification:** Many rushes are classified with a physiological dormancy [10].
**Potential viability:** Our collections had approximately 93% seed fill.
**Pre-treatments:** Seeds may benefit from 60 days of cool-moist stratification (1 to 5°C) [11].
**Germination protocols:** Germinate seeds on a moist soil surface to a depth no greater than 1cm [12]. Seeds will germinate between 15°C to 30°C and require light.
**Other propagation methods:** None found.
**Field planting:** Surface plant seeds in the fall to a depth no greater than 1cm [11,12]. Seedlings are very small and will need to be kept moist until established [11].

## Other

**Canadian commercial sources:** None found.

**Useful links and Further reading:**

Caution, when using a google search to find photos of more information on Dudley's rush, many plants are mis-identified. See Michigan flora online http://michiganflora.net/species.aspx?id=1509
https://gobotany.newenglandwild.org/species/juncus/dudleyi/
http://www.illinoiswildflowers.info/grasses/plants/dd_rush.htm

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# common juniper

Family: Cupressaceae

Scientific name: *Juniperus communis* L.

Cree Name: ___________

Synonyms: 4 recognized varieties.


Photo 1: Common juniper plant.

## Quick Seed Guide

**When and what to collect**: August to November, plump-blue berries. Berries are persistent. Wear gloves to collect.
**Seed Processing**: Threshing berries on corrugated

**Storage:** Cool dry.
**Pre-treatment of seed:** Complex (see details below); warm stratify (14 wks) then cold stratify (12 wks).
**How to Grow:** Seed: Germination 15°C/5°C & 8h/16h (light/dark cycles); Vegetative: Stem cuttings.

## General

**Plant Description:** This coniferous shrub usually grows to about 1m in height [1]. There are varieties of common juniper that are a tree form and can reach 10 m in height. This species often has an unusual growth form, with the appearance that it grows on an angle (photo 1). The bark is brown, peeling in long vertical strips on older branches. The leaves are short and sharp pointed needles, uncomfortable to touch. Leaves are green and often whitened on lower surface with a distinct band (furrow) that runs the length of the needle (photo 2). The berries are technically cones, they are round, 6 to 13mm diameter, each with 2 to 3 seeds.

**Field Identification:** The needles are sharp to touch, whorled around the branch in a group of 3. Common juniper has multiple stems per plant unlike coniferous trees that will have only one stem. The berries have a distinct and powerful smell. **Similar species:** may include creeping juniper (*Juniperus horizontalis*), but grows horizontally and has soft, scale-like needles.

**Life Form:** Shrub; woody stem persists for many years and through the winter.

**Reproduction:** This species is dioecious, so each plant has either male or female flower parts, not both [1]. Berries take 2 years to develop and mature (up to 3 years in subarctic) [2]. They begin to develop in the spring, but it is not until the following year that they become fertilized and develop into mature seed.

**Continental Range:** Present in all Canadian provinces[3]. This species is mostly restricted to northern and eastern states, as far south west as Wyoming, but is considered critically imperiled in NE, IA, IL, and east to NY, NH, and VT.

**HBL regional range:** Widespread and common in the Hudson Bay Lowlands[4].

**Habitat:** Common juniper grows in a distinct habitat, typically low to no organic material, in sandy, gravelly soils, rocky outcrops, limestone, and river shores[1].
It is commonly found growing near kinnickinnick (*Arctostaphylos uva-ursi*) and creeping juniper in HBL range; 0-1000 m.


Photo 2: Ripe cones (berries) of common juniper shrub.

## Reclamation value

**Nitrogen fixing:** No.

**Symbioses:** Arbuscular endomyorrhiza and ectomycorrhizal [5].

**Growth rate:** Slow [6].
**Successional stage:** Early [2].


Photo 3: Common juniper hand collection.

## Seed and propagule properties

**Fruit description:** Berries are actually cones**.** Round, 6 to 13mm diameter, bluish with a whitish covering [1].
**Dispersal:** Animal dispersed, likely by birds [7].
**Fruit weight:** (fresh) 96.3 mg [8].
**Seeds /propagule:** 2 to 3 seeds per berry [1].
**Seed size and description:** Seeds 4 to 5mm [1].
**Average seed weight:** (cleaned; air dried) 9.6mg [8], (filled seed) 15.1 to 18.7mg [2].
**Seeds/kg:** 68000 to 109000 [2].

## Seed Collection

**Timing collections:** Berries persist but can be easily protected from birds (their main dispersers) using netting. Check the seed lot quality and maturity using a cutting test to determine if seed is viable, look at multiple berries and check if seeds are still white and plump [9]. Select another collection area if seeds are highly parasitized or if berries are consistently empty. Collect berries from late August to November, berries will be plump and blue for the highest quality seed. Generally berries with the most seed fill are plump and bluish in colour compared to older wrinkled or immature green berries [9].

**Collection protocols:** Seed can be collected by hand using thick gloves to protect from sharp needles. We placed an open tray or container below a branch and ran our hands along the branch to detach berries. We were not overly selective of ripe or unripe berries, because this selection process would have made collection efforts less efficient. The berries do not detach easily from the plant, we found flailing branches was not an effective approach to harvesting. Place in refrigerator until ready to process.

**Collection effort:** (cleaned, dried seed) 55g/hour; approximately 550g of berries [10].

**Potential density:** In peak years up to 1000 cones/$m^2$ [11].

**Cautions:** Needles are quite sharp, use long, thick gloves to protect your hands while collecting.


Photo 4: Juniper berries being crushed on a threshing mat.

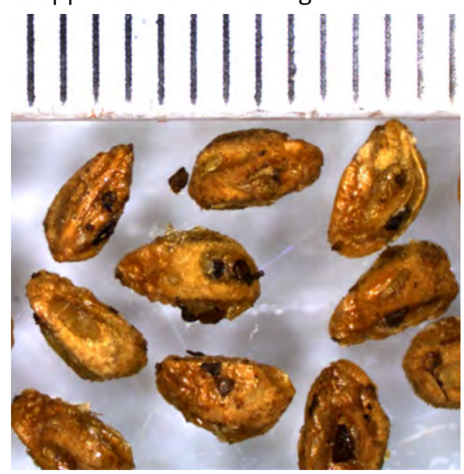
Photo 5: Common juniper seed.

## Seed Cleaning

**Processing protocols:** Crush berries on a corrugated rubber mat. Rinse the material into a bucket with water and discarded the floating material. Reserve the sunken material and allow it to dry. Seeds are threshed again and winnowed for a final cleaning. Seeds are loaded with resin glands and will make your equipment sticky. Alcohol can be used to wash the surfaces.

**Cautions:** None known.

## Seed Storage

**Storage behaviour:** Orthodox [12].

**Storage requirements and longevity:** Seeds can be stored dried at 10 to 12% moisture content, in sealed containers at cool temperature (1 to 5°C) [7]. Seed may remain viable for up to 10 years at 1 to 3°C in sealed containers [13].

## Seed Propagation

**Dormancy classification**: Physiological dormancy [13].

**Potential viability:** Variable, depending on the population, age of berries, and age of plant. Older berries tend to be more highly parasitized [9]. Plants approximately 10 years in age had approximately 70% seed fill, where as plants approximately 75 years of age had only 4% seed fill. Plump purple berries versus wrinkled older blue berries had 77% seed fill versus 17% seed fill respectively.

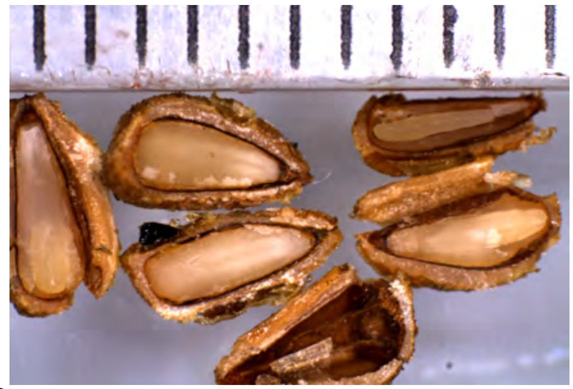
*Photo 6: Viable and non-viable "sinker" seeds of common juniper.*

**Pre-treatments:** Seed pre-treatments to break dormancy involve a period of warm stratification followed by a period of cool stratification. Place seeds into a warm-moist stratification at 15°C for 14 weeks. After 6 weeks, seeds should be removed and allowed to air dry at room temperature for 3 days and then returned to warm stratification for the remaining 8 weeks [14]. Seeds should then be placed into cool-moist stratification at 3°C for 12 weeks.

**Germination protocols:** Up to 80% germination following pretreatments described above. Seeds were placed on a sand-peat substrate. Temperate and light/ dark cycles were 8 hours at 15°C and 16 hours at 3°C. 41% germination at 5°C, 8/16 hours of light/dark respectively [12].

**Other propagation methods:** Stems cuttings have been used successfully for propagation of common juniper, but growth is slow [7]. Stem cutting from female plants treated with 8g/L IBA have had more rooting success than males [2]. Mulch improved survival rates of cuttings [15].

**Field planting:** Seed can be directly sowed in the fall, however seedling emergence will only occur in the second year [7].

**Canadian commercial sources for seed:** None known.

**Useful links and Further reading:**

http://www.nativeseednetwork.org/viewtaxon?taxon_code=JUCO6&release_name=

http://www.natureinthedales.org.uk/species/plants/juniper/mccartan-gosling-2013-guidelines-on-collection-juniper.pdf

Vegetative propagation: http://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=cupressaceae-juniperus-66

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# creeping juniper

Family: Cupressaceae

Scientific name: *Juniperus horizontalis* Moench

Cree Name: ___________

Synonyms: *Juniperus prostrata, etc*

Photo 1: Creeping juniper plant with ripe berries.

## Quick Seed Guide

**When and what to collect**: Collect blue berries in the fall. Hand collect onto a low tray or small sheet placed beneath the branches.

**Seed Processing**: Thresh berries on a corrugated rubber mat. Rinse, reserve only sunken materials. Dry, thresh and winnow.

**Storage:** Dry, cool in sealed containers for many years.

**Pre-treatment of seed:** Acid scarify for 60 min. Rinse seed for 48hrs, warm stratify for 60 days, then cool stratify for 90 days.

**How to Grow:** Seed: Germinate at cool temperatures 13 to 18°C (max.). Vegetative: Stem cuttings.

## General

**Plant Description:** Creeping juniper is a common ornamental plant used in landscaping. It is a coniferous shrub, but it grows along the ground providing a ground cover and the leaves remain green in all seasons [1]. The leaves are scale-like, resembling cedar in appearance, dark green. The leaves are soft to touch. Creeping juniper produces berries that are actually cones, with the distinct juniper smell when crushed.

**Field Identification:** Creeping juniper has unique leaf appearance; its horizontal growth and production of juniper berries make this species distinct.

**Life Form:** Evergreen perennial shrub, stems and leaves persist overwinter.

**Reproduction:** Dioecious; each plant has either male or female flowers, not both. Seed cones take two years to develop into mature seed [1]. Spreads vegetatively by layering [2].

**Continental Range:** Likely found in all Canadian provinces, but is considered imperiled in Prince Edward Island and Alaska [3]. This species is mostly restricted to north and eastern states as far south west as Wyoming, but is considered critically imperiled in much of the southern states where it occurs.

**HBL regional Range:** Widespread and abundant in the Hudson Bay Lowlands [4].

**Habitat:** Sand dunes, sandy and gravelly soils, prairies, slopes, rocky outcrops, and stream banks; 0-1000m [1].

## Reclamation value

Creeping juniper may be a useful species for rehabilitation of disturbed areas such as drylands or moderate slopes with high wind erosion and exposure [2,5]. This species provides a surface cover and is drought tolerant [5]. It tolerates a range of soil pH and low nutrient conditions, such as those of barren mine wastes [5].

**Nitrogen fixing:** No.

**Symbioses:** Forms an arbuscular mycorrhizal association with *Glomus fasciculatum* [6].

**Growth rate:** Moderate [7].

**Successional stage:** An early colonizer of disturbed habitats, but persists into late successional habitats that have low canopy coverage [2]. This species is shade-intolerant.

Photo 2: Creeping juniper plant growing across a rocky outcrop.

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## Seed and fruit properties

**Fruit description:** Berries are round, blue at maturity, 4 to 5mm diameter [1] containing 4 seeds on average, up to 6.
**Dispersal:** Animals, birds [2].
**Fruit weight:** 81mg fresh weight per berry.
**Seeds /propagule:** Four to 6 seeds per berry.
**Seed size and description:** Seeds are brown at maturity, smooth seed coat (no resin glands like common juniper). Seed about 4mm long x 2.5mm diameter.
**Average seed weight:** (cleaned, dried seed) 13.38mg [8].
**Seeds/kg:** 75 000 seeds/kg [8].

*Photo 3: Creeping juniper berries were full of larva that escaped the berries after being placed in a refrigerator.*

## Seed Collection

**Timing collections:** Berries ripen in September; they are still firm at maturity, but are blue in colour. If uncertain on the mature of the berry, cut it open to check for seed readiness and to monitor seed fill of a population. Immature berries are green.
**Collection protocols:** Berries of creeping juniper are found low to the ground. Collect berries by hand onto a tray with a short lip. If possible, lift the long productive branch onto a small sheet to collect berries more rapidly. Place berries into a plastic bag in the refrigerator until you are ready to process.
**Collection effort:** Seed fill was very poor for junipers in our region. Nearly half the seeds we collected were empty and not included in collection rates. One person collected an average of 46g pure, dry seed in one hour.
**Potential density:** No information found.
**Cautions:** None known.

## Propagule processing

**Processing protocols:** 1. Place berries on a corrugated rubber mat and thresh. Some sources recommend soaking berries first to soften the flesh, but we did not find this made processing easier. Berries will need to be threshed forcefully, but the seeds are very durable. 2. Rinse fully crushed material into a 5 gallon bucket and stir to separate floating (empty seeds) from filled seeds. 3. Allow the sunken material to dry on a paper towel. 4. Thresh the dried material to break apart. 5. Winnow to remove chaff. The berries can also be processed in a blender, but we found the blender often left several berries uncrushed and so threshing was required afterwards to fully remove seeds.
**Cautions:** None known.

*Photo 4: Creeping juniper 'sinkers'. This is the material that sank when placing the rushed berries in a bucket of water. Once dried, we can easily remove the impurities by winnowing.*

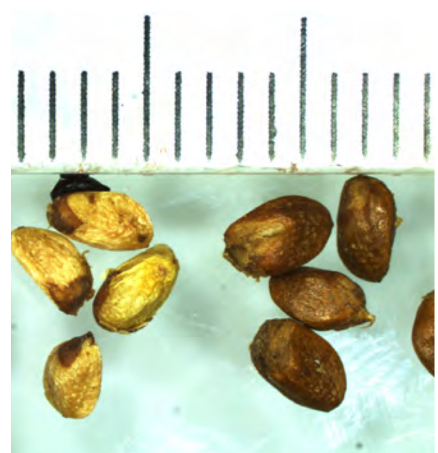

*Photo 5: Whole creeping juniper seed.*

## Storage

**Storage behaviour:** Not available for this species, however of the known Junipers (*Juniperus* ssp.) 100.00% are orthodox[8].
**Storage requirements and longevity:** Seed stores well when it is dried to 10 to 12% moisture content and kept in sealed containers at cool temperatures (between 1 to 5°C), the longevity is not described [9]. One author suggested seed remains viable for up to 10 years in sealed containers [10].

## Seed Propagation

**Dormancy classification:** Physiological dormancy[11].

**Potential viability:** Uncleaned seed lots had a viability of 14 to 48%, however seed cleaning will increase seed viability by removing empty seed.

**Pre-treatments:** One author recommends rinsing seed for 48 hours, then placing it in a 60 day warm stratification followed by a 90 day cool-moist stratification [10]. Acid scarification for 60 minutes prior to these pre-treatments may enhance germination success [9,10].

**Germination protocols:** Juniper seeds need cooler than typical temperatures to germinate. Germination will occur between 13 to 18°C, in conditions of light and dark [10].

**Other propagation methods:** Cuttings are the more common method of propagating creeping juniper, due to poor seed fill and poor germination of many juniper seeds and the successful rooting of juniper stem cuttings [2]. Semi-hardwood cuttings taken in May over 13cm long and treated with rooting hormone had 55% rooting success[10]. Cuttings taken in late summer, fall and winter are easy to root [9].

**Field planting:** Planted in fall to a depth of 0.6cm, with mulch for further protection [9].

*Photo 6: Sectioned creeping juniper seed. The two seeds on the left are not viable.*

## Other

**Canadian commercial sources:** None found.

**Useful links and Further reading:**

https://www.fs.fed.us/database/feis/plants/shrub/junhor/all.html#117

http://michiganflora.net/images.aspx?id=888

https://gobotany.newenglandwild.org/species/juniperus/horizontalis/

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# marsh vetchling

Family: Fabaceae

Scientific name: *Lathyrus palustris* L.

Cree Name: ___________

Synonyms: *Lathyrus myrtifolius, etc*

*Photo 1: Marsh*

## Quick Seed Guide

**When and what to collect**: Collect brown pea-like pods in the late summer to fall. Collect when they become papery, seed disperses quickly in hot and dry weather.
**Seed Processing**: Dry, thresh, sieve.
**Storage:** Probably a long-lived seed. Dry and store cool in sealed containers.
**Pre-treatment of seed:**
seed coat.
**How to Grow:** Seed: Germinate at 15°C to 21°C and roughly equal light and dark cycles.

## General

**Plant Description:** A perennial flowering legume that climbs other plants to reach a height up to 1m [1]. The stems are often winged and have narrow stipules at the nodes that resemble a butterfly. These stipules are an important identification trait of this plant from other similar species. The leaves often have 2 to 4 pairs of leaflets, 2 to 8cm long by 3 to 20mm wide. The flowers are pink to purple, each flowering head containing 2 to 6 flowers. The fruit are pods, similar to a garden pea but are brown to black when mature.
**Field Identification**: Marsh vetchling resembles the vetches (*Vicia* ssp.) and peas (*Lathyrus* ssp.). The stipules of marsh vetchling are between 5 to 20mm long, which is larger than most vetches; in addition its winged stem is unique to peas. The vetches typically have a 4-sided stem. **Similar species:** There are several similar species to marsh vetchling, however the combination of the number of leaflet pairs (2 or more), the winged stem and size of stipules, can be used to distinguish marsh vetchling from others. For an online identification key, refer to further reading below.
**Life Form:** Perennial forb, stems die back during winter months, the plant survives by buds at or below soil surface [2].
**Reproduction:** Reproduces by seed and underground rhizomes (pers. obs.).

**Continental Range:** Marsh vetchling is found in central and eastern provinces in Canada, west to Manitoba, becoming uncommon in Alberta and absent in the Yukon and Northwest Territories [3]. This species is found mostly in northeastern states, but has a patchy distribution that may be reflective of poor documentation for this species. Marsh vetchling is present in the following states: AK, CA, CT, DC, DE, GA, IA, ID, IL, IN, KY, MA, MD, ME, MI, MN, MO, NC, ND, NE, NH, NJ, NY, OH, OR, PA, RI, SD, TN, TX, VA, VT, WA, WI, WV.
**HBL regional Range:** Widespread to abundant in the Hudson Bay Lowlands [4].
**Habitat:** Common on shores and in wet meadows [1].

*Photo 2: Marsh vetchling plant, note the number of*

## Reclamation value

This species is considered a halophyte (has a high salt tolerance) [2].
**Nitrogen fixing:** Yes.
**Symbioses:** Other peas (*Lathyrus* spp.) species are commonly associated with vesicular arbuscular mycorrhiza [5]. Fixes nitrogen through a relationship with nitrogen-fixing bacteria *Rhizobium*.
**Growth rate:** No information found.
**Successional stage:** No information found.

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## Seed and fruit properties

**Fruit description:** Produces pea-like pods containing numerous seeds. Green when immature, turning brown to black at maturity.
**Dispersal:** Pods will split open when mature to release seed. *Lathryus japonicus* seeds are buoyant and can be transported by water [2].
**Propagule weight:** Dried whole pod weight ranged from 117.8mg to 148.2mg in our collections.
**Seeds /propagule:** Average of 4.5 seeds per pod in our collections.
**Seed size and description:** Seeds are brown to black at maturity, round, about 4mm diameter in our collections.
**Average seed weight:** (cleaned dry seed) 14.9mg [2].
**Seeds/kg:** 67 000 seeds/kg [2].


*Photo 3: Marsh vetchling pods ready for collection.*

## Seed Collection

**Timing collections:** In our region, seed pods begin to ripen at the end of August to mid-September. Seed pods change colour from green to brown or black, changing from fleshy to papery. If the weather is hot and dry, seed pods will mature more quickly.
**Collection protocols:** Seed pods can be collected by hand in the wild. Pull pods off the plant and place in buckets harnessed to the collector. Much of the time spent collecting is searching for pods. Pods should be laid out in thin layers to dry.
**Collection effort:** One person collected 1g to 7g of per dried seed in one hour. Collection rates were low due to poor seed production in our region.
**Potential density:** No information found.
**Cautions:** Despite this plant being a pea, the fruit is not edible for humans and can cause paralysis. It is safe to collect, but not for consumption [6].

## Propagule processing

**Processing protocols:** When material is dry, many pods open and release their seed. Thresh dried pods or a corrugated rubber surface, just enough to open any pods that have not split open. Sieve and winnow material to remove chaff.
**Cautions:** The seed is not edible for humans and can cause paralysis. It is safe to collect, but not for consumption.


*Photo 4: These marsh vetchling pods have been threshed and have opened to release the seed. The seed has fallen through to the lower sieve.*

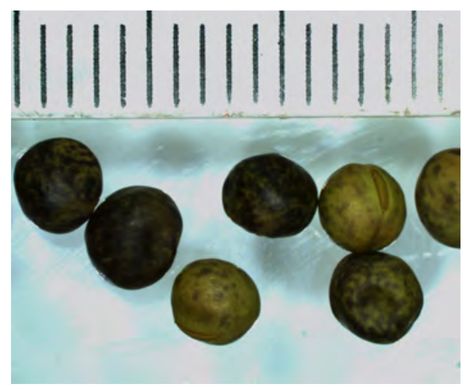
*Photo 5: Marsh vetchling whole seed.*

## Storage

**Storage behaviour:** Orthodox [2].
**Storage requirements and longevity:** This species has a hard seed coat and is long lived. Seed stored dry (6 to 10% moisture content) and frozen can be stored for at least 18 years without loss in viability [2].

## Seed Propagation

**Dormancy classification:** Physical [7].
**Potential viability:** Cleaned seeds in our collections had 97% viability on average. Any underdeveloped seed were removed by the cleaning process.
**Pre-treatments:** Seeds require scarification of the seed coat prior to germination. This can be done physically by rubbing seeds between sand paper or chipping at the seed coat, being careful not to penetrate the seed inside [7].

**Germination protocols:** Germination rates of 88 to 100% in laboratory conditions at temperatures from 15°C to 21°C and 12/12 hours or 8/16 hours light/dark cycles [2].
**Other propagation methods:** None found.
**Field planting:** No information found.

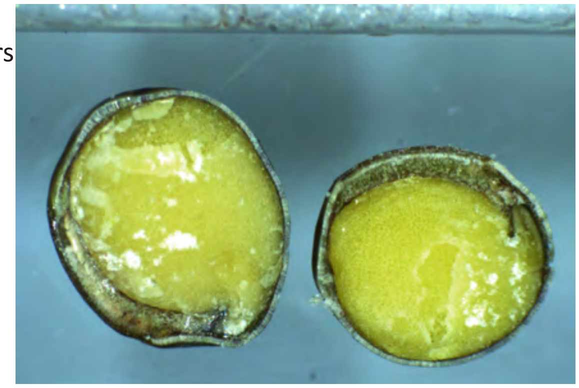

Photo 6: Sectioned marsh vetchling seed.

## Other

**Canadian commercial sources:** None found.
**Useful links and Further reading:**
Online identification key: http://michiganflora.net/genus.aspx?id=Lathyrus
https://gobotany.newenglandwild.org/species/lathyrus/palustris/
http://eol.org/pages/703976/overview
https://nativeplants.evergreen.ca/search/view-plant.php?ID=00981
https://www.prairiemoon.com/seeds/wildflowers-forbs/lathyrus-palustris-marsh-vetchling.html

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# star false Solomon’s-seal

Family: Asparagaceae

Scientific name: *Maianthemum stellatum* (L.) Link

Cree Name: ___________

Synonyms: *Smilacina stellata, etc*

Photo 1: Star false Solomon’ .

## Quick Seed Guide

**When and what to collect**: Berries ripen in the later summer to fall when they change from green and hard to red and soft. Collect using a hands free container.

**Seed Processing**: Thresh on corrugated rubber mat. Rinse, reserve sunken material. Dry, winnow.

**Storage:** Dry seed and store cool in sealed containers.

**Pre-treatment of seed:** Cool stratify for at least 100 days.

**How to Grow:** Seed: Germinate at 15°C or 20°C with 8/16 hours of light/ dark.

Vegetative: Rhizome cuttings taken in May.

## General

**Plant Description:** Star false Solomon’s seal is a flowering deciduous herb, reaching 15 to 50cm heights from single stem [1]. It occurs in colonies, due to its spreading by rhizomes. There are 8 to 11 leaves per stem that clasp the stem and are arranged alternately. The flowers are borne at the top of the plants, small and white continuing the alternate arrangement like the leaves. The berries, when immature, have a distinct stripping pattern, turning to a deep red at maturity.

**Field Identification:** This species has several alternating leaves along its stem, with obvious linear venation. **Similar species:** Unlike false Solonomon’s seal (*Maianthemum racemosum*), our species has an unbranching flower head and unlike false mayflower (*Maianthemum trifolium*) has more stem leaves (over 4).

**Life Form:** Deciduous perennial forb; dies back overwinter, but survives by rhizomes below the soil surface [2].

**Reproduction:** Rhizomes and seeds [1]. Flowering in the late spring to summer in our region.

**Continental Range:** Found in most of Canada, west to British Columbia and east to Newfoundland [3]. Populations in Nunavut and the Northwest Territories are unranked but critically imperiled in Alaska. This species is present throughout the United States, however its status is largely unknown. Populations as far south as Ohio, Arizona, and Illinois are possibly extirpated or critically imperiled.

**HBL regional Range:** Widespread and abundant in the Hudson Bay Lowlands [4]**.**

**Habitat:** Sand dunes, marginal woodlands, oak openings, also found in moist habitats such as riparian habitat and forest understories; 0-3200m[1,5].

Photo 2: Star false Solomon’s seal with unripe berries.

## Reclamation value

**Nitrogen fixing:** No.

**Symbioses:** Vesicular arbuscular mycorrhiza [6].

**Growth rate:** No information found.

**Successional stage:** Likely tolerant of a range of successional stages [5]. This species had a low cover post grazing, fire, or logging in northern Idaho. However, where we have seen this species, it tolerates moderate annual disturbance and only partial shading. A late successional species of dunes [5].

# star false Solomon's-seal

## Seed and fruit properties

**Fruit description:** When immature, berries are green with dark strips and hard, turning a deep red and softening when ripe.
**Dispersal:** Animals, birds [7].
**Propagule weight:** (dried whole berry) 67.0mg [8], (fresh whole berry) 306mg [7]. Fresh pulp:seed mass, roughly 7:1 [7].
**Seeds/ fruit:** Mean of 2.21 [7]. Range of 1 to 3 in our collections.
**Seed size and description:** Seeds round, about 3.5mm diameter. Light brown at maturity.
**Average seed weight:** (dried, clean seed) 12.0mg [8].
**Seeds/kg:** 83 000 seeds/kg for dried, clean seed [8].

*Photo 3: Ripe star false Solomon's seal berries on top, slightly unripe berries on bottom are okay for collecting.*

## Seed Collection

**Timing collections:** In our region, berries formed by August, but ripening was sporadic from August to September. Collections were most productive in September. Berries are quickly consumed once ripe. It is not efficient to protect plants with netting because they are typically spaced apart. Berries are red and soft when mature, however often a single plant with have both ripe and unripe berries. Some further ripening can occur in the refrigerator after several days.
**Collection protocols:** Collect berries by hand into buckets wrapped around the collector. Plants are well spaced apart and most of the collection time is spent searching for productive plants. Keep berries in a plastic bag to allow further berry ripening, which improves seed processing.
**Collection effort:** One collector picked an average of 11g pure dry seed in one hour.
**Potential density:** No information found.
**Cautions:** None known.

*Photo 4: Processed star false Solomon's seal berries. Once dry they can be winnowed for further cleaning.*

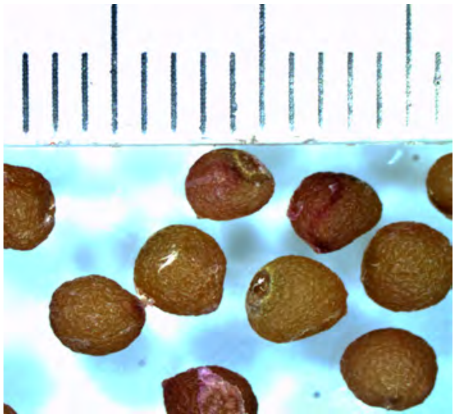

*Photo 5: Whole star false Solomon's seal seed.*

## Propagule processing

**Processing protocols:** Crush berries on a corrugated rubber mat using a threshing paddle. Rinse into a 5 gallon bucket and float off pulp and empty seed. Reserve sunken material and set out on paper towels to dry. Any pulp or remaining impurities can be winnowed once seed is dry. Alternatively, berries can be cleaned using a blender, but take caution to avoid damaging seed by dulling the blender blades and only blending in short pulses.
**Cautions:** None known.

## Storage

**Storage behaviour:** Orthodox [2].
**Storage requirements and longevity:** For short-term storage of orthodox seed, dry seed well and place in cool conditions (1 to 5°C) in sealed containers. Uncertain on longevity.

## Seed Propagation

**Dormancy classification:** Morphophysiological dormancy [9].
**Potential viability:** Cleaned seed from our collections had an average of 95% viability.

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**Pre-treatments:** In the natural environment this species takes 2 years to germinate (winter, summer, winter, germinating in the spring). At maturity this species has an underdeveloped embryo, embryo growth occurs during warm conditions. Seeds should be cool-moist stratified for at least 100 days, but up to 1 year may improve germination percentages [10]. Seed placed in cool-moist stratification for only 6 weeks (5 to 10°C) had high germination percentages [2].

**Germination protocols:** Up to 95% germination for seeds germinated on a moist medium 15°C or 20°C with 8/16 hours of light/dark [2]. It is unclear, if seed needs to be returned to cool conditions for full emergence of the seedling. Seed germination may be delayed while embryo development occurs during warm conditions.

**Other propagation methods:** This species is also propagated by rhizome cuttings approximately 20cm in length, taken in June [10].

**Field planting:** No information found.

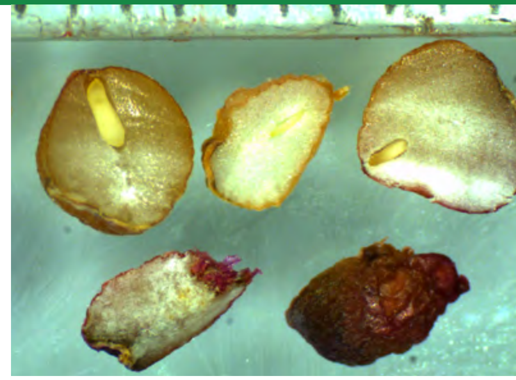

*Photo 6: Sectioned star false Solomon's-seal seed.*

## Other

**Canadian commercial sources:**

http://botanicallyinclined.org/seeds-shop/maianthemum-stellatum-buy-seeds/

http://www.wildaboutflowers.ca/plant_detail.php?Star-Flowered-False-Solomon-s-Seal-86

**Useful links and Further reading:**

https://www.fs.fed.us/database/feis/plants/forb/maiste/all.html#21

https://gobotany.newenglandwild.org/species/maianthemum/stellatum/

http://www.wildflower.org/plants/result.php?id_plant=MAST4

https://www.prairiemoon.com/plants/bare-root/wildflowers-forbs/smilacina-stellata-starry-solomons-plume.html

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# tall bluebells

Family: Boraginaceae

Scientific name: *Mertensia paniculata* (Aiton) G. Don

Cree Name: ___________

Synonyms: *4 recognized varieties*

*Photo 1: Tall bluebells stand*

## Quick Seed Guide

**When and what to collect**: In late August seeds ripen, changing colour from green to yellow or brown. Clip entire seed head using scissors or pull off by hand.
**Seed Processing**: Dry, thresh, winnow.
**Storage:** Dry seed, store in sealed containers and cool conditions.
**Pre-treatment of seed:** Cool stratify for over 12 weeks,

**How to Grow:** Seed: Germinate at 14/8°C for 18/6hours of light/dark. Expect about 40% germination rates. Vegetative: Divide plants in the spring.

## General

**Plant Description:** A perennial flower 20 to 60cm in height [1]. Tall bluebells has two growth forms, one made up of basal leaves and no flowering stem (often in forest or shaded habitats) and a second form which grows tall and produces a flowering stem (often in well exposed sites or forest openings). Basal leaves are large, rounded at the base and pointed to the tip. The leaves are densely covered by fine short hairs. The second form, has stems also covered in dense hairs. The leaves along the stem are alternate, prominently veined, 5 to 14cm long, similar in shape to the basal leaves attached by a long winged stalk. Flowers are borne at the top of the stem, blue in colour, hanging like small bells by a long stalk.
**Field Identification:** Tall bluebells can be identified by a combination of features: its bell-shaped flower, hairy leaves and stem, prominent leaf veins, and the winged leaf stalk. **Similar species:** Before flowering, tall bluebells may be confused with large-leaf aster (*Eurybia macrophylla*) or Lindley's aster (*Symphyotrichum ciliolatum*). Their leaves are very similar in appearance and size, but they are easily distinguished by their different flowers.
**Life Form:** A perennial forb; stems die back during the winter months, surviving by an underground rhizome below the soil surface [2].
**Reproduction:** Seeds and clonal reproduction by underground rhizomes [3]. In northern environments this species may favour clonal reproduction over seed regeneration [3].

**Continental Range:** Found in all north and western provinces and Alaska, east to Quebec, where the populations are considered vulnerable [4]. Not present in the Maritime provinces. Also restricted to the northern most states, where the status is largely not ranked.
**HBL regional Range:** Widespread to occasional in the Hudson bay Lowlands [5].
**Habitat:** Common in boreal forests, in particular balsam-fir communities with aspen and white spruce communities [2,6]. Also found on disturbed, high light exposure sites such as river shorelines [6] and along roadsides (per. obs.).

*Photo 2: Tall bluebell plant, erect growth form.*

# tall bluebells

## Reclamation value


Photo 3: Tall bluebells developing seed.

Tall bluebells tolerate a range of successional stages, being present in mature and newly disturbed sites [6]. This species reproduces clonally through underground rhizomes and may be a useful understory species to include early in the restoration of disturbed sites in the north. This species was successfully established from nursery stock into a moderately disturbed site in Alaska [2].
**Nitrogen fixing:** No.
**Symbioses:** Vesicular arbuscular mycorrhiza [7].
**Growth rate:** Fast. Grows quickly following clipping [8] and post-fire [2].
**Successional stage:** Tall bluebells is shade tolerant and persists in all successional stages, perhaps most common in mid-succession[2]. Following fire in Alaska, this species increased in cover and frequency over time into 120 year old white-spruce forests, but was absent in 220 year old or climax spruce forest in Alaska.

## Seed and propagule properties

**Propagule description:** Fruit are nutlets. Each containing a single seed. Green turning yellow to dark brown at maturity.
**Dispersal:** Possibly by ants [9].
**Seeds/ propagule:** Up to 4 per flower. Only one seed per nutlet.
**Seed size and description:** Nutlets are treated as seeds.
**Average seed weight:** No information found.
**Seeds/kg:** No information found.

## Seed Collection

**Timing collections:** Seeds are ripe in August to September in northern Alberta [10]. In our region, seeds begin to disperse by the middle of August. Seeds are large and plump, yellow to light brown at maturity. Plants in shaded habitats do not commonly produce seed. Plants are difficult to find after flowering, so mark productive stands early in the season when plants are flowering. Seeds do not persist once mature.
**Collection protocols:** The seed heads can be clipped using scissors or pulled off by hand into a collection bucket. Place plant material on trays or paper bags for drying. We found only a single plant that produced seed after flowering in our region.
**Collection effort:** Not determined.
**Potential density:** No information found.
**Cautions:** None known.

## Propagule processing

**Processing protocols:** We were unable to collect sufficient quantities of seed for testing cleaning protocols. After drying, seeds may be separated by a gentle threshing on a corrugated rubber surface. Winnow to remove chaff.
**Cautions:** None known.

## Storage

**Storage behaviour:** Not available for this species, however of the known bluebells (*Mertensia* spp.), 100% have orthodox seed.
**Storage requirements and longevity:** Uncertain. Best practices for short-term storage of orthodox seed is to dry seed well and place in sealed containers in cool conditions (1 to 5°C) such as a refrigerator.

## Seed Propagation

**Dormancy classification:** Related species of bluebells (*Mertensia* spp.) have a physiological seed dormancy [9].
**Potential viability:** Not determined.
**Pre-treatments:** Seeds of other bluebells require a cool-moist stratification [9]. Germination of *Mertensia maritima*, was highest when seed was cool stratified for a period of 12 weeks and the seed coat was damaged by crushing and tearing at the surface [11].
**Germination protocols:** Other bluebells have shown moderate germination percentages at +/- 40%, grown at 14/8°C for 18/6 hours light/ dark [11]. One author suggests planting seed fresh (without drying) will reduce their dormancy, which may improve germination percentages [12].
**Other propagation methods:** Virginia bluebells (*Mertensis virginiana*) is propagated by divisions [13]. Rhizomes are carefully divided in the fall when plants are dormant and planted in a moist potting soil.
**Field planting:** No information found.

## Other

**Canadian commercial sources:**
http://www.wildaboutflowers.ca/plant_detail.php?Tall-Bluebells-64
**Useful links and Further reading:**
https://plants.usda.gov/core/profile?symbol=MEPA
https://www.acrre.ualberta.ca/Portals/14/ACRREDocuments/Mertensia_paniculata.pdf
https://www.minnesotawildflowers.info/flower/northern-bluebells
http://ontariowildflowers.com/main/species.php?id=254

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13. Phillips, H. *Growing and Propagating Wild Flowers*. (The University of North Carolina Press, 1985).

# common ninebark

Family: Rosaceae

Scientific name: *Physocarpus opulifolius* (L.) Maxim.

Cree Name: ___________

Synonyms: *Opulaster alabamensis, etc.*

*Photo 1: Common ninebark shrub. It is hard to mistaken this plant for another species when it has its bright red husks.*

## Quick Seed Guide

**When and what to collect**: Seeds ripen in August to September when husks turn red to brown and papery. Collect by hand, with a hands free container.

**Seed Processing**: Thresh fresh husks to minimize dust.

**Storage:** Dry seed and store in sealed containers at (3 to 5°C) for up to 3 years.

**Pre-treatment of seed:**

**How to Grow:** Seed: Germinate at 25/10°C and 8/16 hours of light/ dark. Vegetative: Stem cuttings taken in July and treated with rooting hormone can be rooted.

## General

**Plant Description:** A deciduous shrub often found in dense thickets, 1 to 3m in height [1]. The branching pattern is alternate. The bark is brown to orange in colour and peeling. The leaves are 3-lobed, 6 to 8.5cm long by 4 to 7cm wide, from a 1 to 3cm stalk. Leaf margins are unequally toothed. The flowering heads are round, made up of 30 to 50 white flowers. The flowers have 5 petals and are 7 to 10mm in diameter. The stamens (the male flower parts) often extend beyond the petals making the flowers appear 'hairy' (photo 2). The fruit is husk-like made of 3 to 5 compartments called follicles, each containing 2 seeds. The follicles turn from a green-yellow to a bright red-brown at maturity [1,2].

**Field Identification:** The leaf appearance and growth of common ninebark may resemble many common shrubs, however the flowers and mature fruits of this species make it distinct from others. **Similar species:** Common ninebark does not overlap in its range with other ninebarks (*Physocarpus* ssp.) [3]. The leaves and growth of common ninebark resembles those of currants and gooseberries, but are easily distinguished by their showy flowers and husk-like fruit.

**Life Form:** A perennial deciduous shrub; has a woody stem that persists through all seasons and buds are above ground [4].

**Reproduction:** Reproduces naturally by seed. Flowering from May to June; fruiting July to September [1]. Also reproduces vegetatively and one author reported a mean of 10 to 30cm between stems [5]. A similar more western species, mountain ninebark (*Physocarpus malvaceus*) reproduces via rhizomes [6].

**Continental range:** Common ninebark is found as far west as Manitoba, east to Nova Scotia, but not in Newfoundland and Labrador [3,7]. Populations are secure in Ontario and Quebec [7]. Also distributed through much of central and eastern United States, west to Colorado and south to Florida where the population is considered critically imperiled [7].

**HBL regional range:** Restricted to the southern interior (non-coastal) regions of the Hudson Bay Lowlands, occasional [8].

**Habitat:** Tolerates a variety of soil types and alkalinity, prefers open habitats in full sun, rocky banks and lake shores, moist woods, 0-1300 m [1,2].

*. Note the long stamens*

.

## Reclamation value

**Nitrogen fixing:** No.

**Symbioses:** Arbuscular mycorrhiza [9].

**Growth rate:** Slow [3].
**Successional stage**: Uncertain. Likely tolerant of early successional conditions, due to its habitat tolerances and shade intolerance [1,10].

Photo 3: Collecting ripe common ninebark husks into a hands free collection container.

## Seed and fruit properties

**Fruit description:** Husk-like fruit, made of 3 to 5 follicles, turning from green to brown or red at maturity.
**Dispersal:** Uncertain. Seeds have no apparent appendages, follicles split open to release seed, but further dispersal is not described.
**Seeds /propagule:** Two seeds per follicle; 6 to 10 per husk.
**Seed size and description:** Seeds generally pear-shaped, about 2mm long x 1mm in diameter.
**Average seed weight:** (cleaned dried seed) 0.46mg [5].
**Seeds/kg:** 2.17 million seeds/kg.

## Seed Collection

**Timing collections:** Seed follicles (papery pods containing seeds) will turn red to brown at maturity. In the HBL, this was about the end of August to early September. To confirm seed readiness, open up the follicle and look for a small seed that is light brown in colour, firm and plump. Follicles will open to release seed, but they may persist for a couple of weeks before opening, depending on the weather. Our collections had high rates of seed parasitism and some populations were worse than others; check seeds prior to collecting for bore holes and if possible avoid highly parasitized populations.
**Collection protocols:** Seeds follicles are often abundant. Use a collection container that is wrapped around your body, such as a bucket with a strap so you can have both hand free for collecting. Pull follicles off the plant in clumps into your container, the collector should wear gloves to avoid damaging his or her hands. If possible, try to process fruits before drying. If this is not possible, set material out to dry.
**Collection effort:** Due to high rates of parasitized or empty seeds our collection rates were low. As a rough estimate, over 50% of seeds in some collections were empty. One collector picked 46g of dried, pure seed in one hour with a range of 28g to 81g per hour.
**Potential density:** No information found.
**Cautions:** None known.

## Propagule processing

**Processing protocols:** Thresh the husk when they are fresh to reduce the dust created from dried husks. If you are unable to process the follicles when they are fresh, dry them but wear a mask. Thresh on a corrugated rubber mat, seeds fall in between the ridges. Pour this material through stacked sieves (Mesh sizes top to bottom: #5, #10, #18, #35, bottom pan) and the seed stays in #18 or #35 sieves. Unopened follicles, from the top sieve can be returned to the threshing mat for a second processing. Winnow seeds across a low air flow to remove leaves and empty seed.
**Cautions:** Wear a mask; crushed follicles create a lot of dust that may cause respiratory discomfort.

Photo 4: Threshing common ninebark husks to release seed.

## Storage

**Storage behaviour:** Orthodox [4].
**Storage requirements and longevity:** Seeds may maintain viability if stored in sealed containers with a mix of moistened perlite and vermiculite and kept cool (3 to 5°C) for up to 3 years. Another author found seeds dried to 8% moisture content could be kept for up to 5 years at -18°C in sealed containers [11]. Our seeds were eaten by insects when stored dry and cool (3 to 5°C) in envelopes. Store dry seed in sealed containers to reduce concerns from pests in storage.

## Seed Propagation

**Dormancy classification:** Uncertain, benefits from cool-stratification [12] so may exhibit physiological dormancy.
**Potential viability:** Cleaned seeds from our collections had a viability of 40 to 74%.
**Pre-treatments:** Seeds of common ninebark benefit from cool-moist stratification [12] for 90 to 150 days [13]. Some sources reported no pre-treatment is required for seed germination [2,4].
**Germination protocols:** Seeds may germinate well (81%) on a moist medium at 25/10°C and 8/16 hours light/ dark cycles [4].
**Other propagation methods:** Stem cuttings are commonly used to propagate this species [2,9,14]. Cuttings are taken in July, over 15cm long and treated with rooting hormone. They are rooted in a perlite medium [14].
**Field planting:** Untreated seeds can be sown in the fall [11,12]. One author reports planting rates of approximately 0.45kg of seed in 98m$^2$ (1770 seeds in a linear meter) will result in 110 to 130 seedlings per m$^2$.


*Photo 5: Common ninebark seed.*

## Other

**Canadian commercial sources:** Many seed cultivars available online. No native wild sources found in Canada.
**Useful links and Further reading:**
https://gobotany.newenglandwild.org/species/physocarpus/opulifolius/
https://www.wildflower.org/plants/result.php?id_plant=phop
https://www.prairiemoon.com/seeds/trees-shrubs-vines/physocarpus-opulifolius-prairie-ninebark.html

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9. Matysiak, B. & Falkowski, G. Response of three ornamental plant species to inoculation with arbuscular mycorrhizal fungi depending on compost addition to peat substrate and the rate of controlled release fertilizer. *J. Fruit Ornam. Plant Res.* **18,** 321–333 (2010).
10. Garrah, K. L. Upland ecosystems in the Hudson Bay Lowlands provide reference conditions for the reclamation of mine waste stockpiles. (MSc. thesis, Laurentian University, 2013).
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# white spruce

Family: Pinaceae

Scientific name: *Picea glauca* (Moench) Voss

Cree Name: ___________

Synonyms: *Picea canadensis var. glauca, etc.*

Photo 1: Young white spruce stand.

## Quick Seed Guide

**When and what to collect**: Seeds ripen in the late summer, collect cones before the scales have opened. Collecting cones is a challenge, refer to seed collection below.

**Seed Processing**: Dry in warm temperatures to open scales. Shake cones to release seed. Sieve. Thresh to break wings off seeds. Winnow.

**Storage:** Store dry seed in sealed containers at 2 to 4°C for many years.

**Pre-treatment of seed:** Cool-moist stratify for 21 days.

**How to Grow:** Seed: Optimal germination is between 12.8°C and 23.9°C, light required.

## General

**Plant Description:** White spruce is a common coniferous tree that can reach a height of 30m [1]. The shape of the tree is conic, like a Christmas tree. The bark is a gray-brown, becoming deeply furrowed with age. The twigs themselves (beneath needles) are pinkish brown to tan and are hairless. The leaves are short pointed needles (uncomfortable to grab with bare hands), bluish-green, 1.5 to 2cm long, 4-angled in cross section. The cones are generally at the top of the tree, typically 2.5 to 6cm long.

**Field Identification:** The overall shape of this tree, the short stout needles, and the cones can be used to distinguish this tree from other conifers. **Similar species**: Black spruce (*Picea mariana*) can be distinguished by its more slender growth. Its twigs are covered in fine dense hairs and its cones are much shorter and rounder than white spruce. Balsam fir (*Abies balsamea*) may be confused for white spruce, but its needles are flat and soft to touch, the bark is not furrowed like white spruce and may have several swollen blisters containing a fragrant sap. Norway spruce (*Picea abies*) is an introduced species that may be planted in towns throughout Ontario and eastern Canada [2], its cones are much longer than white spruce cones.

**Life Form:** Coniferous tree; stems and needles persist year-round, buds are above the ground.

**Reproduction:** This species is monoecious, it has separate male and female cones on one plant [3]. Trees will begin to produce cones after 15 to 30 years of age. White spruce also reproduces by layering from lower branches, especially in northern climates. The seed and cone production is rather complex, the process takes two years, beginning with the formation of male and female buds in July. The following spring flowering occurs; the female buds are erect and the scales are spreading open to receive the pollen. Once pollinated the buds start to hang and develop into cones, maturing in the fall [3]. Female cones are mostly situated near the tops of the tree.

**Continental Range:** Secure in all Canadian provinces, except in Nunavut where the population is not ranked [4]. White spruce is restricted to northern states in the United States.

**HBL regional Range:** Widespread and abundant in the Hudson Bay Lowlands [5].

**Habitat:** Lowland forests, recovering farm fields, bogs, river banks and slopes. Well drained soils. Tolerates a high range in soil pH; 0-1000m [1,6].

Photo 2: A fallen white spruce tree. This tree was still living so we were able to harvest cones from it without special equipment and so we did not need to cut a healthy tree.

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# white spruce

Photo 3: White spruce cones have open following drying in a heated room. Cones can be tumbled or shaken to release their seed. We used a garbage container, but any large container will serve the purpose.

## Reclamation value

White spruce has been planted on coal-mine sites in Alberta and Alaska and is a common natural colonizer of abandoned agricultural fields [6].

**Nitrogen fixing:** No.

**Symbioses:** Ectomycorrhizal (ECM) [7]; *Thelephora americana* and *Amphinema byssoides* were the dominant species of ECM in container seedlings. In addition there may be endomycorrhiza that can associate with the seedlings similar to ericoid mycorrhizae [8,9].

**Growth rate:** Slow [2].

**Successional stage:** Early, middle, and late [3,6]. White spruce can establish on recently disturbed sites, but persists for many years and becomes a dominating cover species as early successional trees die off [3,6].

## Seed and cone properties

**Cone description:** Cones are 3 to 6cm long [1], located at the top of the tree and contain numerous seeds.

**Dispersal:** Wind [3].

**Propagule weight:** (dried, winged seed) 2.25mg [10].

**Seeds/ cone:** A wide range from 32 to 130 [3,11].

**Seed size and description:** Seeds are 2.5mm by 2mm wide, with the attached wing, up to 10mm long [1].

**Average seed weight:** (clean, dried seed) 1.52mg [10].

**Seeds/kg:** 658 000 seeds/kg [10].

Photo 4: Seeds were poured over a rack with a large opening, escaped seed and cones are sieved

seeds are ready for threshing.

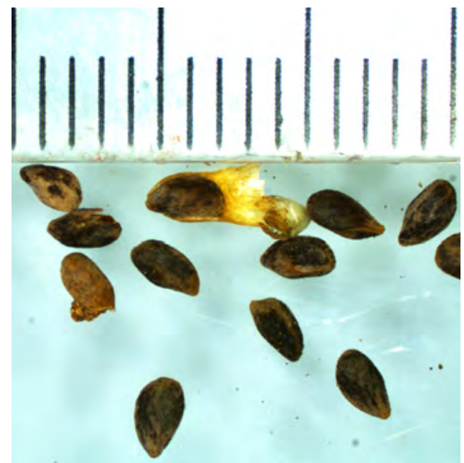

Photo 5: Whole white spruce seed following cleaning.

## Seed Collection

**Timing collections:** Cones ripen at the end of August to early September in our region. Cones should be collected abuot 1-2 weeks before the scales open[3], about the middle to the end of August. Although the cones can persist for years, seed dispersal occurs over a 10 day period and is dependent on moisture [3,11]. Cones open more quickly when the weather is dry, if the weather is damp or cold the cones may remain closed which will slow down increase the seed dispersal. Good seed years apparently occur every 2 to 12 years, however every year trees will produce some cones.

**Collection protocols:** Collecting cones from white spruce is a challenge because cones occur at the top of the tree and are not easily reached by pole pruners. For small quantities, pole pruners are sufficient. Cutting a tree down presents the safest opportunity for cone collection. If possible, partner with someone that is harvesting wood for lumber or firewood in the late summer, because the branches are usually left behind. Another option is collecting from **fresh** squirrel caches if you can find them. The cones from the cache must be recent or else the seeds will have poor viability. Place cones immediately for drying, or store cold (1 to 5°C) for a few days if you are shipping cones to a processing facility.

**Collection effort:** Collection effort is high for this species, but can be improved with a good partnership from those harvesting white spruce for lumber or fire wood. We collected approximately 62g of pure dry seed in one hour.

**Potential density:** Seed rain density ranged from 440 to 3700 seeds/m$^2$ depending on the year [12].

**Cautions:** Follow required safety precautions and use appropriate safety equipment if you are cutting down trees.

## Propagule processing

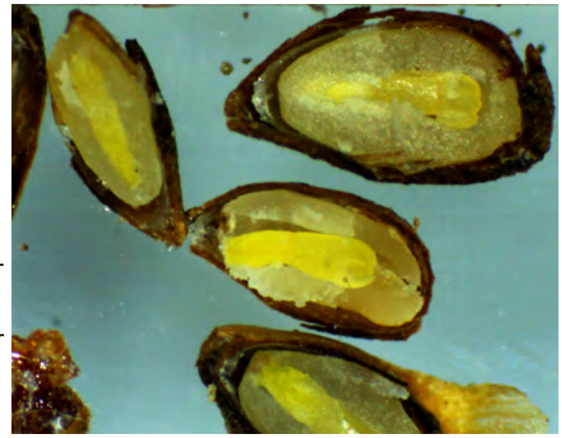

Photo 6: Sectioned white spruce seed.

**Processing protocols:** Immediately place cones on racks or trays in thin layers for drying. Separate as many cones as possible from the branches, because the needles are a similar size and weight and are difficult to separate from the seeds later. Cones will require some heat to allow the scales to open [13], seeds of white spruce tolerate up to 49°C for short periods, but will be damaged at temperatures above 56°C [14]. 1. Once the scales have opened, the cones can be tumbled to release the seed. We placed our cones in a large garbage container with a lid and shook it for approximately 1 minute. 2. Pour cones into a sieve or over a large rack with a 2cm opening to separate seeds from cones. Recover the cones and shake them again to ensure most seeds are freed. 3. Gently thresh seeds on a corrugated rubber mat to break the wings. 4. Winnow the material to remove the wings from our final seed lot.
**Cautions:** None known.

## Storage

**Storage behaviour:** Orthodox [15].
**Storage requirements and longevity:** Seed that is well dried (3.6 to 8% moisture content) can maintain its viability for up to 20 years in sealed containers at 2 to 4°C [16,17].

## Seed Propagation

**Dormancy classification:** Non-dormant [18].
**Potential viability**: Variable: 29 to 82% [11,12].
**Pre-treatments:** Some seed provenances may show some dormancy, such as Ontario populations, therefore stratifying seed at 2 to 4°C for 21 days can improve germination success [19].
**Germination protocols:** Optimal germination temperature for this species is between 12.8°C and 23.9°C [20]. Germination begins about 4 days after planting and is mostly complete after 28 days. Seed from Moosonee, ON, has optimal germination percentages at 12.8°C and 15.5°C, but the onset of germination is delayed compared to warmer temperatures. The species requires light for germination [14].
**Other propagation methods:** None found.
**Field planting:** White spruce seed apparently germinates better on exposed mineral soils than thick organic soils, but moisture must be adequate for the survival of seedlings (reviewed in [6]). Seeds will germinate in the spring when conditions are favourable. It may be best to plant seeds in the early spring (March to April depending on your region) following pre-treatments so seeds are not damaged from winter frost and will germinate when conditions are suitable. Sow to a depth of 0.5cm [14].

## Other

**Canadian commercial sources:**
https://www.ontario.ca/page/buy-ontario-tree-seeds-or-cones
**Useful links and Further reading:**
https://gobotany.newenglandwild.org/species/picea/glauca/
https://www.fs.fed.us/database/feis/plants/tree/picgla/all.html#197
https://www.na.fs.fed.us/spfo/pubs/silvics_manual/Volume_1/picea/glauca.htm
https://plants.usda.gov/plantguide/pdf/pg_pigl.pdf

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# black spruce

Family: Pinaceae

Scientific name: *Picea mariana* (Mill.) Britton, Sterns & Poggenb. Cree Name: ___________

Synonyms: *Abies mariana, etc.*

*Photo 1: Black spruce stand, note the thin trees with a heavy load of cones at the top.*

### Quick Seed Guide

**When and what to collect**: Seed collection can occur from fall until spring. A tree may need to be cut down to access seed located at the crown. Refer to seed collection for more information.
**Seed Processing**: Complex, refer to seed processing.
**Storage:** Dried seed stored in sealed containers at 2 to 4°C can remain viable for over 5 years.
**Pre-treatment of seed:** Cool stratify for 24 days.
**How to Grow:** Seed: Germinate at 20°C and 8/16 hours of light/dark. Seed begins to germinate after 5 days.

## General

**Plant Description:** A coniferous tree that can reach 25m in height [1]. The shape of the tree is narrowly conic, due to the drooping of the branches. The bark is greyish-brown and scaly, the inner bark is a unique olive-green colour. The new growth (twig) is yellow-brown, and covered in small fine hairs. The leaves are needles, blue-green, sharp tipped 0.6 to 1.5cm long, 4-sided in cross section. The seed cones are 1.5 to 2.5cm long, generally egg-shaped, and borne near the top of the tree.
**Field Identification:** Black spruce is first recognized by its tall, skinny growth, often straggling appearance. The needles are short, uncomfortable to touch and grow out of the twig in all directions. **Similar species:** White spruce (*Picea glauca*) has longer, thinner cones and has no fine hairs on the new growth of the branches.
**Life Form:** Coniferous tree, a woody stem and leaves that persist year-round.
**Reproduction:** This species reproduces by seeds, layering, and sprouting from the root crown [2]. Trees are monoecious so they have separate male and female cones on every tree. Meaningful cone production occurs after 30 years [3], but can begin at an earlier age. Good cone crops are produced every 2 to 4 years, but some cone production occurs every year [2].

**Continental Range:** Found in all Canadian provinces and Alaska [4]. Populations in the United States are restricted to north-eastern states.
**HBL regional Range:** Widespread and abundant in the Hudson Bay Lowlands [5].
**Habitat:** Found in a range of habitats including well-drained open sites and poorly drained muskegs and swamps; 0-1500m [1,2]. This tree grows faster and taller in open well-drained sites.

*Photo 2: (right to left) Black spruce cone, scales, winged seed, and cleaned seed.*

## Reclamation value

A valuable species for revegetation in northern climates. May be suitable for abandoned peat-mines, or roads and was established on disturbed sites following direct seeding and transplanting [2].
**Nitrogen fixing:** No.
**Symbioses:** Ectomycorrhizal [6,7].
**Growth rate:** Slow [2,8].
**Successional stage:** Present in all stages of succession in the boreal forest, intermediate in its tolerance to shade [2]. Black spruce establishes well after fire disturbances, because the resinous covering on the cones is burned off and allows for the seeds to be released quickly and the fire prepares the soil surface for black spruce establishment [2].

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# black spruce

## Seed and cone properties

**Cone description:** Cones are usually 1.5 to 2.5 cm long, generally egg-shaped [1]. They are purplish-brown and contain numerous seeds. They are called semi-serotinous because they are covered by a resinous material that seals the cone.
**Dispersal:** Seed dispersed by wind [3].
**Propagule weight:** (dried, winged seed) 0.98mg [9].
**Seeds/ cone:** One author reported 7.3 to 14.4 seeds/cone on average near Cochrane Ontario [3], however another source reported a maximum of 78 seeds/cone in Alaska (cited in [2]).
**Seed size and description:** Seeds are black at maturity, with a long thin wing. Winged seeds are about 7mm long or if de-winged are about 2.5mm long x 1mm wide.
**Average seed weight:** (de-winged, dried seed) 0.97mg [9].
**Seeds/kg:** Approximately one million seeds/ kg [9].


Photo 3: Black spruce cones taken from a squirrel cache. This cache was old and had very low seed viability. Collect from a cache only if you are certain it is fresh.

## Seed Collection

**Timing collections:** Black spruce cones are semi-serotinous so they release their seeds slowly over several years. Approximately 50% of the seeds remain in cones 5 years after maturity in northeastern Ontario [3]. Cone collection is best accomplished from August up until the following spring. The highest seed volume and seed viability will be from cones under two years old [3]. Seed dispersal is greatest in the spring.
**Collection protocols:** Collecting cones from black spruce is a challenge because cones occur at the top of the tree and are not easily reached by pole pruners. For small quantities, pole pruners are sufficient. Cutting a tree down presents the safest opportunity for cone collection. If possible, partner with someone that is harvesting wood for lumber or firewood in the late summer, because the branches are usually left behind. Collectors cover their hands in an oily substance such as vegetable oil or lard to avoid the cones from sticking to their hands [10]. Another option is collecting from **fresh** squirrel caches if you can find them. The cones from the cache must be recent or the seeds will have poor viability. Place cones immediately for drying, or store cold (1 to 5°C) for a few days if you are shipping cones to a processing facility.
**Collection effort:** High.
**Potential density:** Potential of 7,474 cones per tree [3], 1 to 4.9 million seeds/ha from a northern Ontario population.
**Cautions:** None known. Follow precautions for cutting trees and ensure you are properly trained to use equipment.

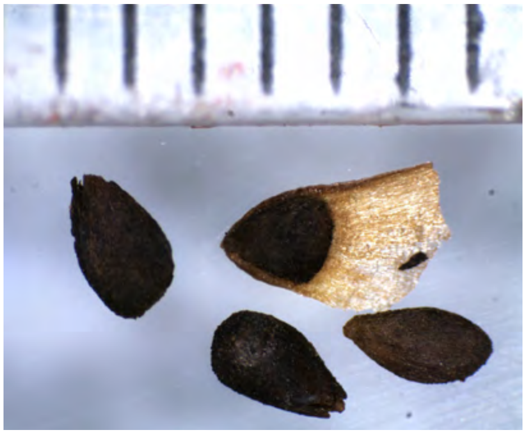
Photo 4: Black spruce whole seed.

## Propagule processing

**Processing protocols:** Black spruce cones need to be processed immediately after their collection. As a minimum, lay cones out in a thin layer in a warm dry room (seed tolerates up to 84°C for brief periods). Separate the cones from the branches and needles as much as possible because they are difficult to separate from the seed later. Black spruce cone processing is fairly laborious. These are methods described by Young and Young (1992) in detail. 1. Soak cones in water for 3 to 4 hours, then dry at room temperature for 20 minutes. 2. Heat cones in a kiln or oven at 55°C for up to 11 hours. 3. Shake cones to release seeds and pour over a screen (less than 1cm opening). 4. Repeats steps 1 to 3 two more times to remove all seeds.
5. To de-wing seeds, they can be lightly threshed on a corrugated rubber mat. 6. Winnowing will remove the broken wings from the seed lot.
**Cautions:** None known.

## Storage

**Storage behaviour:** Probably orthodox [11].

**Storage requirements and longevity:** Seed that is well dried (4% to 13.5% moisture content) and stored in sealed containers at 2° to 4°C maintains viability for 5 up to 17 years [12,13].

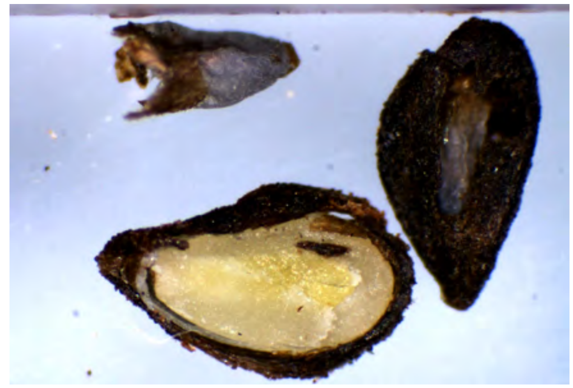

Photo 5: Sectioned black spruce seed.

## Seed Propagation

**Dormancy classification:** Physiological dormancy [14].

**Potential viability:** Often 50-60% of seeds are viable a marked decline in seed viability occurs with cone age [3].

**Pre-treatments:** Cool-moist stratification for 24 days is recommended [15].

**Germination protocols:** Seeds germinates well under controlled laboratory conditions, 100% germination percetages reported for seeds grown on a moist medium at 20°C and 8/16 hours of light/dark [11]. Seeds require light for germination [15,16]. Germination begins after 5 days and is complete after approximately 22 days [15].

**Other propagation methods:** None found.

**Field planting:** Seeds can be planted at a depth of approximately 0.5cm on a moist soil in the fall or early spring. Seedlings are sensitive to drying out and are best established on mineral soil with some organic material, mosses like *Pleurozium schreberi* may facilitate their germination (reviewed in [2]).

## Other

**Canadian commercial sources:**

https://www.ontario.ca/page/buy-ontario-tree-seeds-or-cones

**Useful links and Further reading:**

https://gobotany.newenglandwild.org/species/picea/mariana/

https://www.fs.fed.us/database/feis/plants/tree/picmar/all.html#SeedProduction

https://plants.usda.gov/plantguide/pdf/pg_pima.pdf

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13. Wang, B. S. P., Charest, P. J. & Downie, B. Ex Situ Storage of Seeds, Pollen and In Vitro Cultures of Perennial Woody Plant Species. in *FAO Forestry Paper 113* 1–64 (Food and Agriculture Organisation of the United Nations, 1994).
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# jack pine

Family: Pinaceae

Scientific name: *Pinus banksiana* Lamb.

Cree Name: ___________

Synonyms: *Pinus divaricata*

Photo 1: Jack pine tree.

## Quick Seed Guide

**When and what to collect**: Jack pine seed ripens in the fall, however cones do not release seed rapidly. Tan coloured (not gray cones) can be collected throughout the fall.

**Seed Processing**: Dry at high temperatures to open cone scales. Shake to release seed, repeat if needed. Sieve; thresh seed to break wings; winnow to clean.

**Storage:** Dry seed can maintain viability for over 20 years if kept in sealed containers at 2° to 4°C.

**Pre-treatment of seed:** Cool stratify for 8 weeks.

**How to Grow:** Seed: Germinate at 30/20°C for 8/16 hours of light/ dark.

## General

**Plant Description:** Jack pine is a coniferous tree that reaches 27m in height [1]. The profile shape of a jack pine tree is often irregular and the top or crown is generally rounded. The branches are spreading horizontally. The bark is scaly, orange to reddish-brown. The needles are in groups of 2, forming a V-shape, 2 to 5cm long by 1 to 1.5mm wide. Cones are often found on the upper half of the tree, borne in the branches. Cones are highly variable in shape, 3 to 5.5cm long, often curved and tightly wrapped around the braches.

**Field Identification:** Jack pine trees are recognized by their bark colour, cone shape, and needles. **Similar species:** Red pines (*Pinus resinosa*) and white pines (*Pinus strobus*) have longer needles, over 7cm. Scots pine (*Pinus sylvestris*) is an introduced tree, that looks very similar to jack pine overall, but its needles are twisted.

**Life Form:** Coniferous tree, it has woody stems that persist year-round and overwintering buds above ground.

**Reproduction:** Jack pine reproduces primarily by seeds [2]. Trees are monoecious and have separate male and female cones on a single tree. This species does not reproduce vegetatively. Under natural conditions, jack pines begin to produce seed at 5 to 10 years of age.

**Continental Range:** Found in all Canadian provinces except the Yukon [3,4]. In the United States it is restricted to north central or northeastern states.

**HBL regional Range:** Restricted to southern portions of the Hudson Bay Lowlands; occasional [5].

**Habitat:** Sandy soils, recently burned sites, tolerant of fires, tundra transition; 0-800m [1]. Also grows on thin soils across the Canadian shield, tolerating a range in pH, but prefers well-drained loamy-sandy soils [2].

*Photo 2: Jack pine cones collected from bows that had fallen after a recent wind storm. Cone scales are beginning to open.*

## Reclamation value

Jack pine may be a valuable reclamation tree because it tolerates, drier, coarser textured soils that other coniferous trees can tolerate[2]. It is a recommended tree species for the oil sands revegetation in Alberta and on other well-drained sandy mine spoils [6].

**Nitrogen fixing:** No.

**Symbioses:** Ectomycorrhizal [7], may also form associations with arbuscular mycorrhiza and dark septate endophytes [8]. Likely forms associations with ectendomycorrhizas, that have demonstrated tolerance in disturbed habitats [9].

**Growth rate:** Rapid [4].

# jack pine

**Successional stage:** An obligate pioneer species [2,6]. Jack pine invades exposed mineral soils following fire; it is shade intolerant [6]. It is replaced by longer lived conifers and declines after 90 years of age, unless it is disturbed by fire [6]. However on severely dry sites, where other trees cannot grow, jack pine may persist [2].

## Seed and cone properties

**Cone description:** Seed cones take 2 years to mature, are tan in colour, 3 to 5.5cm long and often curved at the tip [1]. Cones stay closed even after seeds mature and can maintain good viability for up to 5 years. Seeds are contained within the cone scales, winged 4 to 5mm, brown to black.
**Dispersal:** During very dry, hot conditions or from fires, cones will open to release seed [2]. Seeds are then wind dispersed.
**Propagule weight:** (Dried, winged seed) 2.20mg [10].
**Seeds/ cone:** There are 15 to 75 seeds per cone (cited in [2]).
**Seed size and description:** Seeds are 4 to 5mm long, brown to near black at maturity, over 12mm long (with wing) [1].
**Average seed weight:** (dried, de-winged seed) 2.00mg [10].
**Seeds/kg:** 500 00 seeds/kg [10].

## Seed Collection

**Timing collections:** Cones can be collected from August to October [11]. Cones become tawny yellow when ripe. Gray cones are older and have lower viability.
**Collection protocols:** Cones are usually more concentrated at the top of the tree. Therefore collecting cones can be a challenge. If you are collecting small quantities of cones, pole pruners will be sufficient to cut branches. However this method is not effective for collecting large quantities of cones; instead cutting the tree down will be required. If possible, seek permission to visit logging sites and collect cones from branches that have been left behind following logging. After a windstorm, pieces of branches bearing cones (bows) may be knocked to the forest floor and can be collected.
**Collection effort:** Not determined.
**Potential density:** Four million seed per hectare in mature, well stocked stands [2].
**Cautions:** None known.

## Propagule processing

**Processing protocols:** After collection, cones must be allowed to air dry for 3 to 10 days to avoid seed contamination or overheating from decomposition that will kill seed. Separate the cones from the branches and needles as much as possible because they are difficult to separate from the seed later. Cones can also be opened by kiln drying for up to 4 hours at 72°C [12] or under an incandescent light bulb. These seeds tolerate high temperatures, but should not be left at these high temperatures for long periods of time. The lower most scales will not fully open, but these seeds are typically not full. Therefore cones should be removed from the kiln if the upper ¾ of the cones scales have opened. Once the scales have opened, shake the cones to release the seed. We placed ours between sheets and stepped on the cones to further open the scales. Pour the cones over a screen with 2cm or smaller opening. Collect the seeds that have fallen through the screen and gently thresh on a corrugated rubber mat. Winnowing this material will remove the wings and result in clean seed.
**Cautions:** None known.

*Photo 3: Cones have fully opened and seeds were shaken from the cones.*

*Photo 4: Winged seeds are threshed gently to break wings off seeds.*

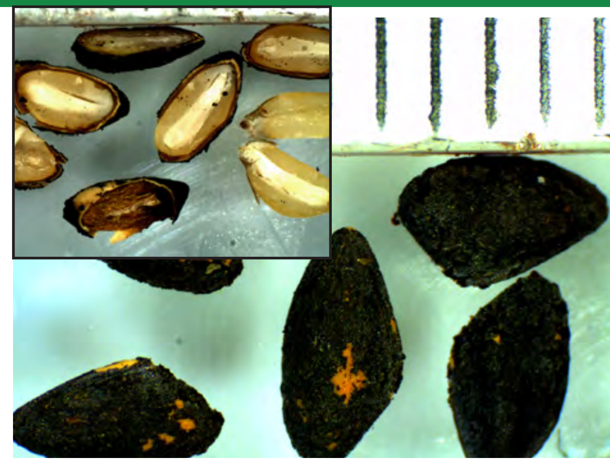

Photo 5: Jack pine seed. (inset photo) Sectioned jack pine seed.

## Storage

**Storage behaviour:** Orthodox [13].

**Storage requirements and longevity:** Seed viability was only slightly decreased after 21 years in sealed containers at 2° to 4°C, when seed was dried to about 5% moisture content [14].

## Seed Propagation

**Dormancy classification:** Physiological dormancy [15].

**Potential viability:** Our cleaned seed lots had a 97% viability.

**Pre-treatments** Cool-moist stratified for 8 weeks [13].

**Germination protocols:** Seed germinates well on a moist medium at 30/20°C, for 8/16 hours of light/ dark [13].

**Other propagation methods:** Seed is the most practiced method to propagate jack pine, however stem cuttings from young plants have been successfully rooted [2].

**Field planting:** Jack pine seeds germinate best on a mineral soil seed bed without competition with grasses (cited in [2]).

## Other

**Canadian commercial sources:**
https://www.ontario.ca/page/buy-ontario-tree-seeds-or-cones

**Useful links and Further reading:**
https://gobotany.newenglandwild.org/species/pinus/banksiana/
https://www.fs.fed.us/database/feis/plants/tree/pinban/all.html
https://www.na.fs.fed.us/spfo/pubs/silvics_manual/Volume_1/pinus/banksiana.htm

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# fowl bluegrass

Family: Poaceae

Scientific name: *Poa palustris* L.

Cree Name: ___________

Synonyms: *Poa eyerdamii, etc.*


*Photo 1: Fowl bluegrass seed head.*

## Quick Seed Guide

**When and what to collect**: In August seed ripens; seed heads change colour from green to tan.
**Seed Processing**: Dry, thresh to remove seed from plant. Winnow to clean.
**Storage:** Dried seed will remain viable for 5 to 7 years if stored cool in sealed containers.
**Pre-treatment of seed:** None required.
**How to Grow: Seed:** Germinate at 25/10°C and 8/16 hours of light/ dark.

## General

**Plant Description:** Fowl bluegrass is a perennial grass, 25 to 120cm in height [1]. It grows in clumps or can be stoloniferous (so stems are spread apart). The nodes along the stem are swollen. The leaf blades are flat, 1.5 to 8mm wide, but the tip of the leaf blade is cupped like the end of a canoe. The ligules are 1.5 to 6mm long. The flowering head is 13 to 30cm long, spreading open at maturity containing hundreds of seeds. Each spikelet has 2 to 5 seeds.
**Field Identification:** The bluegrasses (*Poa* ssp.) can be recognized by the cupped tip of the leaf blade and if you pull a seed from the spikelet it will have webby hairs attached at the base of the seed. **Similar species:** Fowl bluegrass is a very general grass in its appearance, a botanical text should be consulted for its identification. Michigan flora has a free online key to the grasses, most of which are found in Ontario http://michiganflora.net/family.aspx?id=Poaceae.
**Life Form:** Graminoid; perennial. Stems die back every year, regenerating from buds at or below the soil surface.
**Reproduction:** Reproduces by seeds and vegetatively spreads by stolons.

**Continental Range:** Fowl bluegrass is widespread throughout North America [2]. Present and largely secure in all Canadian provinces and Alaska. Populations are largely unranked in the United States, present south to New Mexico.
**HBL regional Range:** Widespread and abundant in the Hudson Bay Lowlands [3].
**Habitat:** Habitat variable. Found in moist to dry and open to partly shaded habitats [1]. Meadows, forest openings, dry rocky uplands.

## Reclamation value

Fowl bluegrass is recommended for planting on low to mid elevation sites, highway right-of ways, wet sites, and disturbed permafrost sites in the Yukon [4]. It was successfully planted on amended mine soils in the subarctic northern Ontario [5]. Fowl bluegrass produces large amounts of overall biomass compared to other native grasses and shows promise as a generalist in restoration that may colonize disturbed sites and persist [6].
**Nitrogen fixing:** No.
**Symbioses:** Found to form associations with arbuscular mycorrhiza and found to be non-mycorrhizal [7].
**Growth rate:** Moderate [8].
**Successional stage:** Tolerant of early successional, recently disturbed sites [6,9].


*Photo 2: Fowl bluegrass growing on amended mine waste soils.*

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# fowl bluegrass

## Seed properties

Photo 3: Fowl bluegrass seed separates from the plant by threshing.

**Dispersal:** Seeds fall from the spikelets when mature. Long distance dispersal mechanisms are uncertain.
**Seeds/ propagule:** One plant can have up to 500 seeds [1]. There are multiple seeds per spikelet.
**Seed size and description:** Florets (seeds with outer covering structures) are about 2.5mm long x 0.8mm wide.
**Average seed weight:** (clean, dry seed) 0.18mg [10].
**Seeds/kg:** 5.56 million seeds/kg [10].

## Seed collection

**Timing collections:** Seeds ripen in August when the grass heads change from greenish-purple to tan. Collect seeds before the stems are completely straw coloured to avoid losses. Check the seed head closely and feel the spikelets for plump (but small) seeds. The seed should be easy to pull from the plant.
**Collection protocols:** Collect the entire grass head using scissors or grass cutting shears. Place material into a large leaf bag. A mechanical harvester will increase seed yields if the stand is dense. Lay materials out to dry on racks or sheets following harvesting.
**Collection effort:** Using scissors, one collector can harvest an average of 800g, cleaned dry seed in one hour.
**Potential density:** No information found.
**Cautions:** None known.

## Propagule processing

**Processing protocols:** When plant materials are sufficiently dried, place a layer of seed heads onto a corrugated rubber mat inside a short cardboard box (to help contain material). 1. Thresh seed heads on a rubber mat to detach the seeds from the plant. 2. To clean seed, winnow the materials in front of a low air flow, this will blow out glumes and other chaff.
**Cautions:** Threshing creates dust; wear a mask and work in a ventilated space.

Photo 4: Fowl bluegrass cleaned seed.

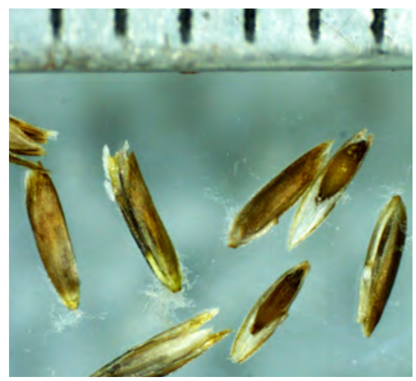

Photo 5: Fowl bluegrass seed. Note the webby callus hairs at the base of the seed.

## Storage

**Storage behaviour:** Likely orthodox [10].
**Storage requirements and longevity:** Dried seed from bluegrasses (*Poa* ssp.) stored in sealed plastic bags maintains viability for 5 to 7 years [11].

## Seed propagation

**Dormancy classification:** Other bluegrass species are non-dormant [12].
**Potential viability:** Cleaned seed from our collection had an average of 78.6% viability.
**Pre-treatments:** None required.
**Germination protocols:** Seeds grown in laboratory conditions without pre-treatments had 100% germination on 1% agar at 25/10°C, 8/16 hours of light/dark [10].
**Other propagation methods:** None known.
**Field planting:** Seed can be planted in spring or fall. Seed is small and should be planted on the soil surface or to shallow depths and not be allowed to dry out [13].

## Other

**Canadian commercial sources:**
https://www.brettyoung.ca/professional-turf-and-reclamation/seed/native-grasses
**Useful links and Further reading:**
https://gobotany.newenglandwild.org/species/poa/palustris/
https://www.prairiemoon.com/seeds/grasses-sedges-rushes/poa-palustris-fowl-bluegrass.html

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# balsam poplar

Family: Saliceae

Scientific name: *Populus balsamifera* L.

Cree Name: ___________

Synonyms: *Populus balsamifera ssp. balsamifera, etc.*

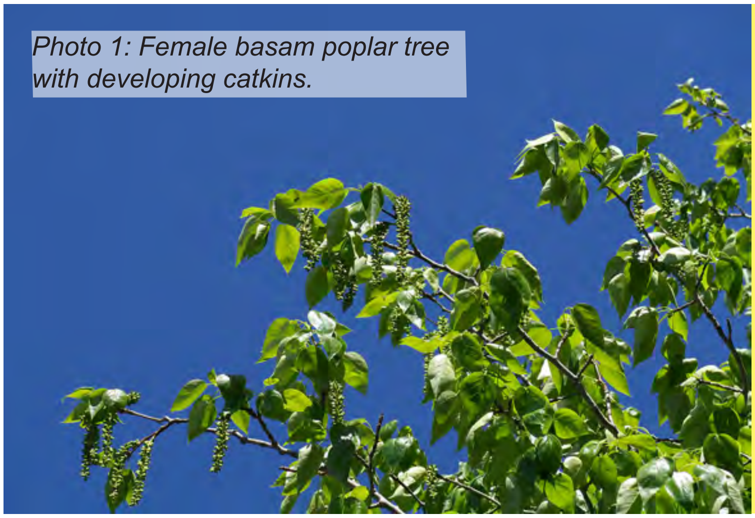

Photo 1: Female basam poplar tree with developing catkins.

## Quick Seed Guide

**When and what to collect**: Seeds ripen in early July. Check capsules for fully developed seed. Collect before capsules open to disperse seed.
**Seed Processing**: Dry capsules in a contained but breathable container. The shop vacuum method is used for seed cleaning. Refer to seed processing below.
**Storage:** Seed is sensitive. Dry seed well and stored in sealed containers at -10°C for up to 3 years.
**Pre-treatment of seed:** None required.
**How to Grow:** Seed: Fresh seed germinates quickly and at a range of temperatures 5 to 25°C.
Vegetative: Stem cuttings taken in spring to summer.

## General

**Plant Description:** A deciduous tree that can reach 40m in height [1]. The bark of young trees is smooth and beige to yellowish-gray, the trunks becoming gray and deeply furrowed with age. Leaves are stalked, leathery, shiny on the upper surface but whitened on the lower surface. The leaf margins are very finely toothed. Winter buds are reddish and resinous so they are sticky to touch and if crushed produce a strong balsamic odour.
**Field Identification:** Balsam poplar can be distinguished by its gummy, sticky buds and its shiny leaves with a pointed tip.
**Similar species:** Trembling aspen (*Populus tremuloides*) and large tooth aspen (*Populus grandidentata*) are also found in Ontario, but they are easily distinguished by differences in their leaf appearance.
**Life Form:** Deciduous tree; woody stems persist year-round and buds are above ground.
**Reproduction:** This species reproduces sexually by seed and asexually through the production of root suckers, producing large colonies of clonal trees [2]. A dioecious species (separate male and female plants) flowering March to June, fruiting May to July [1]. Reaches maturity by 8 to 10 years of age [2].

**Continental Range:** Found in all Canadian provinces, it is considered imperiled in Newfoundland and Prince Edward Island [3]. Present in Alaska. Found through much of the northern states, west to east, extending south to California, imperiled in the eastern states.
**HBL regional Range:** Widespread and abundant in the Hudson Bay Lowlands [4].
**Habitat:** Habitat variable. Found in rich lowland forests to open disturbed sites, such as rocky slopes [1]. Can tolerate seasonally wet soils. Found in forests along streams and rivers in tundra, 0-2900$^{+}$m.

Photo 2: Balsam poplar and slender wheatgrass naturally recolonizing an eroded slope.

## Reclamation value

A natural colonizer of disturbed sites including borrow pits, abandoned coal mines, and those of recent fire or logging [5]. A potential species for erosion control of wet sites such as river banks [5].
**Nitrogen fixing:** No.
**Symbioses:** Ectomycorrhizal [6]. Also forms an association with another type of mycorrhizae known as ectendomycorrhizae, specifically the species *Wilcoxina mikolae* var. *mikolae,* that are not well studied but seem to have an important relationship with plants in disturbed habitats, such as mine spoils [7,8].
**Growth rate:** Rapid [9].

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**Successional stage:** Early <u>successiona</u>l, <u>pioneer</u> species [5]. Is eventually replaced by longer lived trees.

*Photo 3: Collecting poplar catkins using a pole and hook and hand pruners.*

## Seed and fruit properties

**Fruit description:** Female catkins are 7.5 to 15 cm in length, made up of several green capsules [1]. Each capsule has 2 valves, from which it splits open at maturity. These capsules contain numerous small seeds.
**Dispersal:** Wind [10].
**Propagule weight:** (Dried seed with hairs intact) 0.42mg [11].
**Seeds/ capsule:** There are 15 to 22 seeds / capsule [1].
**Seed size and description:** Seeds are very small, brown at maturity, about 1.4mm long x 0.5mm in diameter.
**Average seed weight:** (dried, cleaned seed) 0.13mg [11].
**Seeds/kg:** 7.7 million seeds/kg [11].

## Seed Collection

**Timing collections:** Catkins begin to open in early July in the HBL, but can mature earlier in southern regions and depending on the weather conditions. Check female catkins prior to seeing the white fluff appear. If you can open the capsules and see well developed seed hairs and plump (but small) tan seeds, they are ready for collecting. Capsules are green to yellow in colour when seeds are mature. Seed dispersal peaks for about 1 to 2 weeks, but occurs over a period of 1 month [10]. In regions where poplars are common, it is apparent when seeds are dispersing because there is an abundance of fluffy seeds in the air.
**Collection protocols:** Only female plants produce seeds. Often this plant occurs in clonal colonies, so when you find one female, there are several in the same stand. Collecting catkins can be accomplished using a combination of pole pruners and for younger trees using a pole and hook and hand pruners. Clip off branches with catkins and place materials into large paper leaf bags. Place catkins in thin layers in large paper bags in a warm dry room until the capsules open. Seed is easily airborne once the capsules open, so ensure that catkins are contained in a breathable container for drying. Do not leave seeds in warm conditions for more than 7 days or the seed will deteriorate.
**Collection effort:** One person can collect 163g to 324g of pure, dried seed in one hour.
**Potential density:** In a natural popular stand, seed rain density was approximately 1700-3100 seeds/$m^2$ [10].
**Cautions:** The fluff and aromatic oils are flammable. Keep away from flame.

*Photo 4: Blowing air into a 5 gallon bucket containing poplar catkins, to emptied capsules after air was forced through the sieve set. Seed is in lower sieves.*

## Propagule processing

**Processing protocols:** Once the capsules have opened, they should be processed within 7 days. If immediate processing is not possible, well-dried catkins can be placed in cold conditions (1 to 5°C) for a few months until processing is possible. Once capsules have opened, seed can be cleaned using a shop vacuum, sieve set, and 5 gallon bucket. **1.** Cut a tight-fitting hole into the lid of a 5 gallon bucket, so it fits your sieve tightly. **2.** Place catkins and fluff into the pail about 1/3 of the way full. Place a fine sieve (60mesh) through the opening in the lid. Blow air into the bucket, adjusting the motion and direction of the airflow to toss the plant materials around the bucket for up to 30 seconds. The fluff should separate from the capsules and some seed will be dislodged and settle on the bottom of the bucket. Separate the fluff from the catkins. If no seed is trapped in the fluff, then discard, if the fluff is not clean further processing maybe required. **3.** Pour catkins and seed from the bucket into a 10mesh stacked sieve set for further cleaning. Sieves are stacked in this order from bottom to top: bottom pan, mesh #60, #35, #18, #10, #140. Fill the sieve about ¾ of the way. **4.** Blow air through the top sieve using a shop vacuum moving the hose around the sieve. Do this for about 30 seconds, stir the catkins and repeat. The final fluff should be mostly free of seed. The seed will be trapped in the #40 and #60 sieves. If the capsules have not fully opened return to a paper bag for drying and you may be able to extract more seeds from the catkins. If you do not need to quantify or clean your seed, then place dry opened capsules in a tumbler with a mixture of rocks and sand for about 20 minutes. The rocks and capsules can be sieved out and the result is a mixture of sand and seed that can be directly planted [12]. Only use this technique if seed will be immediately planted. **Cautions:** Process catkins in a large well-ventilated space that is draft free, a mask may be worn to avoid irritation from airborne fluff.

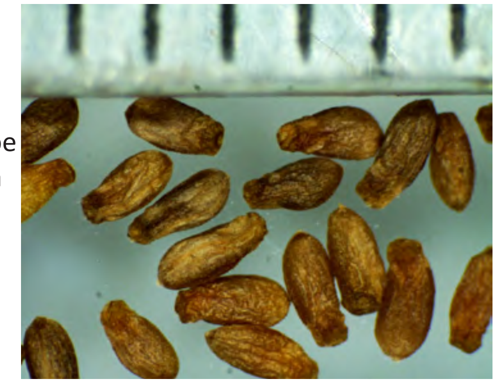
*Photo 6: Balsam poplar seed.*

## Storage

**Storage behaviour:** Orthodox [13].
**Storage requirements and longevity:** Balsam poplar seeds are short-lived. At room temperature, they lose viability quickly after 1 week. Seed should be dried well immediately following collection [14]. Seed that is well-dried can be stored in sealed containers at -10°C and will be viable for 3 years [15].

## Seed Propagation

**Dormancy classification:** Non-dormant [16].
**Potential viability:** Nearly 100% [15].
**Pre-treatments:** No pre-treatments are required. Germination is highest for fresh seed.
**Germination protocols:** Optimal germination temperatures are between 5 to 25°C, germination at cooler temperatures will result in a few days delay to the onset of germination [15,16]. Germination begins after 1 day at 25°C and 5 to 10 days at 5 to 10°C [15].
**Other propagation methods:** Hardwood cuttings taken March to April, softwood cuttings taken May to July are successfully rooted. Cuttings are 15 to 20cm and 0.8cm to 1cm in diameter, treated in rooting hormone [17].
**Field planting:** Sow fresh seeds in the spring, germination occurs in two days [12]. Preferred soils for seedling establishment are those of moist mineral soils versus moist organic soils [10].

## Other

**Canadian commercial sources:** None found.
**Useful links and further reading:**
https://gobotany.newenglandwild.org/species/populus/balsamifera/
https://www.na.fs.fed.us/pubs/silvics_manual/volume_2/populus/balsamifera.htm
https://www.fs.fed.us/database/feis/plants/tree/popbalb/all.html
https://tidcf.nrcan.gc.ca/en/trees/factsheet/53
http://www.pfaf.org/user/Plant.aspx?LatinName=Populus+balsamifera

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# trembling aspen

Family: Salicaceae

Scientific name: *Populus tremuloides* Michx.

Cree Name: ___________

*Populus tremula ssp. tremuloides, etc*

Photo 1: Trembling aspen female tree.

## Quick Seed Guide

**When and what to collect**: Collect female catkins in June, before they begin to open to release seed. Check capsules for well developed seed. Collect with pole pruners or a pole and hook for shorter trees.

**Seed Processing**: Dry catkins. Use the shop vacuum method for cleaning; refer to propagule processing below.

**Storage:** Seed is sensitive. Dry well and keep in sealed containers in the refrigerator for a year, or freeze for up to 2 years.

**Pre-treatment of seed:** None required.

**How to Grow:** Seed: Germinates easily between 5 and 30°C with equal light and dark. Vegetative: Root cuttings.

## General

**Plant Description:** A deciduous tree that can reach 35m in height [1]. Young trees have a white, smooth bark that becomes dark gray and furrows at an older age. Leaves are stalked, pointed at the tip, rounded or heart shaped at the base, 3 to 7cm long by 3 to 7cm wide. The upper surface of the leaf is dark green and the lower surface of the leaf whitened, leaf margins are finely toothed. Buds are smooth and resinous.

**Field Identification**: Trembling aspen has white to light green and smooth bark for many years; its leaves tremble in the wind because of their long stalk which is where it gets its name. **Similar species:** Large tooth aspen (*Populus grandidentata*) has larger teeth on the leaf margins and has hairy buds and hairy new branches.

**Life Form:** Deciduous tree; woody stems that persist year-round.

**Reproduction:** This species reproduces by seed and asexually through the production of root suckers, producing large colonies of clonal trees [2]. This species is dioecious (separate male and female plants). Trees produce seed after 10 years of age. Good seed crops occur every 4 to 5 years [2].

**Continental Range:** Found in all Canadian provinces and Alaska. Trembling aspen is found in most of the United States, absent in the southeastern states [3].

**HBL regional Range:** Widespread and abundant in the Hudson Bay Lowlands [4].

**Habitat:** Habitat variable; found in dry to wet sites, open habitats to forests, disturbed sites such as mine tailings, roadsides; 0-3000$^{+}$m [1].

Photo 2: Trembling aspen branch on the left. Balsam poplar branch to the right.

## Reclamation value

Trembling aspen is a valuable reclamation species; it is versatile in its habitat tolerances, capable of stabilizing soil due to extensive root networks [5]. It produces large amounts of leaf litter that rapidly decays and is higher in nitrogen, phosphorus, potassium, and calcium compared to other hardwoods, contributing to soil development. Trembling aspen has been successfully planted or has naturally colonized eroded riparian sites, strip mines, and phosphate mine spoils (cited in [5]).

**Nitrogen fixing:** No.

**Symbioses:** Ectomycorrhizal and arbuscular mycorrhizal [6]. Forms ectomycorrhizal relationship with *Sphaerosporella brunnea,* an E-strain mycorrhizae capable of forming ectendomycorrizal associations with other trees such as pine and larch [7].

# trembling aspen

**Growth rate:** Rapid [8].
**Successional stage:** Early to mid-successional species [9]. It is replaced by longer lived trees [5]. Seedlings establish best on exposed mineral soil, shade intolerant [9].

*Photo 3: Trembling aspen catkins have burst open and are ready to be processed.*

## Seed and fruit properties

**Fruit description:** Female catkins are green to brown at maturity, 4 to 7 cm long, made up of many capsules that split into two valves. Capsules contain many seeds.
**Dispersal:** Wind [9].
**Seeds/catkin:** Up to 1000 seeds/catkin. Approximately 10 seeds/capsule [2].
**Seed size and description:** Seeds are very small, brown at maturity.
**Average seed weight:** (cleaned, dried seed) ) 0.1mg [10].
**Seeds/kg:** 8 million [2] to 10 million seeds/kg [10].

## Seed collection

**Timing collections:** Trembling aspen catkins may mature slightly earlier than balsam poplar; begin collection in early to mid-June [11,12]. Collect catkins before you can see the white fluffy seed emerging. In northern climates or at higher elevations, seed production may be highly reduced [2]. Scout for female plants in early June and mark female trees for future collections.
**Collection protocols:** Collecting catkins can be accomplished using a combination of pole pruners and for younger trees using a pole and hook and hand pruners. Clip branches with catkins and place them into large paper leaf bags. Place catkins in thin layers in large paper bags in a warm dry room until the capsules open.
**Collection effort:** Not determined.
**Potential density:** No information found.
**Cautions:** None known.

## Propagule processing

**Processing protocols:** Seed is easily airborne once the capsules open, so ensure that catkins are contained in a breathable container for drying. Do not leave seeds in warm conditions for prolonged periods. Once the capsules have opened, they should be processed. If immediate processing is not possible, well-dried catkins can be placed in cold conditions (1 to 5°C) for a few months until processing is possible. Once capsules have opened, seed can be cleaned using a shop vacuum, a sieve set, and a 5 gallon bucket. **1.** Cut a tight fitting hole into the lid of a 5 gallon bucket, so it fits your sieve. **2.** Place catkins and fluff into the pail about 1/3 of the way full. Place a fine sieve (60mesh) through the opening in the lid. Blow air into the bucket, adjusting the motion and direction of the airflow to tossle the plant materials for up to 30 seconds. The fluff should separate from the capsules and some seed should become dislodged and settle on the bottom of the bucket. Separate the fluff from the catkins, if no seed is trapped is the fluff, then discard; if the fluff is not clean further processing maybe required. **3.** Pour catkins and seed from bucket into a #10 stacked sieve set for further cleaning. Sieves are stacked in this order from bottom to top: bottom pan, #60 mesh, #35, #18, #10, #140. Fill the sieve about ¾ of the way. **4.** Blow air through the top sieve using a shop vacuum moving the hose to toss the seed material around the sieve. Do this for about 30 seconds, stir the catkins and repeat. The final fluff should be mostly free of seed. The seed will be trapped in the #40 and #60 sieves. If the capsules have not fully opened, return them to a paper bag for drying; you may be able to extract more seeds from the catkins.
If you do not need to quantify or clean your seed, then place dry opened capsules in a tumbler with a mixture of rocks and sand for about 20 minutes. The rocks and capsules can be sieved out and the result is a mixture of sand and seed that can be directly sown [13].
**Cautions:** Process catkins in a large well-ventilated space that is draft free, a mask may be worn to avoid irritation from airborne fluff.


Photo 4: Trembling aspen seedlings. Seed germinates readily on a moist medium at room temperature.

## Storage

**Storage behaviour:** Orthodox [10].

**Storage requirements and longevity:** Although this species is considered orthodox, it is short lived and must be dried and placed into cool storage quickly after collection; after 1 week at room temperature seed viability will decline rapidly. Seed should be dried immediately following collection[14]. Viability can be maintained for one year if seed is dried and stored in a sealed containers at 5°C [15] and for up to 2 years if seed is frozen [5].

## Seed propagation

**Dormancy classification:** Non-dormant [16].

**Potential viability:** High, 80 to 95% for fresh seed [5].

**Pre-treatments:** No pre-treatments are required [16].

**Germination protocols:** Optimal germination is between 5 to 25°C or 30/20°C for with 12/12 hours of light/dark cycles [16].

**Other propagation methods:** Root cuttings of 10 to 20cm taken in June from lateral roots can be effectively propagated[17]. Stem cuttings have a low rooting success [2]. For more information refer to http://ucce.ucdavis.edu/files/repositoryfiles/ca2201p14-65352.pdf.

**Field planting:** Sow fresh seed in the spring. Seed is small and should be surface sown.

## Other

**Canadian commercial sources:** None found.

**Useful links and further reading:**

https://gobotany.newenglandwild.org/species/populus/tremuloides/
https://www.fs.fed.us/database/feis/plants/tree/poptre/all.html
https://www.na.fs.fed.us/spfo/pubs/silvics_manual/volume_2/populus/tremuloides.htm
https://plants.usda.gov/plantguide/pdf/cs_potr5.pdf

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# silverweed cinquefoil

Family: Rosaceae

Scientific name: *Potentilla anserina* L

Cree Name: ___________

synonyms: *Argentina anserina*; *4 recognized varieties.*

*. Note the extensive network of stolons.*

## Quick Seed Guide

**When and what to collect**: Seed ripens in August. Collect capsules when the seeds inside are plump and are easy to separate from the capsule.

**Seed Processing**: Dry, thresh seed on corrugated rubber surface. Winnow.

**Storage:** Dry seed can remain viable for 5 years.

**Pre-treatment of seed:**

**How to Grow: Seed:** About 50% germination rates for seed grown at 25°C/ 5°C and 12/12 hours of light/ dark.

## General

**Plant Description:** A short herb that likely gets its name from its silver basal leaves [1]. The basal leaves are compound leaves with several toothed leaflets, 3 to 20cm long. There is a large amount of variation in silverweed leaf appearance. The colour and hairiness of silverweed leaves, ranges from silvery with a dense covering of cottony hairs to hairless and dark green. Silverweed is obviously stoloniferous often forming large colonies, giving rise to small daughter plants from a stolon extension. Flowers are yellow, 5-petaled, 1 to 2cm in diameter. They arise from the plant on long stalks.

**Field Identification:** Silverweed cinquefoil is a distinguished plant, recognized by its silvery, or compound basal leaves and horizontal growth. **Similar species:** Other cinquefoils (*Potentilla*) are distinguished because they have either a vertical growth or fewer leaflets per leaf. Some avens (*Geum*) have similar basal leaves, but produce an erect, tall stem when flowering.

**Life Form:** Perennial forb; dies back during winter months, but regenerates from buds at or below the ground surface.

**Reproduction:** Reproduces vegetatively by stolons to produce small daughter plants [2]. Also reproduces by seed production.

**Continental Range:** Found in all Canadian provinces and Alaska [3]. In the United States, silverweed is distributed through much of the western and northern states.

**HBL regional Range:** Widespread and abundant in the Hudson Bay Lowlands [4].

**Habitat:** Wide ranges of habitat tolerances: Dry to moist meadows, pastures, open dry pine and aspen forests, dry sandy and gravelly stream shores and seashores, sand dunes, inland alkaline habitats, dry ruderal habitats; 0-3000 m [1].
Also common in waste sites, roadsides, and lawns [2].

*Photo 2: Silverweed cinquefoil is tolerant of a variety of soil types and found growing in harsh environments.*

## Reclamation value

A ground cover herb, tolerant of cold climates, a variety of soil conditions and moisture regimes, has some salinity tolerance and grows well in alkaline soils [2]. Silverweed cinquefoil spreads quickly once established due to its horizontal, stoloniferous growth.

**Nitrogen fixing:** No.

**Symbioses:** Arbuscular mycorrhiza [5,6].

**Growth rate:** Rapid [7].

**Successional stage:** Tolerant of disturbance and open conditions, tolerant of early successional conditions [2]. Silverweed cinquefoil declined in abundance along a successional gradient on a Baltic seashore, near Stockholm, Sweden, becoming replaced by more dominating species where disturbance was reduced [8].


*Photo 3: Silverweed cinquefoil capsules with developing seed. Seed is ready to be collected.*

## Seed and capsule properties

**Capsule description:** Bracts of the flower, close around the developing seeds to form a capsule. This capsule is brown at maturity, spreading open to release the seed. Containing numerous achenes (seeds).
**Dispersal:** Seeds float. Seeds fall close to the mother plant when mature, but they may be transported by water for dispersal to new locations [2].
**Seeds/ capsule:** A potential of 20 to 60 achenes per capsule [1], but a more typical average of 9 to 13 seeds actually develop, depending on the year, pollen availability, and nutrient availability [9].
**Seed size and description:** Seeds are within an achene, largely variable in size, 1.5 to 2.3 mm long and 0.9 to 1.7 mm in diameter [2].
**Average seed weight:** (cleaned, dried seed) 0.8mg [10].
**Seeds/kg:** 1.25 million seeds/kg [10].

## Seed collection

**Timing collections:** Seeds ripen from August to September. Collect capsules before they open to release seed, but when they are full and plump. Achenes are plump, reddish, yellow, or tan at maturity. Seed dispersal is rapid for this plant in highly exposed sites.
**Collection protocols:** Seed production is low in our region for silverweed cinquefoil. This plant grows low to the ground. Use a hand's free collection container, such as a bucket that is adjusted to the hip height of the collector for rapid movement between stands. Pinch the entire capsule from the plant. Place materials to dry following collection.
**Collection effort:** High, capsules are often difficult to see and grow low to the ground. One collection hour can yield 27 to 40 g of cleaned seed [11].
**Potential density:** No information found.
**Cautions:** None known.

## Propagule processing

**Processing protocols:** 1. Dried capsules can be threshed on a corrugated rubber mat. Seeds will separate easily from the capsules. 2. Winnow in front of a low to moderate air flow to remove chaff.
**Cautions:** None known.

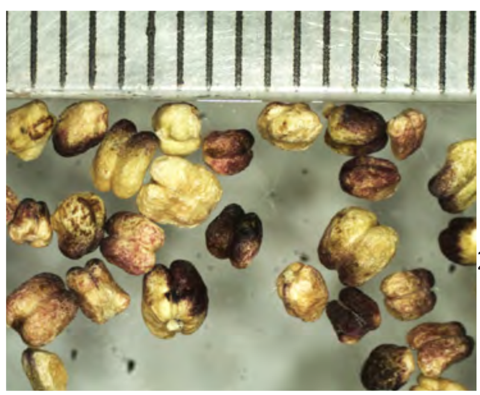
*Photo 4: Silverweed cinquefoil seed.*


*Photo 5: Sectioned silverweed cinquefoil seed. Note the spongy outer layer.*

## Storage

**Storage behaviour:** Probably orthodox [10].
**Storage requirements and longevity:** Dried seed can remain viable for at least 5 years (cited in [2]).

## Seed propagation

**Dormancy classification:** Dormant for the winter [2], other cinquefoils (*Potentilla* ssp.) have physiological dormancy [12].
**Potential viability:** Our cleaned seed lots have seed viabilities of 76% to 97%.
**Pre-treatments:** Cool-moist stratification.
**Germination protocols:** Over 50% germination rates for seeds planted on a moist medium at 25°C/ 5°C and 12/12 hours of light/dark (cited in [2]).
**Other propagation methods:** No information found.
**Field planting:** In nursery application, approximately 100 seeds are planted per linear meter to a depth of 0.6cm and kept moist for 14 days until emergence [11].

## Other

**Canadian commercial sources:** None found.
**Useful links and further reading:**
https://gobotany.newenglandwild.org/species/argentina/egedii/
https://www.minnesotawildflowers.info/flower/silverweed-cinquefoil
https://plants.usda.gov/core/profile?symbol=ARAN7

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# Mistassini primrose

Family: Primulaceae

Scientific name: *Primula mistassinica* Michx.

Cree Name: ___________

Synonyms: *Primula intercedens, etc.*

## Quick Seed Guide

**When and what to collect**: Seeds ripen from July to August. Capsules change from green to yellow and seeds inside are brown.

**Seed Processing**: Dry. Thresh capsules, sieve.

**Storage:** Dry, store cool in sealed containers.

**Pre-treatment of seed:**

**How to Grow:** Seed: Do not bury seed; germinate between 10 to 15°C; temperatures above 20°C may inhibit germination.

## General

**Plant Description:** A small herb with a prominent purple flower [1]. Plants are 5 to 15 cm tall. Often occurs in groups with many other plants. Seen throughout the growing season by its small, bright green basal rosette leaves. Leaf margins have small round or weakly pointed teeth. Leaves are rounded at the tip and narrowing to the base, 1 to 2cm long and 0.2 to 1.6cm wide. The erect stem gives rise to 1 to 10 purple to pink flowers with a yellow center. Flowers are small (+/-1cm wide), the petals are lobed.

**Field Identification:** Mistassini primrose is a delicate herb, recognized by its basal leaves and small purple flower. **Similar species:** Greenland Primrose (*Primula egaliksensis*) has white flowers and thick untoothed basal leaves. Mealy primrose (*Primula laurentiana*) is very similar, but has thicker basal leaves and a thicker stem, overall less delicate than Mistassini primrose. Erect Primrose (*Primula stricta*) is also very similar, to distinguish this plant you must examine the underside of the flower. The green bracts below the flower form a small sac in erect primrose.

**Life Form:** Perennial forb; stems die back during the winter and regenerate from buds at or below the soil surface.

**Reproduction:** Reproduces by seed. Flowering in spring to early summer.

**Continental Range:** This species is present in all Canadian provinces except Nunavut and Prince Edward Island [2]. Canadian populations of Mistassini primrose are largely vulnerable or imperiled, except in Ontario and Quebec where they are secure. In the United States, this species is only found in northeastern states.

**HBL regional Range:** Widespread and occasional in the Hudson Bay Lowlands [3].

**Habitat:** Open meadows, stream banks, lake shores, and cliff faces on calcareous substrates; 0-1500m [1].

## Reclamation value

**Nitrogen fixing:** No.

**Symbioses:** No information, other *Primula* form associations with arbuscular mycorrhiza [4].

**Growth rate:** Mistassini primrose has a high specific leaf area which may indicate its ability to grow quickly.

**Successional stage:** Tolerates early successional conditions such as disturbed open sites [5].

*Photo 2: Mistassini primrose basal leaves and mature seed capsule.*

De Beers Canada Victor Mine

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NSERC CRSNG

# Mistassini primrose

## Seed and capsule properties

Photo 3: Cutting the capsules off the top of Mistassini primrose plants.

**Capsule description:** Capsules are small (6 to 10mm long) and contain numerous seeds.
**Dispersal:** Uncertain; seeds have no appendages but are small and may be carried short distances by the wind. Capsules open to release seed that falls close to the mother plant.
**Seeds/ capsule:** Unknown, numerous.
**Seed size and description:** Seeds have a pitted surface, light brown to dark brown at maturity, +/-0.3mm in diameter.
**Average seed weight:** (cleaned, dry seed) 0.03mg [6].
**Seeds/kg:** Over 33 million seeds/kg [6].

## Seed collection

**Timing collections:** Capsules can be collected from mid-July to early August. To check seed readiness, open a capsule. If seeds inside are still green, they are immature, when capsules turn yellow and seeds inside are brown, they are ready to collect. If the weather is hot and dry, seeds will not persist for long. Once capsules open, seed is quickly lost.
**Collection protocols:** Collect capsules from plants using scissors, this plant is often found in colonies and you can clip multiple stems at one time. Collect onto a short tray or bucket that is harnessed to your body so you can quickly move between plants.
**Collection effort:** One collector can pick 4g (approx. 130 000 seeds) of cleaned, dried seed in one hour.
**Potential density:** No information found.
**Cautions:** None known.

## Propagule processing

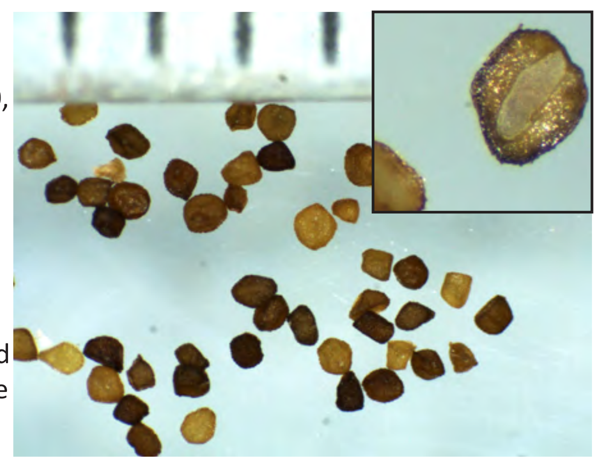

Photo 4: Mistassini primrose seed. (inset photo) A sectioned viable seed.

**Processing protocols:** Place capsules on trays to dry, in case capsules burst open, seed can be recovered. Thresh capsules on a corrugated mat to separate seed. Sieve the crushed material into a sieve stacked #18, #35, #60, and bottom pan. Seed remains in #60 mesh sieve.
**Cautions:** None known.

## Storage

**Storage behaviour:** No data available for species. Of the known *Primula* taxa, 100% are orthodox [7].
**Storage requirements and longevity:** If seed is orthodox, it can be well dried and stored below 5°C to maintain viability. Seeds of *Primula parryi* that were stored for 3 years in sealed containers at 2 to 4°C maintained viability.

## Seed Propagation

**Dormancy classification:** Other *Primula* ssp. have a physiological dormancy [8].
**Potential viability:** Our collections had a 100% seed fill.
**Pre-treatments:** Unknown, cool-moist stratification is recommended for many species in cold climates with a physiological dormancy [8].
**Germination protocols:** Germinate on moist soil, without burying seed at temperatures between 10°C and 15°C, temperatures above 20°C may inhibit germination, germination may take 3 to 6 weeks or longer (Accessed June 9, 2017 from: https://www.plant-world-seeds.com/store/view_seed_item/3494). Light is required for germination of other species of *Primula* [8].
**Other propagation methods:** None found.
**Field planting:** Surface sow, seed is small and requires light to germinate so it should not be buried.

## Other

**Canadian commercial sources:**

http://botanicallyinclined.org/seeds-shop/primula-mistassinica-buy-seeds/

**Useful links and further reading:**

https://gobotany.newenglandwild.org/species/primula/mistassinica/
https://www.minnesotawildflowers.info/flower/mistassini-primrose
http://michiganflora.net/species.aspx?id=2352
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# heal-all

Family: Lamiaceae

Scientific name: *Prunella vulgaris* L.

Cree Name: ___________

Synonyms: *3 recognized subspecies*

## Quick Seed Guide

**When and what to collect**: Seeds ripen in August. Cut the entire spike when it turns brown and papery.
**Seed Processing**: Dry capsules. Thresh, sieve, winnow.
**Storage:** Dry seed and store cool in sealed containers.
**Pre-treatment of seed:** None required.
**How to Grow:** Seed: Germinate seed at 5°C to 25°C and 12/12 hours or 8/16 hours of light/ dark.

## General

**Plant Description:** A common perennial flower, 10 to 60cm tall [1]. Stems are square in cross section. Leaves are arranged opposite along the stem. Leaves have a short stalk, margins are smooth, but the leaf shape is variable from egg-shaped to longer with narrow tips. The flowering head is a spike made of several violet to pink flowers, overall 2 to 5cm long and 1.5 to 2cm wide, with two leaves at the very base. Below every flower is a bract with stiff hairs along its edges. The flowers themselves are irregular, tube shaped, small, 7 to 10mm long.
**Field Identification:** Heal-all is easily recognized when it is in flower. Its dense flowering spike, irregular purple flowers, coupled with the opposite leaf arrangement of this plant are prominent features. **Similar species:** Wild mint (*Mentha arvensis*) also has purple flowers and a square stem, but flowers are found in between leaves along the stem rather than at the top and wild mint leaves have a minty fragrance.
**Life Form:** Perennial forb; dies back during unfavourable conditions, regenerates by buds at or below the soil surface.
**Reproduction:** Reproduces by seeds and spreads by straggling stems that develop roots at the nodes [2].

**Continental Range:** Canadian populations of heal-all are of both native and exotic origin [3]. Found in all Canadian provinces except the Northwest Territories and Nunavut. Present in all states in the U.S.
**HBL regional Range:** Abundant in southern portions of the Hudson Bay Lowlands [4].
**Habitat:** Wide range of habitat tolerances: Disturbed sites, roadsides, lawns, waste area, meadows, forest openings [2]. We found heal-all on river shores with fine textured soils and rocky sites.

## Reclamation value

**Nitrogen fixing:** No.
**Symbioses:** Arbuscular mycorrhizal or non-mycorrhizal [5].
**Growth rate:** Rapid [3].
**Successional stage:** Common on early successional, disturbed, open sites.

## Seed and capsule properties

**Capsule description:** Spikes contain numerous capsules, changing colour from green to brown at maturity.
**Dispersal:** Capsules dry and open to release seed. Seeds have no appendages to aid in dispersal.
**Seeds/ collection unit:** 2.1 seeds per capsules, and 27 seeds per spike [6].
**Seed size and description:** Seeds are actually nutlets, but can be treated as seeds. Dark brown at maturity, about 1.7mm long an 1mm wide.

*Photo 2: Heal-all mature spike and capsules.*

**Average seed weight:** (cleaned, dry seed) 1.0mg [7]. Our seeds were dried and had a mean seed weight of 0.55mg.
**Seeds/kg:** One to two million seeds/kg [7].

Photo 3: Heal-all spikes on a threshing mat. Threshing this seed will separate seed from capsules.

## Seed Collection

**Timing collections:** Heal-all seeds ripen in August. The flowering heads begin to change colour from green to brown and turn papery. To confirm seed readiness, open the capsule, if seeds are firm and light brown they are ready to collect. If seeds are green and can be crushed by your fingers, it is too early to collect. Once capsules are dry, seeds disperse quickly.
**Collection protocols:** Plants are often in clumps. Collect the entire clump of spikes using scissors. Plants are low to the ground, use container that can be harnessed to your body so you can move quickly from plant to plant. Set collections out to dry on trays or in thin layers in paper bags.
**Collection effort:** One collector picked between 20 to 60g of clean, dry seed in one hour.
**Potential density:** No information found.
**Cautions:** None known.

## Propagule processing

**Processing protocols:** After capsules were fully dried, they were threshed on a corrugated rubber mat. Seeds are hard and tolerate threshing well. We sieved materials to isolate seed and further cleaned by winnowing. Seed purity was almost 99%.
**Cautions:** None known.

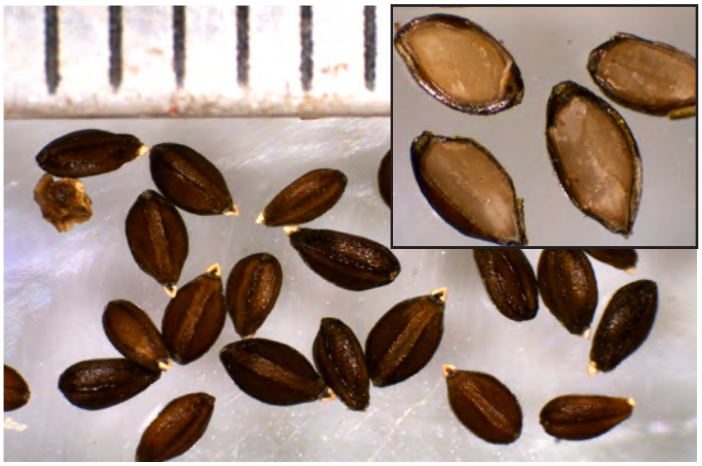

Photo 4: Heal-all seed. (inset photo) Viable sectioned heal all seed.

## Storage

**Storage behaviour:** Orthodox [7].
**Storage requirements and longevity:** Seed that is well dried and frozen at -18°C, has maintained viability for 12 years in storage [7].

## Seed Propagation

**Dormancy classification:** Non-dormant [8].
**Potential viability:** Our collections had nearly 98% seed viability.
**Pre-treatments:** No pre-treatments required. Seed germinates equally well, with and without cool-moist stratification. Prolonged cool moist stratification may inhibit this species germination [9].
**Germination protocols:** Very good germination in laboratory conditions (>95%) at temperatures: 15°C to 25°C and 12/12 hours or 8/16 hours of light/ dark cycles [7].
**Other propagation methods:** None known [3].
**Field planting:** Requires light to germinate, germination may be inhibited by leaf cover from other plants [8].

## Other

**Canadian commercial sources:** None found, plants in Canada are both native and non-native origin.
**Useful links and further reading:**
Amazing close up photos of the plant: http://microscopy-uk.org.uk/mag/indexmag.html?http://microscopy-uk.org.uk/mag/artnov10/bj-heal-all.html
https://www.wildflower.org/plants/result.php?id_plant=PRVU
https://www.minnesotawildflowers.info/flower/self-heal

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# alderleaf buckthorn

Family: Rhamnaceae

Scientific name: *Rhamnus alnifolia* L'Hér.

Cree Name: ___________

Synonyms: None found.

*Photo 1: Female buckthorn plant.*

## Quick Seed Guide

**When and what to collect**: Berries ripen in August; they will change colour from green to purple and soften at maturity. Collect by hand or with berry rakes.

**Seed Processing**: Thresh berries on a mat; rinse into a bucket of water. Reserve sunken material. Dry. Thresh again and winnow.

**Storage:** Dry seed and keep in sealed containers at 3 to 4°C for 5 to 7 years.

**Pre-treatment of seed:** Cool-moist stratify for 90 days.

**How to Grow:** Seed: Germinate at 29°C/ 20°C, germination will occur after 15 days.

Vegetative: Softwood stem cuttings taken in June.

## General

**Plant Description:** A deciduous shrub, 0.5 to 1.5m tall [1]. Stems are unarmed, unlike many of the other buckthorns. Young branches are gray to brown. Leaves alternate, strongly veined and shiny on the upper surface, small teeth on the margins, 4.5 to 11cm long. Flowers are small, not showy, star-like, borne within the leaf nodes. Berries are round, deep purple to black at maturity.

**Field Identification:** Alderleaf buckthorn is fairly short shrub, found commonly in colonies. The strong leaf veins, star-like flowers, or black fruit make this species distinct. **Similar species**: Alderleaf buckthorn resembles the dogwoods (*Cornus* ssp.) because of the prominent leaf veins, however their fruits are remarkably dissimilar and alderleaf buckthorn leaves have fine teeth. Chokecherry (*Prunus virginiana*) also has dark fruit and similar leaves, however it is typically much large than alderleaf buckthorn; its flowers are white and somewhat showy and its dark purple berries produce only one large round seed.

**Life Form:** Deciduous perennial shrub; stems persist overwinter and buds are located above ground.

**Reproduction:** A dioecious plant (separate male female plants); reproduces by seeds and layering. Flowering May to July [1].

**Continental range:** Present across Canada, except in the Yukon, Northwest Territories, and Nunavut [2]. Present in the northern United States, south to Tennessee, but many of these populations are considered vulnerable to imperiled.

**HBL regional range:** Abundant in the interior (at least 15km from the coast) and southern portion of the Hudson Bay Lowlands [3].

**Habitat:** Habitat variable in moisture regime and exposure. Fens and swamps, generally calcareous, riparian thickets, shore lines, marshes and mats, wet meadow edges, outcrops, deciduous and coniferous forests; 10-2700 m [1].

*Photo 2: . Note the strong venation and star*

## Reclamation value

**Nitrogen fixing:** No.

**Symbioses:** Possibly arbuscular mycorrhizal (AM), the family Rhamnaceae is commonly associated with AM [4].

**Growth rate:** Moderate [5].

**Successional stage:** No information found.

# alderleaf buckthorn

## Seed and fruit properties

Photo 3: Alderleaf buckthorn with ripe fruit, collected using a berry rake.

**Fruit description:** Dark-purple to black round berries at maturity.
**Dispersal:** Mammals, birds [6].
**Fruit weight:** Fresh weight per berry approximately 245mg.
**Seeds/ fruit**: Hard stone, made of three seeds.
**Seed size and description:** Tear-shaped, about 5mm long and 4mm wide, flattened.
**Average seed weight:** (cleaned, dry seed) 10.83mg [6].
**Seeds/kg:** Approximately 92 000 seeds/kg [6].

## Seed Collection

**Timing collections:** Fruit matures in August, fruits ripen fairly evenly within a stand. They are ripe when the fruit changes from green to purple and softens. Fruit will persist for several weeks unless consumed by animals.
**Collection protocols:** Collect berries by hand into large buckets resting on the ground or containers harnessed to the collector. This species grows in fairly dense patches and ripens all at once. Berry rakes are suitable for collecting this species, however we did not find it increased our collection efficiency above hand collection. Place berries in the refrigerator until ready for processing.
**Collection effort:** One person collects an average of 47g (19g to 122g), pure dried seed in one hour, or an average of 750g (250g to 1500g) of fresh fruit in one hour.
**Potential density:** No information found.
**Cautions:** None known.

## Propagule processing

**Processing protocols:** Crush berries on a corrugated rubber mat with a threshing paddle. Rinse material into a large bucket of water. Float off empty seeds and pulp. Reserve the sunken material in a sieve and lay out to dry on a paper towel. When the material is well dried, place it on a flat rubber mat and thresh to break apart the seeds from one another and any remaining pulp. Winnow in front of a forceful airflow to further clean. Each berry contains a cluster of 3 seeds that require some force to become separated from one another.
**Cautions:** None known.

Photo 4: Alderleaf buckthorn berries waiting to be threshed.

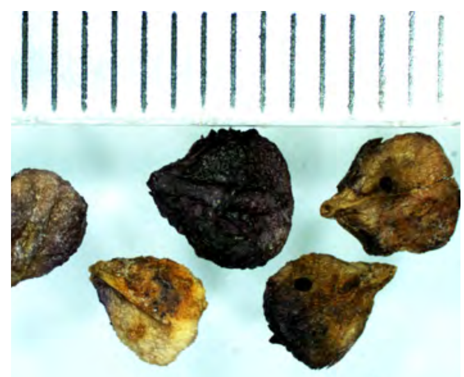

Photo 5: Iderleaf buckthorn whole seed. Note the insect bore whole on the lower right seed.

## Storage

**Storage behaviour:** Probably orthodox [6].
**Storage requirements and longevity:** Seed viability can be maintained for at least 2 years if seed is dried and stored in sealed containers at 5°C [7]. Another source reports 5 to 7 years longevity if stored in sealed containers at 3 to 4°C [8].

## Seed Propagation

**Dormancy classification:** Likely a physiological dormancy. Untreated seeds and scarified seeds do not germinate [9].
**Potential viability:** Seed from our collections were highly damaged by insect consumption, resulting in poor seed fill; average viability was 45%, ranging from 25% to 70%.
**Pre-treatments:** Cool-moist stratification of seeds for 90 days is optimal [9]. Seed has poorer germination rates if it is untreated, scarified, or cool stratified for 120days.

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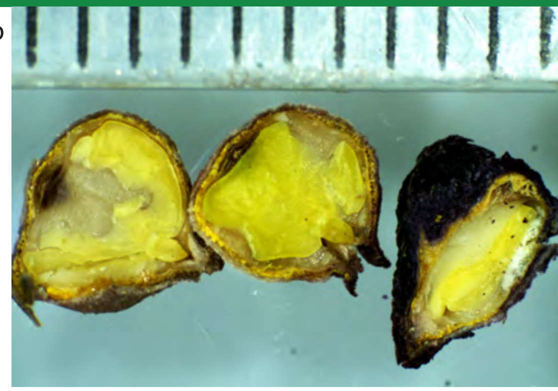
Photo 6: Sectioned alderleaf buckthorn seed.

**Germination protocols:** Pre-treated seed can be germinated at 29°C/ 20°C to approximately 50% [7,9]. Germination occurs after 15 days [7].
**Other propagation methods:** Softwood cuttings taken in June and dipped in 3000ppm IBA had 85% rooting success [9].
**Field planting:** Seed can be planted in the fall or pre-treated seed can be planted in the spring on a moist soil surface [7].

## Other
**Canadian commercial sources:** None found.
**Useful links and further reading:**
http://michiganflora.net/species.aspx?id=2413
http://www.saskwildflower.ca/nat_Rhamnus%20alnifolia.html
https://www.minnesotawildflowers.info/shrub/alder-leaved-buckthorn
https://gobotany.newenglandwild.org/species/rhamnus/alnifolia/
http://ontariotrees.com/main/species.php?id=2021

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# bog Labrador tea

Family: Ericaceae

Scientific name: *Rhododendron groenlandicum* (Oeder) Kron & Judd    Cree Name: ________

Synonyms: *Ledum groenlandicum*, etc

Photo 1: Bog Labrador

## Quick Seed Guide

**When and what to collect**: Collect capsules in September by hand or using scissors. Use a hands free collection container.

**Seed Processing**: Dry, thresh capsules, sieve.
**Storage:** Dry seed, keep cool in sealed containers.
**Pre-treatment of seed:** None required. 60 days of cool

**How to Grow:** Seed: Germinate at 30°C on a peat substrate or a medium with a pH less than 7. Seeds require light.
Vegetative: Cuttings taken from buried stems root well.

## General

**Plant Description:** An evergreen shrub, 0.2-1.5m tall [1]. The stems and twigs are covered in fine brown hairs. The leaves are fragrant, dark green on the upper surface and brown and hairy on the lower surface. Leaf margins are smooth, curling under, rounded at the tip, 2 to 5cm long and 1.5 to 2.5cm wide. The flowers occur at the top of the plant in clusters, forming a dome shaped flower head. Flowers are small and white, each with 5 petals, up to 35 flowers per head.
**Field Identification:** Bog Labrador tea is often found growing in dense stands. Recognized by its fragrant leaves that have a woolly under surface. **Similar species:** Sheep's laurel (*Kalmia polifolia*) grows in similar environments and has a similar growth to bog Labrador tea, however its leaves and flowers are unlike those of bog Labrador tea. Marsh Labrador tea (*Rhododendron tomentosum*) has thinner leaves and more prominent, sunken mid-veins on the upper leaf surface.
**Life Form:** A perennial, evergreen shrub; stems and leaves persist through all seasons, buds are above ground [2].
**Reproduction:** Relies on both sexual and asexual reproduction. Asexually this species reproduces by layering, especially important for survival and re-establishment post fire [3]. Flowering occurs in the spring to early summer [1].

**Continental Range:** This species is present in all Canadian provinces and Alaska [4]. This species is restricted to the northern United States.
**HBL regional Range:** Widespread and abundant in the Hudson Bay Lowlands [5].
**Habitat:** Tolerant of poorly drained habitats, including muskegs, spruce forests, swamps, streams and alpine to tundra zones; 0-2000m [1].

*Photo 2: Note the densely hairy underside of leaves. The hairs on the newer leaves are white and will become rusty with time.*

## Reclamation value

In the Northwest Territories, bog Labrador tea was seeded on a cleared right of way at a rate of 0.5g/$m^2$ and had 375 seedlings/$m^2$ grow in the first season (cited in [3]). Bog Labrador tea has specific germination requirements of soil type and pH, so may be useful for revegetation of specific sites, with a thick organic layer.
**Nitrogen fixing:** No.
**Symbioses:** Forms ericoid mycorrhizal associations [6].
**Growth rate:** Slow [7].
**Successional stage:** Late successional species, not a good primary colonizer of recently disturbed sites, unless bog Labrador tea was previously established at that site, such as post-fire sites [3].

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# bog Labrador tea

## Seed and capsule properties

**Capsule description:** Mature seeds are found in capsules [1]. There are 10 to 35 capsules per flower head. Capsules are tan at maturity, splitting open from 5-valves to release seeds.
**Dispersal:** Primarily wind dispersed [8].
**Propagule weight:** (winged, dried seed) 0.01 mg [9].
**Seeds /propagule:** Up to 50 seeds/ capsule, 10 to 35 capsules per flower head [1].
**Seed size and description:** Seeds are very small, about 2mm long and 0.2mm in diameter, they have two tails or wings at the end of their seeds that are not removed in the cleaning process. Brown at maturity.
**Average seed weight:** (air-dried seed) 0.01 mg [9].
**Seeds/kg:** Over 100 million seeds/kg [9].

*Photo 3: Bog labrador tea with mature seed capsules.*

## Seed collection

**Timing collections:** Small capsules containing mature seed develop in the fall (August to September). Mature when capsules are tan in colour. To examine seed readiness, rub a capsule between your fingers and check for small brown seeds that fall like dust from the capsule.
**Collection protocols:** Hand collect by cutting or pulling entire seed heads from the plant. Collect into a hands free collection container such as a bucket that is wrapped around the collector. Set capsules out to dry in paper bags or on trays, capsules may burst open while drying and release seed so ensure seeds can be easily recovered.
**Collection effort:** One collector picked 18g of pure, dry seed in one hour.
**Potential density:** No information found.
**Cautions:** None known.

## Propagule processing

**Processing protocols:** Dried capsules can be threshed on a flat rubber mat, the goal is to open the capsules to release the seed. Sieve materials in stacked sieves #35, #60, #140, bottom pan. Return any intact capsules to the threshing mat and repeat. Seed purity is about 57% due to large amounts of chaff from broken capsules.
**Cautions:** None known.

*Photo 4: Crushed bog Labrador tea capsules. Re-thresh this material to further release seed.*

## Storage

**Storage behaviour:** Orthodox [2].
**Storage requirements and longevity:** Seed viability decreased from 58% to 40% (germination rates) after 8 months in open storage, compared to fresh seed [10].

## Seed Propagation

**Dormancy classification:** Likely non-dormant.
**Potential viability:** Seed fill ranged from 17% to 44% in our collections.
**Pre-treatments:** Several studies show no pre-treatments are required to germinate this seed [2,11], however germination rates may improve with a 60 days of cool-moist stratification [10,12].
**Germination protocols:** Seeds receiving no pre-treatments, grown on a moist medium at 30°C and 8/16 hours of light/ dark had 100% germination rates [2]. Light is required for germination and a soil medium with an approximate pH of 5.5 is best, peat is a typical substrate [11]. Germination was very reduced on a substrate with pH 7.5 or higher and at temperatures less than 15°C [11]. Fluctuating temperatures of 25/8°C and 14/10 hours light/ dark cycles were optimal germination temperatures in another study.

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**Other propagation methods:** Propagation by cuttings from buried stems is possible [13]. Cuttings taken and planted outside in July in Alaska had 77% survival and shoot production after 45 days [13]. Plants can be divided in winter and transplanted [14].

**Field planting:** Seeds planted in greenhouses grew to approximately 4mm after 4 months of growth, specific substrate is necessary for survival and successful establishment of seed, related to the pH [10]. Seeds can be planted in the fall the same year of collection however the substrate must be slightly acidic and hold moisture. Seeds are small and require light to germinate, they should be surface sown and kept moist.

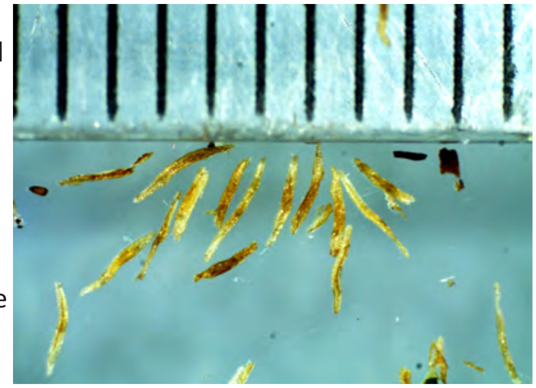

*Photo 5: Bog Labrador tea seed.*

## Other

**Canadian commercial sources:** None found.

**Useful links and further reading:**

https://gobotany.newenglandwild.org/species/rhododendron/groenlandicum/
https://era.library.ualberta.ca/files/6h440t15s/Rhododendron%20groenlandicum.pdf
http://www.northernontarioflora.ca/description.cfm?speciesid=1000637
http://www.wildflower.org/plants/result.php?id_plant=LEGR

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13. Calmes, M. A. & Zasada, J. C. Some reproductive traits of four shrub species in the black spruce forest type of Alaska. *Can. field-naturalist* **96,** 35–40 (1982).
14. Anderson, M. *Plant Guide for bog Labrador tea (Ledum groelandicum)*. (2011).

# red currant

Family: Grossulariaceae

Scientific name: *Ribes triste* Pall.

Cree Name: ___________

Synonyms: *Ribes rubrum var. alaskanum, etc*


Photo 1: Red currant plant with ripe berries.

## Quick Seed Guide

**When and what to collect**: In August berries will ripen, changing from a green to bright red. Collect by hand and cover productive patches with netting.

**Seed Processing**: Blend 3:1, water:berry. Reserve sunken seed. Dry, thresh and winnow for pure seed.

**Storage:** Dry seed, keep in sealed containers at cool temperatures for long periods.

**Pre-treatment of seed:**
200 days.

**How to Grow:** Seed: Germinate with equal light and dark at 16°C to 25°C. Vegetative: Stem cuttings in the fall.

## General

**Plant Description:** Deciduous shrub, 0.3 to 1m tall [1]. Red currant has no thorns on its stems or in the nodes. Leaves are 3 to 5 lobed with toothed margins, arranged alternately. The upper surface of the leaf is smooth, but the underside is hairy. Flower heads hang underneath the leaves from the leaf nodes. Flower heads have 6 to 13 small pink, or reddish flowers, flowers are 5 lobed. Berries are edible, red with a smooth surface, 6 to 10 mm in diameter.

**Field Identification:** The red, smooth surfaced berries and thorn free stem distinguish this currant from other currants (*Ribes* spp.) **Similar species**: Skunk currant (*Ribes glandulosum*) is similar, but the outer surface of the fruit is hairy and the leaves have a skunk odour.

**Life Form:** Deciduous shrub: stems persist in the winter month, buds are 0.5 to 3m above the ground.

**Reproduction:** Flowering from May to July [1]. Plants begin producing seeds at 3 to 5 years of age [2]. Plants also reproduce by layering [2].

**Continental Range:** This species is present in all Canadian provinces and Alaska [3]. Restricted to the northern United States.

**HBL regional Range:** Widespread and abundant in the Hudson Bay Lowlands [4].

**Habitat:** Habitat varies from moist to well drained sites; Bogs, coniferous and mixed woods, stream banks, seepage areas, montane rock slides; 0-1200 m[1].


Photo 2: Red currant shrub with immature berries.

## Reclamation value

**Nitrogen fixing:** No.

**Symbioses:** Unknown. Mycorrhizal associations were lacking in all skunk currant plants examined from a boreal forest in northeastern Ontario [5].

**Growth rate:** Moderate [6].

**Successional stage:** Red currant is found in all successional stages [2].

## Seed and fruit properties

**Fruit description:** Berries red at maturity, smooth surface, 6 to 10mm in diameter [1].

**Dispersal:** Fruit is eaten by animals.

**Fruit weight:** (dried whole berry) 35.6 mg [7], (fresh weight) 134mg per berry.

**Seeds/ berry:** Our collections had an average of 3 seeds per fruit and a maximum of 10.

**Seed size and description:** Seeds are tan, red, or brown at maturity, the seed surface is lightly pitted. Seeds are round and hard, about 2.5mm long and 2mm in diameter.

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# red currant

**Average seed weight:** (clean, dry seed) 2.9mg [7].
**Seeds/kg:** Approximately 350 000 seeds/kg [7].

## Seed Collection

**Timing collections:** Berries that are bright red are ready for collection. Berries were ripe in early August in our region. Fruitful patches of plants can be covered with a mesh netting once green berries have formed to prolong the collection window and so animals cannot consume the fruit.
**Collection protocols:** Collect by hand or using a berry rake. Use a collection container that can be strapped to your body so you have both hands free to collect. Berries are sometimes hidden under leaves of the plant. Place berries in refrigerator until processing is possible.
**Collection effort:** One collector can harvest an average of 19g (5 to 31g) pure, dried seed in one hour.
**Potential density:** No information found.
**Cautions:** None known, berries are edible.


*Photo 3: Red currant berries in the blender for processing.*

## Propagule processing

**Processing protocols:** Berries are processed in a blender with dulled blades, with 3:1 (or higher), water: fruit. Pulse blend at 2 second intervals until all berries have been crushed. Discard floating pulp and floating seed. Pour sunken seeds and materials into a sieve. Place on paper towels or a surface for drying. Dried seeds can be threshed and winnowed to remove any remaining pulp. Seed purity is almost 99%.
**Cautions:** None known.


*Photo 4: Sunken seed and pulp from red currant berries will be set out to dry. A quick thresh and winnowing will remove the pulp from the mix.*

## Storage

**Storage behaviour:** No data available for species. Of the currant (*Ribes)* taxa, 96% have orthodox storage behaviour, 3.5% are uncertain.
**Storage requirements and longevity:** Seeds of currants can be stored for long periods if dried and placed in sealed containers at cool temperatures (1 to 5°C) [8].


*Photo 5: Red currant seed.*
*(inset photo) Sectioned red currant seed, seeds are viable.*

## Seed Propagation

**Dormancy classification:** Other currants have a physiological dormancy [9].
**Potential viability:** Our seed had viabilities of 95%.
**Pre-treatments:** Seeds require cool-moist stratification for 120 to 200 days [8]. Scarification in 10% sulphuric acid can improve germination percentages of some currants.
**Germination protocols:** Seeds of other currants germinate well on a moist substrate between 16°C to 25°C and 8/16 hours or 12/12 hours of light/dark cycles [10].
**Other propagation methods:** Many currants can be propagated by stem cuttings taken in the fall [8].
**Field planting:** Plant untreated seed in the fall to a depth of 0.3 to 0.8cm [8]. If spring planting, seed should be pre-treated in cool-moist conditions.

## Other

**Canadian commercial sources:**

http://beautifulblooms.ab.ca/ecom/?category=14&start=12

**Useful links and further reading:**

Online identification key to Ontario *Ribes*: http://www.northernontarioflora.ca/genusdescription.cfm?genusid=1000236

https://gobotany.newenglandwild.org/species/ribes/triste/

https://nativeplants.evergreen.ca/search/view-plant.php?ID=00990

https://era.library.ualberta.ca/files/8p58pd59w/Ribes%20triste.pdf

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# prickly rose

Family: Rosaceae

Scientific name: *Rosa acicularis* Lindl.

Cree Name: ___________

Synonyms: None found, two recognized subspecies.

Photo 1: Prickly wild rose plant with ripe rose hips.

## Quick Seed Guide

**When and what to collect**: Rose hips ripen in August to September, mature when they are red in colour. Collecting rose hips early, when they are still orange may reduce seed dormancy.

**Seed Processing**: Blend rose hips and other materials. Dry. Thresh and winnow for pure seed.

**Storage:** Store dry in sealed containers at cool temperatures for long term storage.

**Pre-treatment of seed:** Cool stratify 120 days then warm stratify for 60 days.

**How to Grow:** Seed: Germinate at 20/10°C and 16/8 hours of light/dark Vegetative: Stem and rhizome cuttings.

## General

**Plant Description:** A deciduous shrub, typically 50 to 200cm [1]. Branches from the middle to the top of the plant are alternate. The bark is mostly red with varying amounts of thorns, especially thorny on new growth. Compound leaves, 5 to 7 round leaflets; leaf margins are toothed. Flowers from light to dark pink, large 3 to 6cm wide, fragrant, 5 petals. A large ovary is seen at the base of the flower. Rose hips are orange-red to bright red.

**Field Identification:** Prickly wild rose can be identified by its armed stem, compound leaves, and showy fragrant flower and by their rose hips that sometimes persist from the previous year. **Similar species:** Smooth wild rose (*Rosa blanda*) has no or fewer thorns along the main stem.

**Life Form:** Deciduous shrub; buds are 0.5 to 3m above the ground.

**Reproduction:** Reproduces by seed and vegetatively by long underground rhizomes [2]. A single clone often has 8 to 11 stems. Seed production is less common for shaded plants (cited in [2]). Flowering occurs from May through to July [1].

**Continental Range:** This species is found in all Canadian provinces except Newfoundland and Prince Edward Island, populations in New Brunswick and Nova Scotia are considered critically imperiled [3]. In the United States, prickly wild rose is mostly present in the northern and central states.

**HBL regional Range:** Widespread and abundant in the Hudson Bay Lowlands [4].

**Habitat:** A common understory shrub in boreal coniferous and aspen forests [2], also in stony woodland clearings, grassy meadows, floodplains, disturbed river shores; 1500-2800 m [1].

Photo 2:Prickly wild rose in

.

## Reclamation value

May be used for erosion control in cold climate sites with moist to wet soil, although it is moderately drought tolerant [2,5] and spreads quickly through underground rhizomes [2]. Prickly wild rose tolerates shade and may persist from early establishment on disturbed sites to advanced succession when a canopy develops; competes well with grasses [2]. Tolerant of acidic conditions [5].

**Nitrogen fixing:** No.

**Symbioses:** Non-mycorrhizal in one study in the boreal forest [6], but many *Rosa* species form associations with arbuscular mycorrhiza [7].

**Growth rate:** Rapid [8].

**Successional stage:** Present in all stages of succession; re-establishes quickly following fire and is a pioneer on disturbed sites in Alaska (reviewed in [2]). Present in climax communities but not as abundant.

## Seed and fruit properties

**Fruit description:** Rose hips are orange-red to bright red at maturity, firm, softening after a frost.
**Dispersal:** Animals, mammals and birds [2].
**Fruit weight:** (whole, dried fruit) 554.0 mg [9].
**Seeds/ fruit:** 14 to 25 seeds per fruit [1].
**Seed size and description:** Seeds are achenes, hard, tan at maturity, 4mm long and 2 to 2.5mm in diameter [1].
**Average seed weight:** (dried, clean seed) 14.23 mg [9].
**Seeds/kg:** 70 000 seeds/kg [9].

Photo 3: Collecting rose hips using a berry rake.

## Seed collection

**Timing collections:** Rose hips can be collected in August to September, when they are bright red or orange. Rose hips are persistent on the plant for several weeks to overwinter. Apparently unripe rose hips (yellowish-orange) can be collected and have higher germination percentages than fully ripened seed, however ensure that the seeds are firm within unripe rose hips [10].
**Collection protocols:** Collect rose hips using a berry rake if plants and fruit are plentiful. Hand collection is also effective; collect with a gloved hand into a plastic bucket set on the ground or harnessed to the collector, so both hands are free for collecting.
**Collection effort:** Berry rake: 589g of dried pure seed collected in one hour. Hand collection: 280g dried pure seed collected in one hour from the same stand.
**Potential density:** No information found.
**Cautions:** Stems thorny; wear gloves. Rose hips are edible.

## Propagule processing

**Processing protocols:** Blend fruits in a blender with 3 parts water, 1 part fruit. You do not need to remove leaves from your collections before blending. Pulse blend for 3 second intervals until fruits are fully crushed. Pour off floating seeds or pulpy material. Reserve sunken material and set out to dry. Thresh the dry material on a corrugated rubber mat. Winnow in front of a strong air force to remove chaff. Seed purity is 99.5% using these methods. Note: if you plan to germinate seed immediately, do not dry and place immediately into pre-treatment conditions. After blending, rinse seed and float off as much pulp as possible; seed will still be fairly pure.
**Cautions:** None known.

*Photo 4: Slightly unripe rose hips are pictured on top contrasting with fully ripe, red rose hips.*

*Photo 5: Crushed rose hips. Set this material out to dry, quickly thresh then winnow for pure seed.*

## Storage

**Storage behaviour:** No data available for species. Of known storage behaviours for the genus *Rosa*, over 90% are orthodox and approximately 10% are uncertain [11].
**Storage requirements and longevity:** Seeds of roses (*Rosa* ssp.) can be stored dry and cool in sealed containers for up to 4 years [12].

## Seed Propagation

Photo 6: Prickly rose seed. W

brown seed.

**Dormancy classification:** Physiological dormancy [13].

**Potential viability:** Seed viability from our collections was 66% to 89% for cleaned seed.

**Pre-treatments:** Cool-moist stratification for 120 days, followed by 60 days of warm stratification had the best germination results [10]. Shorter cool-moist stratification and prolonged warm stratification reduced germination capacity [10]. Another author reports pre-treatments beginning with warm stratification at 25°C for 115 days, followed by cool-moist stratification for 110 days at 5°C at which point germination begins [14]. Chemical scarification does not enhance germination [14].

**Germination protocols:** Seeds of prickly wild rose will germinate at temperatures as low as 5°C following pre-treatments [14]. Optimal temperatures however at 20/10°C and 16/8 hours of light/dark achieve over 90% germination.

**Other propagation methods:** Rhizome cuttings have high success [2], but require more labour to extract roots and disrupts the soil. Softwood and semi-hardwood cuttings have been successfully rooted to 85% or more [15]. Hardwood cuttings taken in October to December, treated with rooting hormone, rooted after four months in cool conditions in a peat medium, with 85% rooting success [15]. Softwood cuttings taken from the new growth of seedlings were treated with rooting hormone and planted in a fine sand and heated had over 90% rooting in two weeks [15].

**Field planting:** If planting is intended that same season, seed should not be allowed to dry, but kept moist until planting, to reduce seed dormancy [12]. Seed can be out planted but should be covered with a soil medium and/ or mulch [12]. Fall sown seeds have higher emergence than spring sown seeds or whole fruit, nearly 4% emergence by the second season[16].

## Other

**Canadian commercial sources:**

http://beautifulblooms.ab.ca/ecom/?category=12&start=48

## Useful links and further reading:

https://gobotany.newenglandwild.org/species/rosa/acicularis/
http://www.colinherb.com/Rosaceae/Rosa/Acicularis/Rosa_acicularis.htm
https://www.fs.fed.us/database/feis/plants/shrub/rosaci/all.html
https://nativeplants.evergreen.ca/search/view-plant.php?ID=00579
http://www.borealforest.org/shrubs/shrub38.htm

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16. Smreciu, A. & Gould, K. Field emergence of native boreal forest species on reclaimed sites in northeastern Alberta. *Nativ. Plants J.* **16,** 204–226 (2015).

# American red raspberry

Family: Rosaceae

Scientific name: *Rubus idaeus* L.

Cree Name: ___________

Synonyms:

*Photo 1: American red raspberry plant with developing fruit.*

## Quick Seed Guide

**When and what to collect**: Berries ripen in August and can be collected when they are red and have softened.

**Seed Processing**: Place fruit in a blender with water. Allow seed to settle, continue to rinse and pour of pulp, repeat until water is clear, reserve seed and allow to dry.

**Storage:** Seed is not sensitive. Dry and store cool to maintain viability.

**Pre-treatment of seed:** Cool stratify for 120+ days. Acid scarify or a warm stratify before cool-stratifying may improve germination percentages.

**How to Grow:** Seed: Germinate at 30/20°C or 15/10°C with equal light/dark. Vegetative: Stem and root cuttings.

## General

**Plant Description:** A deciduous shrub, typically 1 to 2m tall, often forming thickets [1]. Its stems are armed with many small thorns, reddish brown to tan in colour, the bark usually peeling with age. Compound leaves, with 3 to 5 leaflets, rough to touch, leaf margins toothed. Flowers are white with 5 petals, shedding quickly after opening. Fruits are like the well-known raspberry, bright red when ripe containing many druplets holding seeds.

**Field Identification:** Red raspberry can be distinguished by its red fruit, thorny stems, and vertical growth. **Similar species:** Several other Rubus species are found in Ontario, refer to http://northernontarioflora.ca/description.cfm?speciesid=1003129 for more information on similar *Rubus* species in Ontario.

**Life Form:** Biennial deciduous shrub; Stems dieback every two years, but is a perennial from underground rootstock; buds are 0.5 to 3m above ground [2].

**Reproduction:** This species has many reproductive methods including seed production, spreading from suckering roots or rhizomes [2]. American red raspberry is capable of producing seed without pollination and this contributes to this plant's ability to spread aggressively. Seed production occurs in two year old stems [2]. Flowering May to July [1].

**Continental Range:** This species is present in all Canadian provinces and Alaska [3]. Found in much of the U.S. south to New Mexico.

**HBL regional Range:** Widespread and abundant in the Hudson Bay Lowlands [4].

**Habitat:** Fields, woodlands, roadsides, disturbed areas, dry to moist soil; 0-3400 m [1].

*Photo 2: American red raspberry growing on an eroded slope with hard packed mineral soil.*

## Reclamation value

Red raspberry is a drought tolerant species and had been used successfully for stabilization of road cuts in Utah and for erosion control in Alberta (cited in [5]). Tolerant to a variety of soil textures, moderate salinity, and acidic soils [5]. Recommended for establishment in cold climates, on well-drained soils [2]. Has established from seed on reclaimed oil sands sites in Alberta [6] and in the Hudson Bay Lowlands on amended kimberlite and mine waste soils [7].

**Nitrogen fixing:** No.

**Symbioses:** Arbuscular mycorrhizal and non-mycorrhizal [8].

**Growth rate:** Rapid [9].

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# American red raspberry

**Successional stage:** Early successional sites, a pioneer on disturbed sites [2]. Shade intolerant, is replaced by taller plants.

*Photo 3: Collecting American red raspberry fruit with a berry rake.*

## Seed and fruit properties

**Fruit description:** A red, soft and juicy berry at maturity.
**Dispersal:** Animals eat the fruit.
**Fruit weight:** (dried whole berry) 108.7mg [10].
**Seeds/ fruit:** Ten to 60 seeds per fruit [1].
**Seed size and description:** Seeds are kidney shaped with a pitted surface, light pink or tan at maturity, +/- 2mm long and +/- 1mm wide.
**Average seed weight:** (dry, clean seed) 1.5mg [10].
**Seeds/kg:** 667 000 seed/kg [10].

## Seed collection

**Timing collections:** American red raspberry fruits ripen at the end of July to the end of August. Collect red berries when they are soft and easily squished. Berries are often abundant, but netting can be wrapped around plants to reduce herbivory and extend the collection window. Berry ripening is somewhat uneven.
**Collection protocols:** Collect into plastic buckets resting on the ground or harnessed to the collector so you can utilize both hands. Berry rakes were tested but resulted in similar collection quantities and large amounts of leafy material and unripe berries.
**Collection effort:** One collector picked 41 to 62g of pure, dried seed in one hour.
**Potential density:** Over 14 000 seeds/$m^2$ in dense four year old stands [11].
**Cautions:** Plants armed with thorns, wear gloves.

## Propagule processing

**Processing protocols:** American red raspberry fruits clean very well and easily in a blender. Place fruits in water (use about 2:1 to 5:1, water: fruit or) and run the blender until the fruit is fully crushed, about 30 seconds. Pour material into a sieve and rinse underwater. Return to a large bucket of water and float off pulp and empty seeds. If your collections are clean the sunken seed will be nearly 100% pure, full seed.  Strain material and set out to dry. If your collections contained leafy material, thresh and winnow the sunken material after it has dried.
**Cautions:** None known, berries are non-toxic.

*Photo 4: Raspberries in preparation for blending.*

*Photo 5: Raspberry seed after several rinses to remove pulp. Sunken material is nearly pure seed.*

## Storage

**Storage behaviour:** Probably orthodox [12].
**Storage requirements and longevity:** Dry seed and store in sealed containers at low temperatures [13]. American red raspberry seeds are very long-lived with approximately 50% of seed remaining viable after 150 years in the soil seed bank [11].

# American red raspberry

## Seed Propagation

Photo 6: American red raspberry seed.

**Dormancy classification:** Physiological [14].
**Potential viability:** Our cleaned seeds had 76 to 100% viability and likely varied due to differences in the cleaning regime.
**Pre-treatments:** Seeds of American red raspberry will germinate after 120+ days of cool-moist stratification [13]. However scarification in concentrated sulphuric acid for 20 minutes prior to 120 days of cool-moist stratification gives better results [15,16]. Alternatively warm stratification at 20 to 30°C for 90 days, followed by cool-stratification for 90 days can break dormancy [17].
**Germination protocols:** Germination percentages up to 87% at 30°C/20°C or 15°C /10°C and 8/16 hours of light/dark cycles for pre-treated seed [17]. Germination begins after 10 days.
**Other propagation methods:** Semi-hardwood cuttings take in early August, cut to 15 to 25cm long, and a stem diameter of 1cm minimum [18]. Cuttings treated with rooting hormone 2000ppm Naphthaleneacetic acid (NAA) had 69% rooting after 16 to 20 weeks. Some of these rooted cuttings rotted before they were transplanted. Root cuttings, taken when the plant is dormant have also been successful [2,19].
**Field planting:** Fall planted seed sown to a depth of 0.3 to 0.5cm have been established [2]. Cleaned seeds planted in the fall have superior emergence to seeds sown in the spring or whole fruits sown in spring or fall on reclaimed oil sands sites in Alberta [6]. Emergence rates are approximately 2% by the second season [6].

## Other

**Canadian commercial sources:** None found.
** *Rubus idaeus* ssp. *idaeus* is the cultivated European variety; use seed sources that make the distinction between native varieties and cultivars.
**Useful links and further reading:**
http://northernontarioflora.ca/description.cfm?speciesid=1003129
https://gobotany.newenglandwild.org/species/rubus/idaeus/
https://www.fs.fed.us/database/feis/plants/shrub/rubida/all.html
http://www.wildflower.org/plants/result.php?id_plant=RUIDS2
https://nativeplants.evergreen.ca/search/view-plant.php?ID=01602

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7. Hanson, A. Testing technosols over an ultramafic gradient for rehabilitation of diamond mine wastes in a subarctic region. (Laurentian University, 2017).
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# dwarf red raspberry

Family: Rosaceae

Scientific name: *Rubus pubescens* Raf.

Cree Name: ___________

Synonyms: One accespted variety

## Quick Seed Guide

**When and what to collect**: Fruit ripens in August; look under leaves for deep red fruit. Hand collect.
**Seed Processing**: Blend; pour of pulp. Dry sunken material, thresh then winnow to remove chaff.
**Storage:** Dry seed and store in cool temperatures in sealed containers.
**Pre-treatment of seed:** Cool stratify 90 to 120 days.
**How to Grow:** Seed: Optimal germination temperatures, 21-23°C. Vegetative: Stem cuttings.

## General

**Plant Description:** A herbaceous shrub that grows along the ground rather than upwards, up to 40cm tall [1]. Stems may be moderately hairy or smooth but have no thorns. Compound leaves with 3 leaflets, pointed at the tip, margins toothed. Flowers are white, 5-petals, in groups of 1 to 3 arising from a long stalk. Fruits a deeper red than commercial raspberries.
**Field Identification:** A low creeping shrub with 3 leaflets, 5-petaled white flower and unarmed stem. **Similar species:** Northern dwarf raspberry (*Rubus acaulis*) is very similar but has pink to purple flowers and broader pointed or round leaf tips. Other similar raspberries (*Rubus* ssp.) have simple leaves rather than compound leaves. Strawberry (*Fragaria virginiana*) has rounder leaves and produces strawberry fruit.
**Life Form:** Perennial, herbaceous and deciduous shrub; stems persist through the winter month, buds are above the soil surface.
**Reproduction:** Produces by seed and vegetatively [2]. Dwarf red raspberry reproduces by primocanes, root suckers, and sprouts [2]. Flowering May to July [1].

**Continental Range:** This species range extends through all of Canada [3]. Not present in Alaska. Dwarf raspberry is restricted to northern United States, south as far as Colorado, extending from west to east.
**HBL regional Range:** Widespread and occasional in the Hudson Bay Lowlands [4].
**Habitat:** A range of moisture and habitats, shade tolerant, but also common in full exposure sites. Swamps, bogs, fens, stream banks, moist woods, gravel sites, sandy soil; 0-2200 m [1].

*Photo 2: Dwarf red raspberry plants naturally recolonizing an old mine exploration camp.*

## Reclamation value

Forms a dense ground cover. Reproduces and spreads vegetatively [2]. A long-lived herbaceous shrub, living up to 30 years and may persist from early successional conditions on bare mineral soil into a closed canopy [2].
**Nitrogen fixing:** No.
**Symbioses:** Vesicular arbuscular mycorrhiza [5] and non-mycorrhizal [6].
**Growth rate:** Likely rapid [7] produces independent vegetative offsets after one year of growth [2].

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# dwarf red raspberry

**Successional stage:** Persists from early successional to late successional conditions [8]. We have found dwarf red raspberry naturally colonizing gravelly soils with few other species. Also a dominant species on highly disrupted river shorelines with exposed mineral soils.


Photo 3: Dwarf red raspberry fruit.

## Seed and fruit properties

**Fruit description:** A deep red coloured raspberry, soft and juicy at maturity [1]. The fruit doesn't detach from the leafy receptacle like fruits from American red raspberry (photo 3) [1].
**Dispersal:** Animals consume berries.
**Fruit weight:** (whole, dried berry) 31.4mg [7], (fresh whole berry) 325mg.
**Seeds/ fruit:** Our fruits had an average of 7.7 seeds per berry, 10 to 25 seeds per berry possible [1].
**Seed size and description:** Seeds are kidney shaped,about 3mm long and 2mm wide, hard, have a pitted surface, tan to light pink at maturity.
**Average seed weight:** (cleaned, dry seed) 2.00 mg [7].
**Seeds/kg:** 500 000 seeds/kg [7].

## Seed collection

**Timing collections:** Raspberry berries are red and soft to touch when ripe. Berries ripen continuously from the end of July to the end of August, peaking in early August in our region. Berries are quickly consumed by animals as they ripen.
**Collection protocols:** Fruits are often hidden under leaves, are spaced apart, and grow low to the ground making this species a challenge to collect. Lift the leaves to find berries, collect into a basket or a bucket harnessed to the collector because fruit density is low and you will need to regularly move between plants for collecting. Keep berries in the fridge until processing.
**Collection effort:** One collector picked an average of 8g, pure dry seed in one hour.
**Potential density:** Average density: 55 seeds/m$^2$ (range: 4 to 107) [2].
**Cautions:** None known.


Photo 4: Cleaned dwarf red raspberry seed.

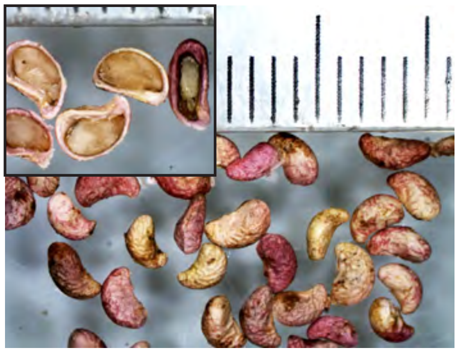
Photo 5: Dwarf red raspberry seed. (inset photo) Sectioned seed.

## Propagule processing

**Processing protocols:** Removing leaves from your collections is not required. Place fruits in a blender with water (use about 2:1 to 5:1, water: fruit) and run the blender until the fruit is fully crushed, 30 seconds or more. Pour material into a sieve and rinse underwater. Return to a large bucket of water and float off pulp and empty seeds. Strain material and set out to dry. Thresh dried material on a corrugated rubber mat and winnow to remove any chaff.
**Cautions:** None known.

## Storage

**Storage behaviour:** No data available for species. Most raspberries (*Rubus* ssp.) with known storage behaviour are orthodox, some are uncertain.
**Storage requirements and longevity:** Dry seed and store in sealed containers at 1 to 5°C [9]. Seeds are not long lived in the soil seed bank [2].

## Seed Propagation

**Dormancy classification:** Unknown for this species, other *Rubus* ssp. have a physiological dormancy [10].
**Potential viability:** Our collections had an average of 46% viable seed.
**Pre-treatments:** Standard pre-treatments include a 90 to 120 day cool-moist stratification [10]. In natural conditions, seeds germinate the following spring after a winter chill [2].
**Germination protocols:** Other raspberries germinate at an optimal temperature of 21-23°C [10]. In field experiments, 69% (84% of viable seed) of buried dwarf red raspberry seeds germinated in the spring after a winter chill, however survival of seedlings was poor.
**Other propagation methods:** Stem cuttings taken in July to August, or tip layering [11].
**Field planting:** Plant seed in the fall for spring emergence.

## Other

**Canadian commercial sources:**
http://botanicallyinclined.org/seeds-shop/rubus-pubescens-buy-seeds/
**Useful links and further reading:**
https://gobotany.newenglandwild.org/species/rubus/pubescens/
http://www.northernontarioflora.ca/description.cfm?speciesid=1005057
http://www.pfaf.org/user/Plant.aspx?LatinName=Rubus+pubescens
https://nativeplants.evergreen.ca/search/view-plant.php?ID=01109

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# false mountain willow

Family: Salicaceae

Scientific name: *Salix pseudomonticola* C.R. Ball

Cree Name: ___________

Synonyms: *Salix barclayi var. pseudomonticola*, etc.

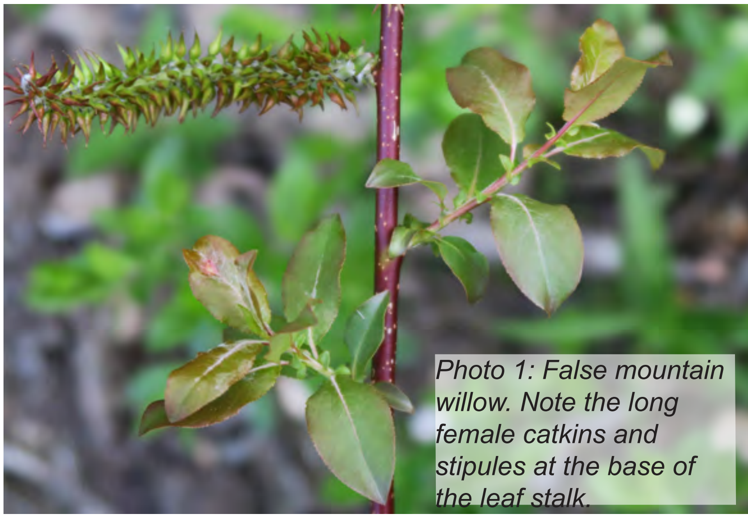

*Photo 1: False mountain willow. Note the long female catkins and stipules at the base of the leaf stalk.*

## Quick Seed Guide

**When and what to collect**: Collect catkins in July when capsules are plump and seeds inside are dark and plump (but small)

**Seed Processing**: Dry catkins, process using the shop vacuum method, refer to seed processing below.

**Storage:** Seed is sensitive. If seed is well dried it can be kept in sealed containers at -10˚C for 3 years.

**Pre-treatment of seed:** None required.

**How to Grow:** Seed: Seed grows at a wide range of temperatures, requires light. Vegetative: Stem cuttings taken when the plant is dormant.

## General

**Plant Description:** A deciduous shrub, reaching 1 to 6m in height [1]. Stems range in colour from red-brown, to yellow brown, smooth, not hairy. The youngest branches are also variable in colour and can be smooth or hairy. Leaves and branching arrangement is alternate. Leaves are pointed at the tip, the base of the leaf asymmetric, 2 to 8.5cm long and 1.2 to 5cm wide, a prominent mid-rib, reddish and hairy when young, leaf margins are distinctly toothed. Leaves are stalked and at the base is a stipule (smaller leaf) 1 to 1.5cm long. Female and male catkins emerge before the leaves have fully expanded. Female catkins are 1.5 to 9cm long, not stalked [1,2].

**Field Identification:** The willows are not easy to identify; even experienced botanists have difficulty identifying these species, because they have so much variation in their appearance and regularly hybridize, lending to traits that fit description of multiple species. Sources for willow identification are provided below in further reading. False mountain willow is recognized by several traits: 1. Leaf shape, with asymmetric base and many fine teeth along the margins, stipules at the base of the leaf, 2. Unstalked female catkins (up to 9cm long), pear shaped capsules (5 to 7mm long) that are not hairy. **Similar species:** Many willows resemble false mountain willow, however the most similar species includes: blue-leaved willow (*Salix myricoides*) which has shorter female catkins (3 to 6cm) and more slender leaves and Missouri willow (*Salix eriocephala)* whose leaves are 5 to 15cm long [2].

**Life Form:** A deciduous shrub; stems persist during the winter months, buds are above ground.

**Reproduction:** Dioecious (separate male and female plants). Reproduces by seeds, flowering late April to early June [1].

**Continental Range:** Present in all Canadian provinces except Nunavut and the maritime provinces, populations in Quebec are considered imperiled [3].

**HBL regional Range:** Widespread and occasional in the Hudson Bay Lowlands [4].

**Habitat:** Drainages in white spruce forests, treed bogs, balsam poplar forests, floodplains, river banks, gravelly clearings; 0-2500 m [1,2].

*Photo 2: Female catkins beginning to*

## Reclamation value

No information on false mountain willow, however willows (*Salix* ssp.) are commonly used in revegetation and not identified to species. They are used for stabilizing soils [5], as nurse species to improve the establishment and growth of other desired species [6], and because most willows are easily propagated by stem cuttings [5].

**Nitrogen fixing:** No.

**Symbioses:** Many willows form associations with arbuscular mycorrhiza and ectomycorrhiza [7].

# false mountain willow

**Growth rate:** No information found.
**Successional stage:** Based on described habitats, this species likely persists in a range of successional stages. Willows are often the first colonizers of disturbed sites, because they produce large amounts of seed that travel long distances.


Photo 3: Blowing air with a shop vacuum into a 5 gallon pail to

## Seed and fruit properties

**Fruit description:** Seeds are attached to long silky hairs, within capsules that split open to release seed when mature. There are numerous capsules on one catkin and numerous catkins per plant. Catkins are 3 to 9cm long.
**Dispersal:** Wind. Fluffy hairs are attached to seed help them to be carried by the wind.
**Seeds/ collection unit:** Within one capsule there are approximately 18 seeds [1]. On one catkin there is upwards of 100 capsules.
**Seed size and description:** Seeds are bottle shaped, greenish-blue at maturity about 0.9mm and 0.2mm in diameter.
**Average seed weight:** (cleaned, dry seed) 0.1mg.
**Seeds/kg:** 10 million seeds/kg.

the second sieve. Blow air through the top sieve .

## Seed Collection

**Timing collections:** Female catkins are ripe in the spring, in mid-June. Collect catkins at the first site of capsules bursting or just before. To check for seed readiness, open the capsules and look for well-developed seed hairs and plump (but small) dark seeds. Seed dispersal occurs for about 1 week, leaving the collector with only a short window to collect.
**Collection protocols:** Collect whole catkins by hand; they detach fairly easily from the plant. Have a collection container harnessed to your body so you can collect with both hands and move between plants quickly in search of more female plants. Seed is easily airborne once the capsules open, so ensure that catkins are contained in a breathable container for drying. Do not leave seeds in warm conditions for prolonged periods or they will die.
**Collection effort**: One person collected an average of 23g, pure dry seed in one hour.
**Potential density:** No information found.
**Cautions:** None known.

Photo 5: Pure willow seed falls into lower sieves.

## Propagule processing

**Processing protocols:** Once the capsules have opened, they should be processed. If immediate processing is not possible, well-dried catkins can be placed in cool conditions (1 to 5°C) for a few months until processing is possible. Once capsules have opened, seed can be cleaned using a shop vacuum, sieve set, and 5 gallon bucket. **1.** Cut a tight-fitting hole into the lid of a 5 gallon bucket, so it fits your sieve. **2.** Place catkins and fluff into the pail about 1/3 of the way full. Place a fine sieve (#60 mesh) through the opening in the lid.  Blow air into the bucket, adjusting the motion and direction of the airflow to toss the plant materials for up to 30 seconds. The fluff should separate from the capsules and some seed should become dislodged and settle on the bottom of the bucket. Separate the fluff from the catkins, if no seed is trapped in the fluff, then discard; if the fluff is not clean further processing is required. **3.** Pour catkins and seed from the bucket into a #10 sieve, on a stacked sieve set for further clean. Stack sieves in this order from bottom to top: bottom pan, #60 mesh, #35, #18, #10, #140. Fill the sieve about ¾ of the way. **4.** Blow air through the top sieve using a shop vacuum moving the hose to toss the seed material. Do this for about 20 seconds, stir the catkins and repeat. The final fluff should be mostly free of seed. The seed will be trapped in the #40 and #60 sieves. If the capsules have not fully opened, return them to a paper bag for drying and you may be able to extract more seeds from the catkins.

# false mountain willow

If you do not need to quantify or clean your seed, then place dry opened capsules in a tumbler with a mixture of rocks and sand for about 20 minutes. The rocks and capsules can be sieved out and the result is a mixture of sand and seed that can be directly sown [8]. Only use this technique if seed will be immediately planted.
**Cautions:** Process catkins in a large well-ventilated space that is draft free, a mask may be worn to avoid irritation from airborne fluff.

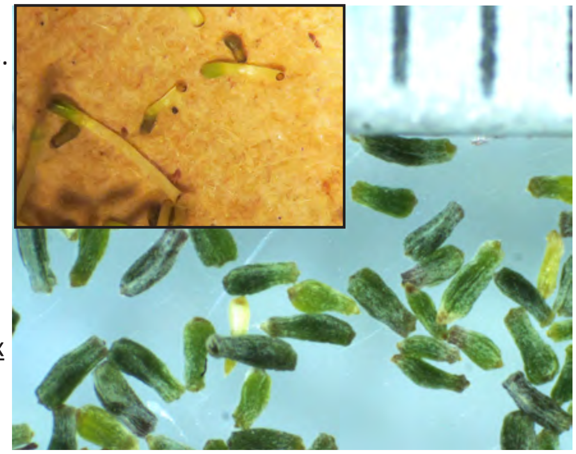

*Photo 6: False mountain willow seed and germinated seed (inset photo).*

## Storage

**Storage behaviour:** Uncertain; over 77% of willows have seed with orthodox storage behaviour; the remainder are recalcitrant or uncertain.
**Storage requirements and longevity:** Seeds of related species (*Salix*) deteriorates after 2 to 4 weeks if stored at room temperature [9]. Dried seed of three alaskan willows, *Salix bebbiana*, *S. alaxensis*, and *S. novae-agliae* showed minimal loss in viability after 3 years when they were well dried and stored in sealed bags at -10°C [10].

## Seed Propagation

**Dormancy classification:** Our collections of false mountain willow were non dormant.
**Potential viability:** Seed viability was approximately 83%.
**Pre-treatments:** No pre-treatments required.
**Germination protocols:** Seed germinates in continuous light from 5 to 25°C on a moist medium [10].
**Other propagation methods:** Willows are easily propagated by cuttings of from softwood or semi-harwood cuttings. No information found for false mountain willow. For Bebb's willow (*Salix bebbiana*) softwood and semi-softwood cuttings taken in the spring and late fall, respectively, were successfully rooted [11]. Cuttings are 15 to 30cm long. Treat the cut bottom with rooting hormone and place in a moist rooting medium such as perlite.
**Field planting:** Seed should be planted in the spring immediately after collection to avoid loss of viability.

## Other

**Canadian commercial sources:** None found.
**Useful links and further reading:**
http://web.acsalaska.net/~kenaiwatershed.forum/Willow_Guide_part_I.pdf
Book: "Shrubs of Ontario" by Soper and Heimburger 1982
http://www.flora.dempstercountry.org/0.Site.Folder/Species.Program/Species2.php?species_id=Salix.pseudo

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# russet buffaloberry

Family: Elaeagnaceae

Scientific name: *Shepherdia canadensis* (L.) Nutt.

Cree Name: __________

Synonyms: *Elaeagnus canadensis, etc.*

*Photo 1: Female russet buffaloberry plant. Note uneven ripening.*

## Quick Seed Guide

**When and what to collect**: July. Look for orange to red berries. Cover female plants with netting earlier to improve ripening evenness and increase collection window. Drop seeds onto tarp.

**Seed Processing**: Place berries in a blender with dulled blades at 3:1 water:berry. Dry seed, thresh, and winnow for further cleaning.

**Storage:** Cool and dry in sealed container, up to 5 years.

**Pre-treatment of seed:** Acid scarify, then 14 weeks cool

**How to Grow:** Seed: germinate at 30/15°C & 12/12hrs of light/dark. Vegetative: Soft-wood stem cuttings.

## General

**Plant Description:** Russet buffaloberry is a characteristic shrub 1 to 3m in height [1,2]. Twigs have opposite branching. Leaves are round at the tip and base, 3 to 5cm long, green on the upper surface, whitenend on lower surface and covered with small brown scales. Roots are variable, fibrous taproots or considered deeply rhizomatous [3]. Male and female flowers are similar. Flowers are small, yellow to tan in colour. Mature fruit is red.

**Field Identification:** Leaves are covered by brown spots, green on upper surface, whitened beneath, and opposite branching pattern. S**imilar species:** *Shepherdia argentea* found in western North America.

**Life Form:** Shrub; woody stem persists for many years and through the winter.

**Reproduction:** Perennial, dioecious. Reproduces primarily by seed. Regenerates by sprouting from the root crown, although not an aggressive grower vegetatively [3].

**Continental Range:** Buffaloberry is present throughout Canada, except in Prince Edward Island [4]. Populations in New Brunswick and Nova Scotia are considered imperiled. In the United States, populations are largely found in western and northern states.

**HBL regional Range:** Widespread and abundant in the Hudson Bay Lowlands[5].

**Habitat:** Habitat varies from dry to moist sites, found in open to partially shaded habitats, forests, fields [2,6]. Prefers calcareous soils.

## Reclamation value

**Nitrogen fixing:** Yes.

**Symbioses:** Known to form a relationship with arbuscular mycorrhiza [7]. In addition, this species is actinorhizal and associates with *Frankia* bacteria to fix nitrogen.

**Growth rate:** Rapid [8].

**Successional stage:** Early to late, ranging from disturbed open habitats to understory in old growth forest [3]. In our study it was found primarily at forest edges and on disturbed, high exposure sites [9].

*Photo 2: Russet buffaloberry growing on disturbed mineral soil. Found frequently on the*

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# russet buffaloberry

## Seed and fruit properties

**Fruit description:** Berry, 5 to 7mm long [6]. Changes from green to orange to bright red and softens with maturity.
**Dispersal:** Animal [10].
**Fruit weight:** (dried, whole fruit) 21.3mg [11].
**Seeds/ fruit:** One seed per berry.
**Seed size and description:** Round about 4mm in length.
**Average seed weight:** (cleaned; dried seed) 5.3mg [11].
**Seeds/kg:** 110 000 [12].

russet buffaloberry.

*Photo 4: Ripe russet buffaloberry fruit.*

## Seed Collection

**Timing collections:** In our region, berries began to turn red in mid July to the end of July, depending on habitat and exposure, but seed ripening was not even. Only female plants have fruit. Berries are orange to red and soft fleshed at maturity [13]. Once berries are red they are quickly eaten, unless the plant is covered with netting to prevent herbivory.

**Collection protocols:** Cover plants with a netting to improve the evenness of the fruit ripening and increase your collection window. Red-orange berries can be hand collected into plastic bags or buckets. If the berries on the plant are abundant, place a sheet below the branches to catch seed as it is tedious to hand pick individual berries into a container. Run your hand along the branch to detach berries.

**Collection effort:** (pure, dry seed) 11g/hour.

**Potential density:** No information found.

**Cautions:** None known. Berry is edible, but not palatable in our opinion.

## Propagule processing

**Post-harvest handling:** Can be stored in refrigerator in a plastic container for short periods to allow for some ripening of the berries.

**Processing protocols:** Because seed may require acid scarification as a pre-treatment, removing the flesh off the seed is recommended. Use a blender with dulled blades. Place a generous amount of water into a blender about 1:5 for berries: water. Pulse material at 2 second intervals, repeating about 6 times. Check for seed damage, although we found no seed damage when pulsing and using this ratio. After material will become foamy and soapy looking, pour everything into a sieve and rinse. Repeat if necessary. Spread seed onto paper towel and allow to dry. Seed will have a paper covering still. Once the seed is dry, place it onto a rubber surface (any rough surface would do the trick) and rub seed with a rubber paddle to remove this covering. Finally winnow this material with a table fan at a medium setting to remove impurities.

*Photo 5: Blender processed fruit. Perhaps where this plant gets its other common name, "soapberry".*

*Photo 6: Cleaned russet buffaloberry seed, following threshing and winnowing with table fan.*

**Cautions:** None known.

## Seed Storage

**Storage behaviour:** Likely orthodox [14].

**Storage requirements and longevity:** Seed can be stored for up to 5 years at 3 to 5°C in sealed containers [12].

## Seed Propagation

**Dormancy classification:** Physiological dormancy [15].

**Potential viability:** In our study, average viability of cleaned fresh seed was 79%.

**Pre-treatments:** Recommendations on the seed pre-treatment vary. High germination percentages reported after a 5 minute acid scarification of seed and a 14 week cool-stratification period [16]. The time required for acid scarification may vary. Seed dormancy will vary by seed lot, therefore an imbibition test is recommended. After pre-treating seed, place a weighed seed sample into water for one week and then reweigh. The seed will gain weight (imbibe) if dormancy is broken.

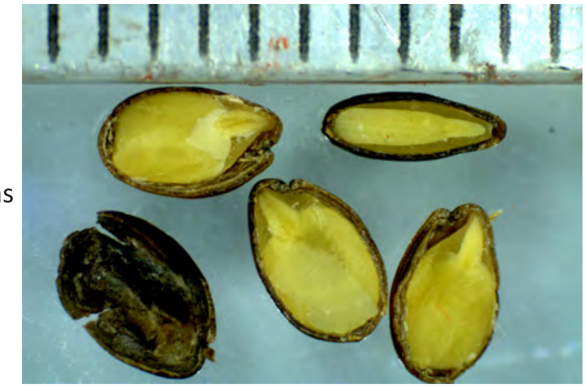

*Photo 7: Longitudinal sections of viable and non viable seed of russet buffaloberry.*

**Germination protocols:** Germination begins 4 to 6 days after planting, germination of viable seed high (>90%) at 30/15°C and approximately 12/12hr of light/dark [16].

**Other propagation methods:** Can be grown vegetatively using semi-softwood, stem tip cuttings [12]. Cuttings are collected in May when leaf buds have just begun to break dormancy. Cuttings are 15 to 20 cm in length and approximately 7mm in diameter. Using this method 67% rooting success was reported.

**Field planting:** Plant seed in the fall.

## Other

**Canadian commercial sources:** None found.

**Useful links and Further reading:**

https://era.library.ualberta.ca/files/j098zb40f/Shepherdia%20canadensis.pdf

http://www.wildflower.org/plants/result.php?id_plant=SHCA

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# mountain blue-eyed grass

Family: Iridaceae

Scientific name: *Sisyrinchium montanum* Greene

Cree Name: ___________

Synonyms: 2 recognized varieties

## Quick Seed Guide

**When and what to collect**: Capsules mature in early August. Collect when the seed inside is dark brown to black. Cut capsules off using scissors.

**Seed Processing**: Dry, thresh capsules, winnow an sieve to clean.

**Storage:** Dry seed and keep in sealed containers at 1 to 5°C.

**Pre-treatment of seed:** Warm stratify for 90 days, then mechanically scarify seed.

**How to Grow:** Seed: Germinate with gibberlic acid, at 20/10°C and 12/12 hours of light a dark. Vegetative: Plants can be divided in the spring.

## General

**Plant Description:** A small perennial herb, with grass-like leaves [1]. Grows in clumps with other plants, up to 50cm tall. Stems have wings that run the length of the stem, 2 to 3.7mm wide. One to three small purple-blue flowers with a prominent yellow center, 6-parted. At the top of the stem there is a leaf bract that extends above the flower. Capsules are round, hanging from a short stalk, green to purplish when immature, turning brown at maturity.

**Field Identification:** Mountain blue-eyed grass is not a grass, but has grass like leaves that are stiffer and stouter than many grass leaves. Recognized by its small purple flower and later by hanging capsules. **Similar species**: Stout blue-eyed grass (*Sisyrinchium angustifolium)* is very similar, but it has a long leaf (bract) that branches from the middle of the stem; mountain blue-eyed grass does not have this leaf. Refer to useful links for more online identification resources.

**Life Form:** Perennial, deciduous forb; dies back during winter months, but regenerates from buds at or below the soil surface.

**Reproduction:** Regenerates by seeds; no information on vegetative reproduction found. Flowering occurs from late spring to early summer [1].

**Continental Range:** Present in all Canadian provinces, imperiled in the Northwest Territories and Alaska [2]. Present in northern and central United States.

**HBL regional Range:** Widespread and occasional in the Hudson Bay Lowlands [3].

**Habitat:** Moist meadows, stream banks, open woods, rocky crevices, sandy to gravelly shores, disturbed areas, clearings, roadsides, banks of ditches; 0-3100m [1,4].

*Photo 2: Mountain blue-eyed grass growing on exposed mineral soil.*

## Reclamation value

**Nitrogen fixing:** No.

**Symbioses:** Vesicular arbuscular mycorrhiza [5].

**Growth rate:** Likely moderate [6].

**Successional stage:** Tolerates open, disturbed conditions. Likely an early successional species, but uncertain on persistence into other stages.

# mountain blue-eyed grass

## Seed and capsule properties

**Capsule description:** Capsules are round 4 to 6.6mm in diameter, greenish-purple, turning tan to dark brown at maturity [1].
**Dispersal:** Capsules burst open to release seed in the vicinity of the mother plant.
**Capsule weight:** (dried, whole) 2.67mg [6].
**Seeds/ capsule**: Not determined.
**Seed size and description:** Seeds are black at maturity, round, 0.9 to 1.5mm in diameter [1].
**Average seed weight:** (cleaned, dried seed) 0.69mg [6].
**Seeds/kg:** 1.45 million seeds/kg [6].

Photo 3: Mature capsules and seed.

## Seed Collection

**Timing collections:** Capsules ripen from the end of July to the end of August, peak collection time was in the first week of August in highly exposed sites. Capsules turn brown and seeds inside are a light brown to black and firm when squeezed between fingers.
**Collection protocols:** Plants often grow in clumps so scissors can be used to cut the capsules off the plants. Much of the time spent collecting may be searching for plants because they become difficult to see once the flowers have disappeared. Allow capsules to dry following collection. Capsules may burst open to release seed, so place material on a tray or in a paper bag.
**Collection effort:** Plants grow low to the ground and are sometimes difficult to see because of their small size and colouration. One collector picked an average of 38g, pure dried seed in one hour.
**Potential density:** Not determined.
**Cautions:** None known.

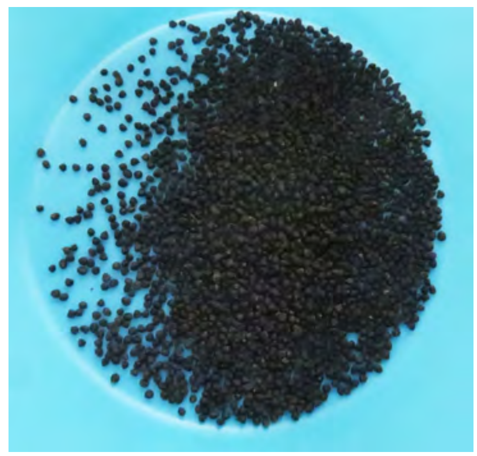

Photo 4: Cleaned blue grass seed.

## Propagule processing

**Processing protocols:** Dried capsules can be thresh ed on a corrugated rubber mat with a rubber paddle. Winnow material to remove chaff and sieve if any large pieces remain.
**Cautions:** None known.

## Storage

**Storage behaviour:** Probably orthodox [7].
**Storage requirements and longevity:** For orthodox seed, dry and store cool (1 to 5°C) in sealed containers. Seed viability was reduced to 55% after 11 months in storage at -20°C [7].

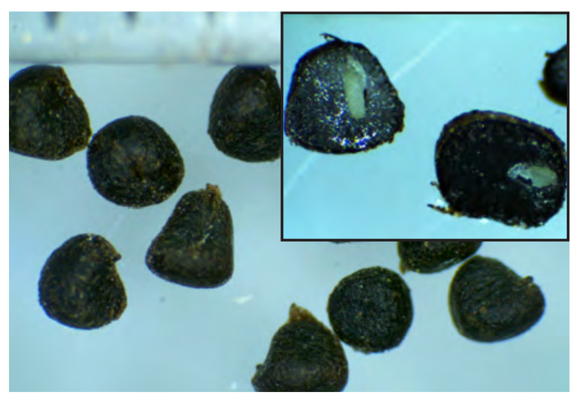

Photo 5: Mountain blue-eyed grass seed. (inset photo) Sectioned, viable seed.

## Seed Propagation

**Dormancy classification:** Not available.
**Potential viability:** Our collections had 100% seed viability.
**Pre-treatments:** Seed is warm stratified at 25/10°C on moist medium for 70 days and then mechanically scarified [7].
**Germination protocols:** Seed germination rates of 75% on a moist medium plus 250mg/L gibberlic acid, at 20/10°C, 8/16 hours of light/dark cycles [7].
**Other propagation methods:** Stems can be divided from the root crown in the early spring for the related blue-eye grass (*Sisyrinchium angustifolium*) [8].
**Field planting:** Plant seeds in late summer or fall in full sun, keep moist. Do not plant in organic soil or heavily mulch the surface, as this may lead to root rot [8].

## Other

**Canadian commercial sources:**

http://www.wildaboutflowers.ca/plant_detail.php?Blue-Eyed-Grass-85

**Useful links and further reading:**

Identification resources: http://ontariowildflowers.com/main/species.php?id=32
http://michiganflora.net/genus.aspx?id=Sisyrinchium
https://gobotany.newenglandwild.org/species/sisyrinchium/montanum/
Seeds from U.S.
https://www.prairiemoon.com/seeds/wildflowers-forbs/sisyrinchium-montanum-strict-blue-eyed-grass.html
http://www.naturenorth.com/spring/flora/begrass/Blue-eyed_Grass.html

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# Canada goldenrod

Family: Asteraceae

Scientific name: *Solidago canadensis* L.

Cree Name: ___________

Synonyms: None found, two recognized varieties.


## Quick Seed Guide

**When and what to collect**: Seed ripens from September to October. Collect when the seed hairs are visible. Use scissors to cut off the entire seed head.
**Seed Processing**: Dry, vacuum seeds to separate from the plant.
mat. Winnow.
**Storage:** Dry seed and store in sealed containers at 3 to 5°C for up to 5 years.
**Pre-treatment of seed:** None required, however some

**How to Grow:** Seed: Germinate at 25/15°C and 8/16hr of light/dark. Vegetative: Rhizome cuttings.

## General

**Plant Description:** A herbaceous, "weedy" flower growing 30 up to 200 cm tall [1]. One to over 20 stems per plant. Stems are covered in fine hairs. Leaves are alternate along the stem, 5 to 19cm long and 0.5 to 3cm wide; three distinct veins. Leaf surfaces can be rough to touch or smooth, but usually there are at least some hairs along the nerves on the upper leaf surface. Leaf margins are sharply toothed. Flowering heads are made up of 150 to over 1300 yellow flowers. The overall flowering head is shaped like a pyramid.
**Field Identification:** No basal leaves, stem leaves have 3-veins, the flowering head is pyramidal shaped. **Similar species:** Rough-leaf goldenrod (*Solidago rugosa*) leaves have one distinct midrib on their leaves, tall goldenrod (*Solidago altissima*) has smooth leaf margins compared to the toothed leaves of Canada goldenrod. Refer to http://michiganflora.net/genus.aspx?id=Solidago for a more detailed identification key and photographic demonstration of these traits.
**Life Form:** A perennial forb; dies back during winter months, regenerates from buds that survive at or below the soil surface [2].
**Reproduction:** Reproduces by seeds and by underground rhizomes [2]. Flowering is in the fall from August to October [1].

**Continental Range:** Canada goldenrod is found in all Canadian provinces, except Nunavut. Present in Alaska [3]. Present throughout the United States, although its presence in the southeastern states is conflicting between sources, suggesting this species is less common in this region [3,4].
**HBL regional Range**: Widespread and abundant in the Hudson Bay Lowlands [5].
**Habitat:** Old fields, pastures, disturbed sites, roadsides, open woods; 0-1000$^{+}$ m [1].

## Reclamation value

Canada goldenrod may have an allelopathic effect on seedlings of other plants [2]. Canada goldenrod spreads quickly by underground rhizomes and produces large amounts of seed soon after it establishes [2]. Maybe useful for erosion control of roadside shoulders [6]. Tolerates moderate drought and a wide range of soil texture conditions and acidic soils [4].
**Nitrogen fixing:** No.
**Symbioses:** Arbuscular mycorrhiza [7].
**Growth rate:** Rapid [4].
**Successional stage:** Early successional, an early colonizer of disturbed sites and post-fire [8]. Moderate shade tolerance in forest openings, but is quickly replaced by shrubs. Important in secondary succession of recovering fields [2].

# Canada goldenrod

## Seed and propagule properties

**Propagule description:** Seeds are achenes, not contained in a capsule or fruit, they are clustered in a disk flower head and have several stiff bristles attached to their seed to help it disperse.
**Dispersal:** Wind [2].
**Propagule weight:** (dried seed with bristles) 0.07mg [9].
**Seeds/ collection unit:** One Canada goldenrod plant can produce upwards of 11 000 seeds (cited in [2]).
**Seed size and description:** Seeds are tan at maturity, about 1.5mm long and 0.4mm in diameter. Achenes can be treated as a seed unit.
**Average seed weight:** (cleaned, dry seed) 0.06 mg [9].
**Seeds/kg:** 16.7 million seeds/kg [9].


Photo 2: Goldenrod with ripe seed. After drying the plant.

## Seed Collection

**Timing collections:** Seeds ripens from early September to October in our region. Yellow flowers quickly change to white, 'fluffy' seeds. You may begin collections when at least half of the seeds on the plant are fully ripe to avoid losses. Seed dispersal occurs more slowly than many other wind dispersed species, but will be accelerated if the weather is hot and dry.
**Collection protocols:** Collect entire flowering head using scissors. Plants are often found in dense stands so collect into a large paper bag. At the brink of dispersal, seeds may be vacuum harvested, this will make seed cleaning easier. Place materials in thin layers to dry immediately following collection.
**Collection effort:** One collector picked an average of 45g pure, dry seed in one hour.
**Potential density:** No information found.
**Cautions:** None known.


Photo 3: Canada goldenrod seed ready to be threshed.

## Propagule processing

**Processing protocols:** 1. Dried seeds can be separated from flowering heads using a shop vacuum (with a fine mesh wrapped around the filter inside) or shaking vigorously in paper bags. 2. Seeds are then placed on a flat side of a rubber mat in thin layers. Having many leaves in with this material will result in lower seed purity. 3. Thresh seeds forcefully using a threshing paddle to break off the bristles. Reserve this material for later winnowing. Continue to thresh remaining materials. 4. Winnow seed material in front of a moderate air flow. Sieve if larger pieces of material remain. If seeds still have bristles they may need to be returned to the threshing mat and steps 3 to 4 repeated.
**Cautions:** Processing this seed creates a lot of dust during the threshing and winnowing steps, wear and mask and work in a ventilated space.


Photo 4: Seed following threshing is ready to be winnowed to remove bristle hairs.

## Storage

**Storage behaviour:** Uncertain [10]. However 97% of goldenrods (*Solidago* ssp.) with a known storage behaviour are orthodox.
**Storage requirements and longevity:** Seed may remain viable for up to 5 years if dried and stored in sealed containers at 3 to 5°C [6].

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# Canada goldenrod

## Seed propagation

**Dormancy classification:** Uncertain, seeds of many goldenrods have a physiological dormancy [11].
**Potential viability:** Ranging from 72 to 100% in our cleaned seed lots.
**Pre-treatments:** None required. Some seed populations may benefit from a period of cool-moist stratification [2]. One author reports collecting seed before the first frost and allowing for 90 days of seed after-ripening (sitting at room temperature) will improve germination rates[2].
**Germination protocols:** Untreated seed germinated 82 to 95% on a moist medium at 25/15°C, 8/16 hours light/dark [10]. Seeds should not be planted deeper than 0.5cm, because this will limit germination [6].
**Other propagation methods:** Seeds are the most common method of propagation, however rhizome cuttings are also used to propagate this species [12].

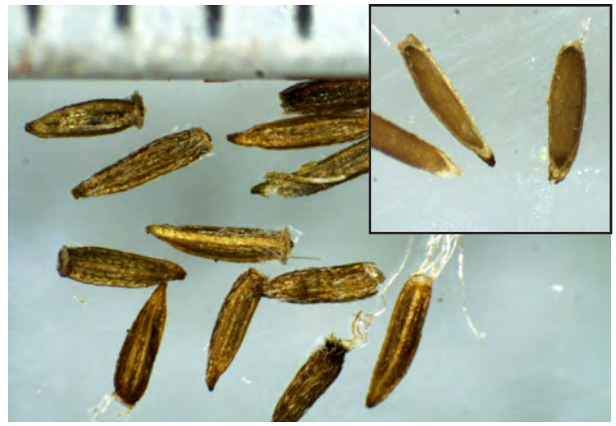

*Photo 5: Canada goldenrod seed. (inset photo) Sectioned goldenrod seed.*

**Field planting:** Seed can be planted in the spring or fall to a shallow depth of 0.3 to 0.6cm [12]. Recommended seeding rates are 0.6kg seed/ hectare or less if sown in a mix.

## Other

**Canadian commercial sources:**
http://www.wildaboutflowers.ca/plant_detail.php?Canada-Golden-Rod-107
**Useful links and further reading:**
https://gobotany.newenglandwild.org/species/solidago/canadensis/
https://plants.usda.gov/core/profile?symbol=SOCA6
http://michiganflora.net/genus.aspx?id=Solidago
http://www.omafra.gov.on.ca/english/crops/facts/ontweeds/canada_goldenrod.htm
http://www.ontariowildflower.com/goldenrods.htm

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12. Pavek, P. *Plant Guide for Canada Goldenrod (Solidago canadensis)*. (2011). https://plants.usda.gov/plantguide/pdf/pg_soca6.pdf

# gray goldenrod

Family: Asteraceae

Scientific name: *Solidago nemoralis* Aiton

Cree Name: ___________

Synonyms: None found.


## Quick Seed Guide

**When and what to collect**: Seed ripens in September. Seed heads can be cut using scissors when the seed hairs are visible.
**Seed Processing**: Dry. Separate seed from stem.

**Storage:** Dry and store in sealed containers at 1 to 5°C for up to 5 years.
**Pre-treatment of seed:** Cool stratify for 84 days.
**How to Grow:** Seed: Seeds require light to germinate. Optimal temperatures are 20/10°C. Vegetative: Stem cuttings; 4 to 6 nodes long.

## General

**Plant Description:** Gray goldenrod is a flowering herb, 20 to 100cm tall [1]. Plants have 1 to 6 stems. Basal leaves are 2 to 9.5cm long and 0.7 to 1.5cm wide, the top of the leaf is wider than the base, leaf margins are smooth. Stem leaves are not stalked and are smaller than the basal leaves. Flowering heads have 10 to 300 small yellow flowers. The overall shape of the flowering head is important for its identification. Overall elongate or pyramid shaped, leaning over at the top, flowers are arranged on one side of the branch.
**Field Identification:** Gray goldenrod is recognized by its yellow flowers in the fall. It varies in its size and appearance making it a challenging species to identify. The stem leaves are smaller than the distinct basal leaves and have one obvious mid-rib (rather than 3), plant stems are hairy. **Similar species:** Hairy goldenrod (*Solidago hispida*) is similar but its stem leaves are the same size as the basal leaves and the top of the flowering head does not lean like that of gray goldenrod.
**Life Form:** Perennial forb; stems die back during winter months; regenerates from buds at or below the soil surface.
**Reproduction:** Reproduction is mostly by seed, however plants also reproduce vegetatively from a branched caudex [2].

**Continental Range:** Present across Canada except in the Yukon, Northwest Territories, Nunavut, and Newfoundland and Labrador [3]. Present throughout the states, except for the western states and Alaska, as far west as Montana.
**HBL regional Range:** Restricted to the southern interior of the Hudson Bay Lowlands [4] however, we found it was quite common in our location.
**Habitat:** Exposed dry soils, sandy, gravelly, and clay soils, disturbed sites, roadsides, prairies, fields; 0-1000+ m [1].

## Reclamation value

**Nitrogen fixing:** No.
**Symbioses:** Arbusulcar mycorrhizal or non-mycorrhizal [2,5].
**Growth rate:** Rapid [6].
**Successional stage:** Early successional sites [2] and a pioneer species [7]. Gray goldenrod is an important component of recovering agricultural fields and waste lands. Although not a long-lived plant, it may persist for several years until replaced by other species.

*seeds developing, seeds dispersing.*

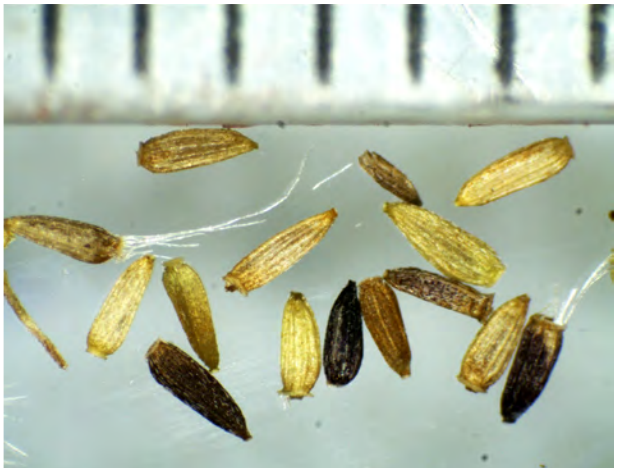
## Seed and propagule properties

**Propagule description:** Seeds are achenes grouped in a tight cluster within a flower head. Achenes have several bristly hairs attached to help them disperse.
**Dispersal:** Wind [2].
**Seeds/collection unit:** Highly variable, 200 to over 5000 seeds per plant [2].
**Seed size and description:** Achenes are treated as seeds. Highly variable: 1.5mm long and 0.5mm wide [2]. Tan to dark brown, to purple at maturity.
**Average seed weight:** (clean, dry seed) 0.013 to 0.30mg [2].
**Seeds/kg:** 3.3 to 77 million seeds per kg [2].

*Photo 3: Gray goldenrod seeds following threshing.*

## Seed collection

**Timing collections:** Seed ripens in September. Yellow flowers develop quickly into seeds that are hairy at maturity. Seeds are fairly persistent but can be collected early to avoid losses. Collect when over half of the flowers have fully matured into seed.
**Collection protocols:** Cut the entire top of the seed head using scissors. Seeds are collected into containers that are attached to the collector, because stems are often spread apart and require a lot of movement from plant to plant.
**Collection effort:** One collector harvested an average of 72g (26 to 100g) of pure dry seed in one hour.
**Potential density:** No information found.
**Cautions:** None known.



## Propagule processing

**Processing protocols:** 1. Dried seeds can be separated from flowering heads using a shop vacuum (with a fine mesh wrapped around the filter inside) or shaking vigorously in paper bags. 2. Seeds are then placed on a flat side of a rubber mat in thin layers. 3. Thresh seed forcefully using a threshing paddle, until bristles have broken off the seeds. Reserve this material for later winnowing. Continue to thresh remaining materials. 4. Winnow seed material in front of a moderate air flow. Sieve if larger pieces of material remain. If seeds still have bristles they may need to be returned to the threshing mat, repeating and steps 3 to 4.
**Cautions:** None known.

## Storage

**Storage behaviour:** Orthodox [8].
**Storage requirements and longevity:** Seeds should be dried and stored in sealed containers at 1 to 5°C. Seeds remain viable for up to 5 years in the seed soil bank [2,9], in dry conditions seed longevity should improve.

## Seed propagation

**Dormancy classification:** Physiological [2].
**Potential viability:** Our cleaned seed lots had an average viability of 84%.
**Pre-treatments:** Cool-moist stratification at 5°C for up to 84 days is optimal [10].
**Germination protocols:** Seeds germinated with light have higher germination percentages [2]. Seed germinates with standard conditions; 20/10°C on a moist medium. Up to 98% germination percentages were reported [10].
**Other propagation methods:** Plants can be divided in the spring and transplanted. Stem cuttings taken in the late spring that are 4 to 6 nodes long can be rooted with 100% success [7].
**Field planting:** Plant seeds in the fall [7].

## Other

**Canadian commercial sources:** None found.

**Useful links and further reading:**

For an online identification key to the goldenrods: http://michiganflora.net/genus.aspx?id=Solidago
http://ontariowildflowers.com/main/species.php?id=54
https://gobotany.newenglandwild.org/species/solidago/nemoralis/
https://www.wildflower.org/plants/result.php?id_plant=SONE
https://www.prairiemoon.com/seeds/wildflowers-forbs/solidago-nemoralis-old-field-goldenrod.html

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# Northern mountain-ash

Family: Rosaceae

Scientific name: *Sorbus decora* (Sarg.) C.K. Schneid.

Cree Name: ___________

Synonyms: *Sorbus groenlandica*, etc.


Photo 1: Northern mountain ash stand.

## Quick Seed Guide

**When and what to collect**: Berries ripen in September, turning a bright red and softening. Pull branches into reach using a pole with a hook and collect by hand.
**Seed Processing**: Thresh, rinse, reserving sunken material. Dry, thresh and winnow to clean.
**Storage:** Dry seed well and store in sealed containers at 2 to 4°C for 2 to 8 years
**Pre-treatment of seed:** Cool stratify for 60 to 120 days at 2°C. Acid scarifying seed may also enhance germination.
**How to Grow:** Seed: Germinate at 15 to 20°C with more light than dark.

## General

**Plant Description:** A deciduous tree or shrub, 3 to 15m tall [1]. Often having more than one trunk. Leaves are compound with 13 to 17 leaflets with toothed margins. Leaflets are 4 to 7cm long and 1.5 to 2.5cm wide. Flower heads are flat-topped to rounded, large 6 to 15cm wide, having 75 to 400 flowers. Flowers are small and white. Fruit is round and bright red at maturity.
**Field Identification:** Northern mountain ash is recognized by its large clusters of reddish-orange fruit and compound leaves. The leaflets are 2.5 to 3 times as long as they are wide, an important trait for distinguishing it from other mountain ash (*Sorbus* sp.). **Similar species:** American mountain ash (*Sorbus americana)* has leaflets that are 3.5 to 4.5 longer than they are wide. European mountain ash (*Sorbus aucuparia*) is a non-native that has been introduced in Canada and can be distinguished by the hairy underside of the leaflets.
**Life Form:** Deciduous tree; woody stems that persist year-round, buds are usually over 3m above ground.
**Reproduction:** Reproduces from seeds, flowering in the spring.

**Continental Range:** Present in eastern and central Canada [2]. Absent west of Saskatchewan and in the Northwest Territories, Yukon, and Alaska. Limited in the United States to only the most northeastern states.
**HBL regional Range:** Occasional in the southern interior (non- coastal) region of the Hudson Bay Lowlands [3].
**Habitat:** Moist or dry woods, rocky slopes, lake and stream shores, thickets; 0-1300 m [1].

## Reclamation value

**Nitrogen fixing:** No.
**Symbioses:** Northern mountain ash is commonly endomycorrhizal [4].
**Growth rate:** Slow [5].
**Successional stage:** No information found.

## Seed and fruit properties

**Fruit description:** Fruit are pomes, bright red to orange-red at maturity, round 4 to 7mm in diameter [1].
**Dispersal:** Berries are dispersed by animals, primarily birds [6].
**Fruit weight:** (Fresh whole berry) 441mg.
**Seeds/ berry:** More than one.
**Seed size and description:** Seeds are brown when mature 2.5 to 3.3mm long and 1.5 to 2mm in diameter[1].
**Average seed weight:** (cleaned, dried seed) 15.3mg [7].
**Seeds/kg:** Over 65 000 seeds/kg.

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# Northern mountain-ash

## Seed collection

Photo 2: Collecting northern mountain-ash berries with a pole and hook to bring branches into reach and a berry rake.

**Timing collections:** Berries are ready to collect in early September, when they are red and soft (easily crushed). Seeds are orange to brown in colour and firm. Berries are eaten by birds, but can persist into winter months if not consumed.
**Collection protocols:** Use a pole with a hook on the end to pull branch into arms reach; the pole can be held between your legs so you can use both hand to collect the fruit. Collect into large plastic buckets resting on the ground or harnessed to the collector. Berry rakes are also effective but due to the large size of the fruit they fill up quickly. Place berries in the fridge until they are ready to be processed.
**Collection effort:** Seed fill was very poor in our populations, often with only one full seed per berry. One collector picked between 2.5 to 4kg of fresh berries in one hour, however the conversion to dry pure seed was only 31 to 35g in one hour.
**Potential density:** No information found.
**Cautions:** None known; berries are edible but not very tasty.

## Propagule processing

**Processing protocols:** Crush fresh berries on a corrugated rubber mat with a paddle. Rinse material into a large plastic bucket. Pour off floating material and reserve sunken material by pouring into a sieve. Allow material to dry on a paper towel. At this stage the seed will still be mixed with pulp and other material. Once dry, thresh material on the flat side of the rubber mat, this will break apart a casing that seeds are contained in. Winnow in front of a moderate air flow to remove chaff and empty seed. Seed purity is about 89%. We also tried processing seed in a blender, but found threshing seed to be a more effective and faster method.
**Cautions:** None known; berries are edible but not very tasty.

## Storage

**Storage behaviour:** Probably orthodox [7].
**Storage requirements and longevity:** Dry seed can be stored in sealed containers at 2° to 4°C for 2 to 8 years [6,8]. Seed moisture content of 6 to 8% is optimal.

Photo 3: Threshed northern mountain-ash berries.

Photo 4: Sunken seed and material. This material will be set out to dry and then threshed and winnowed.

# Northern mountain-ash

## Seed propagation

**Dormancy classification:** Other mountain ashes (*Sorbus* ssp.) have a deep physiological dormancy [9].
**Potential viability:** Seed viability of our cleaned collections ranged from 82 to 97%.
**Pre-treatments:** Mountain ashes require a period of cool-moist stratification from 60 to 180 days [6,9]. Temperatures of 2°C were preferred to those of 6°C or higher. In addition, soaking seed in concentrated sulphuric acid for 10 minutes also had a slight enhancement on germination percentages [10]. A period of warm stratification prior to cool stratification may improve germination percentages [9].
**Germination protocols:** Germination can be accomplished on several substrates at 15 to 20°C [6], other mountain ashes prefer germination conditions with more light than dark [9].
**Other propagation methods:** None found.
**Field planting:** Seeds can be planted in the fall to a shallow depth and mulched [6].

*Photo 6: Northern mountain-ash seed. (inset photo) Sectioned, viable seed.*

## Other

**Canadian commercial sources:**
https://www.ontario.ca/page/buy-ontario-tree-seeds-or-cones
**Useful links and further reading:**
http://michiganflora.net/species.aspx?id=2569
https://gobotany.newenglandwild.org/species/sorbus/decora/
http://www.pfaf.org/user/Plant.aspx?LatinName=Sorbus+decora

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# Robyn's aster

Family: Asteraceae

Scientific name: *Symphyotrichum robynsianum* (Rouss.) L. Brouillet & Labrecque  Cree Name: ________

Synonyms: Synonyms: *Aster robynsianum*, *Aster longifolius* Semple & Heard non Lam., etc.

*Photo 1: Robyn's aster in . Growing along the Attawapiskat river shore.*

## Quick Seed Guide

**When and what to collect**: Seeds ripen in September. Collect when seed hairs become visible.

**Seed Processing**: Dry. Separate seed from plant.

**Storage:** Dry seed and store cool in sealed containers.

**Pre-treatment of seed:** Cool stratify for 60+ days.

**How to Grow:** Seed: Germinate at 15 to 25°C and roughly equal light/dark cycles. Vegetative: Uncertain, may be propagated by stem cuttings.

## General

**Plant Description:** A perennial aster, 10 to 80cm tall [1]. Found in small colonies. Stems are smooth and purplish, often with hairs in lines along the upper part of the stem. No basal leaves are present at the time of flowering. The leaves on the lower half of the plant are 10 to 20cm long and 4 to 8mm wide, shorter on the upper portion of the stem, 1 to 10cm and 1 to 7mm wide. The base of the leaf clasps the stem. Flowers are purple-blue, often in groupings of 1 to 3 disk flower heads.

**Field Identification:** Purple-blue flowers, with long and thin leaves, longer on the lower half than the top. The green base of the flower (involucre) is made of small leafy green bracts called phyllaries and are an important identification trait for the asters. The lower phyllaries on Robyn's aster are smaller than the upper ones. **Similar species:** New York aster (*Symphyotrichum novi-belgii)* is very similar, but has wider leaves and can be taller, purple stem aster (*Symphyotrichum puniceum)* has a much hairier stem (not in lines but all over) and hairs on the mid-ribs of the leaves.

**Life Form:** Perennial forb; stems die back during winter months, the plant regenerates from buds at or below the soil surface.

**Reproduction:** Reproduces by seeds and rhizomes [1]. Flowering from August to September.

**Continental Range:** Present in Nunavut, Manitoba, Ontario, and Quebec. In the United States populations are restricted to Michigan, Minnesota, and Wisconsin [2].

**HBL regional Range:** Widespread and abundant in the Hudson Bay Lowlands [3].

**Habitat:** Wet to damp, open sites, sandy, gravelly, or rocky soils, often calcareous, lake shores, limestone alvars, seasonally wet sites; 10-400 m [1,4].

## Reclamation value

**Nitrogen fixing:** No.

**Symbioses:** Other asters form associations with vesicular arbusular mycorrhiza [5,6].

**Growth rate:** No information found.

**Successional stage:** Based on habitat this species is likely early successional.

*Photo 2: Robyn's aster stem. Note the long and clasping leaves.*

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# Robyn's aster

## Seed and propagule properties

**Propagule description:** Seeds are inside achenes, tightly clustered in a disk flower head, with several stiff bristles attached that help them to disperse
**Dispersal:** Wind.
**Seeds/ collection unit:** Not determined.
**Seed size and description:** Seeds are achenes and are treated as a seed unit. Tan at maturity, about 2.2mm and 0.5mm wide.
**Average seed weight:** (clean, dry) 0.4mg.
**Seeds/kg:** 2.1 million seeds/kg.

*Photo 3: Ripe aster seed. At this stage, aster seed can be vacuum harvested or hand collected using scissors.*

## Seed Collection

**Timing collections:** Seeds from Robyn's aster ripen in September. Seeds are ready to collect when the seed hairs are visible. Seeds will persist for about a week or more after maturity, but should be collected as soon as the seed hairs are showing to avoid losses.
**Collection protocols:** Collect entire flowering head using scissors. Plants are often found in dense stands so collect into a large paper leaf bag. At the brink of dispersal, seeds may be vacuum-harvested; this will make seed cleaning easier. Place materials in thin layers to dry immediately following collection.
**Collection effort:** One collector picked between 10 to 75g of pure dry seed in one hour.
**Potential density:** Not determined.
**Cautions:** None known.

*Photo 4: Aster seed heads collected and dried, ready to be processed.*

## Propagule processing

**Processing protocols:** 1. Dried seeds can be separated from plants using a shop vacuum (with a fine mesh wrapped around the filter inside) or by shaking vigorously in paper bags. 2. Seeds are then placed on a flat side of a rubber mat in thin layers. Having leaves in with this material will result in lower seed purity. 3. Thresh seeds forcefully using a threshing paddle, until the bristles have broken off. Reserve this material for later winnowing. Continue to thresh remaining seeds. 4. Winnow the threshed seed material in front of a moderate air flow. Sieve if larger pieces of material remain. If seeds still have bristles they may need to be returned to the threshing mat, repeating steps 3 to 4.
**Cautions:** Processing this seed creates a lot of dust during the threshing and winnowing steps, wear and mask and work in a ventilated space.

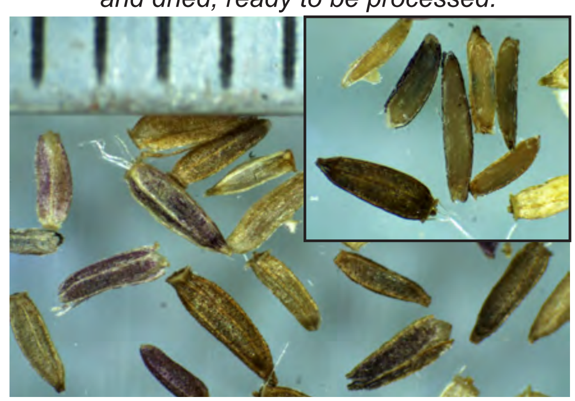

*Photo 5: Robyn's aster seed. The different colour seed may indicate more than one aster species was collected, or this may be part of the plants variation. (inset photo) Sectioned aster seed.*

## Storage

**Storage behaviour:** Unknown for this species, likely orthodox; 100% of asters (*Sympyotrichum* ssp.) with a known storage behaviour are orthodox [7].
**Storage requirements and longevity:** Orthodox seed should be well dried and kept cold to maintain seed viability. Seed dried and kept in sealed containers at 1 to 5°C may maintain their viability for at least a year.

## Seed propagation

**Dormancy classification:** Most asters (*Symphyotrichum* ssp.) have a physiological dormancy [8].
**Potential viability:** Our collections ranged from 57% to 87% seed viability for cleaned seed.
**Pre-treatments:** Seeds of other asters (*Symphyotrichum* ssp.) benefit from cool-moist stratification for 60 days or more [8,9].
**Germination protocols:** Other asters (*Symphyotrichum* ssp.) germinate under standard greenhouse conditions, between 15 to 25°C and roughly equal light/dark cycles [8].
**Other propagation methods:** No information found. Other species of asters (*Symphyotrichum*) can be propagated by stem cuttings taken in the late spring to a length of 20cm if they are treated with rooting hormone and kept moist [9].
**Field planting:** Plant seed in the fall to a shallow depth of 0.5cm or less. Germination will occur in the spring.

## Other

**Canadian commercial seed sources:** None found.
**Useful links and further reading:**
http://michiganflora.net/species.aspx?id=493

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# northern meadowrue

Family: Ranunculaceae

Scientific name: *Thalictrum confine* Fernald

Cree Name: ___________

Synonyms: *Thalitrum venulosum var. confine*, etc.

*Photo 1: Female northern meadowrue . Purple stigmas are one of for this speces.*

## Quick Seed Guide

**When and what to collect**: Seeds ripen in August. Only female plants produce seed. Collect entire seed head when seeds are yellow, before they begin to fall off plant.
**Seed Processing**: Dry, thresh, winnow.
**Storage:** Uncertain, dry seed and store cool in sealed containers.
**Pre-treatment of seed:** Uncertain; cool stratify for prolonged periods.
**How to Grow:** Seed: Uncertain. Germinate at 20 to 28°C, with 250 to 500mg/L gibberlic acid.

## General

**Plant Description:** A perennial herb, growing up to 1m in height [1]. Early in the season this plants basal leaves are prominent and the flowering stem develops in the summer. The leaf shape for this species is distinct, very ornate and lobed. The flowering head occurs at the top of the plant. The flowers have no petals, but the abundance of flowers and location at the top of the plant makes them stand out. Female flowers have a purple stigma (photo 1); male flowers dangle. On female plants, seeds are achenes that are tan at maturity, ribbed with a visible beak.
**Field Identification:** Northern meadowrue is recognized by its ornate, multi-lobed leaves and its fruit. *Thalictrum venulosum* and *Thalictrum confine* are often not distinguished in the literature. **Similar species:** Before flowering, northern meadowrue leaves resemble those of the columbines (*Aquilegia* ssp.) but are easily distinguished by their fruit. Columbine seeds disperse from multi-chambered capsules, whereas meadowrue seeds are not contained in capsules, but are large achenes that simply fall off the plant at maturity. More closely related species are early meadow rue (*Thalictrum diocum)* have achenes that do not curve like northern meadowrue. Veiny meadowrue (*Thalictrum venulosum*) seeds are smaller and have a shorter beak (less than 2.5mm) and the stigmas (if you find this species in flower) are yellow (purple in northern meadowrue) [1].
**Life Form:** A perennial forb; stems die back during winter months, regenerating from buds below the soil surface.
**Reproduction:** A dioecious species (separate male and female plants) reproduces by seeds and rhizomes [1]. Flowering from June to July.

**Continental Range:** Present only in Ontario, Quebec and Prince Edward Island [2]. In the United States it is only present in Michigan and New York where the population is ranked as imperiled.
**HBL regional Range:** Occasional in the southern portion of the Hudson Bay Lowlands [3].
**Habitat:** Rocky calcareous shores, riverbank thickets; 0-200m [1,4].

*Photo 2: Lower leaves of northern meadowrue plant.*

## Reclamation value

**Nitrogen fixing:** No.
**Symbioses:** Uncertain, related species *Thalictrum pubescens* and *T. minus* are colonized by arbuscular mycorrhiza [5,6].
**Growth rate:** Likely moderate to rapid [7].
**Successional stage:** Likely tolerant of early to mid-successional conditions based on habitat tolerances [1].

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# northern meadowrue

## Seed and fruit properties

Photo 3: Northern meadowrue seed head is mature and ready to be colllected.

**Dispersal:** Seeds are within achenes which fall off the parent plant at maturity. Achenes float, which may aid in water dispersal, however we did not determine the duration of flotation for this seed.
**Seeds/ plant:** Not determined.
**Seed size and description:** Seeds are within achenes, but treated as a seed unit, they are curved and beaked, with prominent ribs, 4 to 6mm long plus a beak that is 2.5 to 4mm long [1].
**Average seed weight:** (clean, dry seed) Not available. For *Thalictrum venulosum* 1.34 to 3.09mg [7,8].
**Seeds/kg:** 325 000 to 746 000 seeds/kg (for *Thalictrum venulosum)* [7,8].

## Seed collection

**Timing collections:** Collect seeds as they change colour from green to yellow, but before they are light brown, at which point they quickly fall from the plant. Seeds ripen in August. This species is dioecious; check in June or July and identify stands that have high densities of female plants.
**Collection protocols:** Use scissors or hand pruners to cut the entire top of the seed head. The collector should have has collectoin containers harnessed to their body, because much of the collection effort is spent looking for productive plants. This species is dioecious; approximately half of the plants do not produce seed. Lay seeds out to dry in thin layers following collection.
**Collection effort:** One person collects an average of 38g pure dry seed.
**Potential density:** Not determined.
**Cautions:** None known.

## Propagule processing

Photo 4: Cleaned northern meadowrue seed.

**Processing protocols:** Seeds are easy to clean. Thresh dried plant tops on a corrugated rubber mat to separate the seed from the plant. Empty seeds may be crushed during the threshing, but this will produce higher quality seed in the final lot, full seed is undamaged from threshing. Winnow to separate stems, leaves, and undeveloped seeds from the full seed.
**Cautions:** None known.

## Storage

**Storage behaviour:** Uncertain, 90% of the known *Thalictrum* genus have orthodox storage behaviour [8].
**Storage requirements and longevity:** For best practices of orthodox seed, dry seed well and store in sealed containers at 1 to 5°C. Uncertain on longevity, seeds of *Thalictrum occidentale* maintain longevity for at least 2 years, if dried and stored in sealed containers at 1 to 5°C [9]. In the soil seed bank *Thalictrum flavum* loses about half of its seed viability after two years in the soil bank [10].

## Seed propagation

**Dormancy classification:** Morpho-physiologcal dormancy (see seed photo sections) embryos are underdeveloped at maturity, consistent with other members of the genus *Thalictrum* [11].
**Potential viability:** From 45% to 68%, note seed parasitism by insects was high in our collections and infected seeds could not be separated by the cleaning process.
**Pre-treatments:** No information available for this species. More research is required on the germination requirements of northern meadowrue. Among *Thalictrum* species, seed treated with 250 to 500mg/L gibberlic acid during germination after a cool-moist stratification had higher germination percentages [8,9]. Other meadowrue (*Thalictrum* ssp.) seeds are pre-treated with prolonged cool-moist stratification [10,12].

**Germination protocols:** No information found for this species; seed of other meadowrue (*Thalictrum* ssp.) germinate between 20 to 28°C, treating seed with 250 to 500mg/L gibberlic acid, may improve germination percentages [8,9]. Reported germination percentages are often low.
**Other propagation methods:** Unknown.
**Field planting:** No information found.

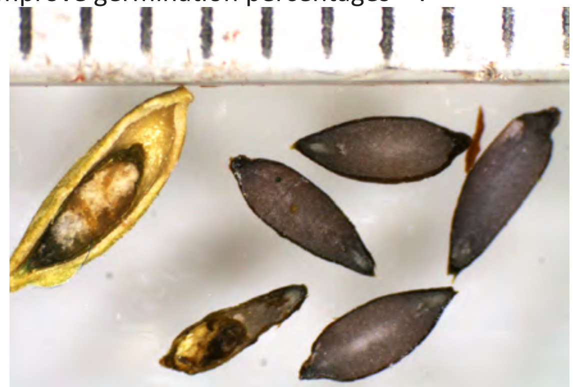

Photo 5: *Sectioned northern meadowrue seed. The seed to the left is not viable. Note the small embryo size in the seeds to the right.*

## Other

**Canadian commercial sources:** None found.
**Useful links and further reading:**
Many web sources consider *Thalictrum venulosum* the same species as *Thalictrum confine*.
http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=233501261

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# lingonberry

Family: Ericaceae

Scientific name: *Vaccinium vitis-idaea* L.

Cree Name: ___________

Synonyms: *Vaccinium vitis-idaea ssp. minus, etc.*

Photo 1: Lingonberry patch with ripe fruit. Growing along a trailside.

## Quick Seed Guide

**When and what to collect**: Seeds ripen from August to September. Berries are bright red when mature. Hand collect.

**Seed Processing**: Blend berries. Rinse. Reserve all seed materials. Dry. Thresh and winnow.

**Storage:** Dry seed and store in sealed containers for many years at cool temperatures

**Pre-treatment of seed:** Cool stratify 60 to 120 days.

**How to Grow:** Seed: Germinate at 35/20°C and 8/16 hours of light/dark with gibberlic acid. Vegetative: Stem and rhizome cuttings taken when the plant is dormant.

## General

**Plant Description:** Lingonberry is a small, evergreen shrub, under 10cm tall [1]. It grows horizontally forming large mats and colonies. Its leaves are bright green and shiny on upper surface, paler on the lower surface, with smooth leaf margins that curl under at the edges. Leaves are small and round, 5 to 18mm long and 3 to 9mm wide. Flowers are pink-white, bell shaped, hanging from a short stalk. Berries are round, changing from white to red at maturity.

**Field Identification:** Small round, glossy leaves, red berries, horizontal growth. **Similar species:** Resembles bearberry (*Arctostaphylos uva-ursi*) in overall growth, leaf shape and berries, however lingonberry leaves have a mid-vein and bearberry leaves do not.

**Life Form:** Evergreen, dwarf shrub; stems persists through winter months.

**Reproduction:** Vegetatively by underground rhizomes and trailing stems may form roots at the nodes [2]. Sizeable fruit production begins in 5 to 10 year old plants [2]. Flowering is in late spring to early summer [1].

**Continental Range:** Lingonberry is present in all Canadian provinces and Alaska [3]. Restricted to northern and eastern states in the United States.

**HBL regional Range:** Widespread and abundant in the Hudson Bay Lowlands [4].

**Habitat:** A boreal plant, common in jack-pine stands, well shaded forests, muskegs, raised bogs, dry- rocky barrens, lichen woodlands; 0-1800 m [1]. Tolerant of a range of soil conditions from moist to dry regimes, pH as low at 2.7 to 8.2 [2].

## Reclamation value

**Nitrogen fixing:** No.

**Symbioses:** Ericoid mycorrhiza [5].

**Growth rate:** Moderate [6].

**Successional stage:** Found in all successional stages, not typically considered a pioneer, but is present on early successional sites [2].

Photo 2: Collecting lingonberry fruit. Note the plants small size.

## Seed and fruit properties

**Fruit description:** Berries are round, 8 to 10mm in diameter, red at maturity [1].
**Dispersal:** Animals eat the fruit [2].
**Propagule weight:** (whole, dried berry) 34.82mg [7].
**Seeds/ fruit:** 3 to 15 seeds per berry [2].
**Seed size and description:** Seeds are small and dark brown at maturity, about 1mm long and 0.5mm wide.
**Average seed weight:** (cleaned, dry seed) 0.17 [7] to 0.3mg [8].
**Seeds/kg:** 3.3 to 5.9 million seeds/kg [7,8].


*Photo 3: A 15 minute collection of lingonberry fruit.*

## Seed collection

**Timing collections:** Seeds mature about 80 days after flowering, from August to September [9]. Berries are bright red with a tough skin but can be easily squished when fully ripe.
**Collection protocols:** Hand collect berries into a plastic bucket or tray with a short lip. Fruits are found growing on the ground. Place berries in the refrigerator until processing is possible.
**Collection effort:** One person collected 5.5g of pure, dry seed in one hour.
**Potential density:** Not determined.
**Cautions:** None known, berries are edible.


*Photo 4: Lingonberry seed following processing. A*

## Propagule processing

**Processing protocols:** 1. Berries can be crushed in a blender with 2 parts water, 1 part berries. Run the blender until fruits are fully crushed. Rinse. Much of the pulp will sink along with the seed, so we reserved all the material. 2. Seeds are very small, pour seed into a sieve with an opening of 0.4mm (mesh 40) or less or into a coares sieve lined with a coffee filter. 3. Lay material out on paper towels to dry. 4. Thresh the dry material on the flat side of a rubber mat. 5. Winnow in front of a low air flow to remove pulp. Seed purity was 96% on average.
**Cautions:** None known.

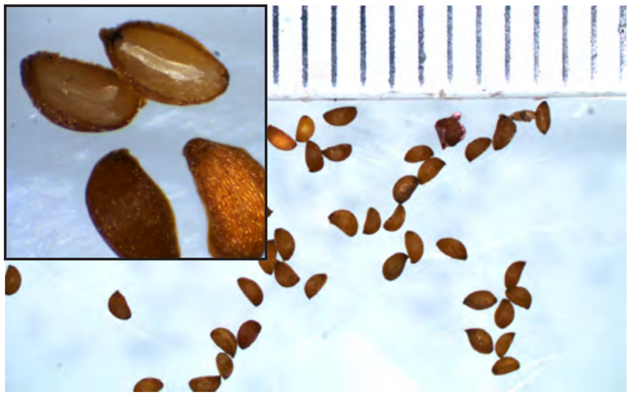
*Photo 5: Lingonberry seed. (inset photo) Sectioned viable seed.*

## Storage

**Storage behaviour:** Orthodox [8].
**Storage requirements and longevity:** Seeds can be dried and stored in cool conditions for many years [10]. Whole fruit can be frozen and maintain seed viability for several years [9].

## Seed propagation

**Dormancy classification:** Physiological dormancy [11].
**Potential viability:** Our cleaned seed lots had viabilities of 92%.
**Pre-treatments:** Cool-moist stratification for 60 to 120 days, enhances germination [9,11]. However high germination percentages have been reported without noting any pre-treatments [12].
**Germination protocols:** The highest reported germination percentages were 89%, for seed grown on a moist medium with 250mg/L gibberlic acid at 35/20°C and 8/16 hours light/dark [8]. Seeds of *Vaccinium* ssp. require light to germinate but are sensitive to the light intensity [10], therefore germination is often higher in a greenhouse than in a lab. Gibberlic acid may also enhance germination. Germination rates of 76% were reached at 21°C in a mix of peat, sand, and soil under greenhouse conditions [12] and >85% after 90 days of cool stratification in similar conditions [9].

**Other propagation methods:** Stem and rhizome cuttings taken when the plant is dormant in the spring or fall (cited in [2]).
**Field planting:** Seeds sown to a shallow depth (0.5cm) in the fall should be protected from drying out. Lingonberry failed to emerge in plots trials in northern Alberta, where seeds were sown in spring and fall or whole fruit was sown in spring and fall [13].

## Other

**Canadian commercial sources:**
http://botanicallyinclined.org/seeds-shop/vaccinium-vitis-idaea-buy-seeds/
**Useful links and further reading:**
http://www.prairie-elements.ca/lingonberry.html
https://plants.usda.gov/core/profile?symbol=VAVI
https://www.minnesotawildflowers.info/shrub/lingonberry

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# squashberry, mooseberry

Family: Adoxaceae

Scientific name: *Viburnum edule* (Michx.) Raf.

Cree Name: ___________

Synonyms: *Viburnum pauciflorum*


*Photo 1: Squashberry plant with developing fruit.*

## Quick Seed Guide

**When and what to collect**: Berries turn bright red in September. Collect berries by hand using a hand free collection container or a berry rake.

**Seed Processing**: Refer to propagule processing below for imporant information.

**Storage:** Store dried seed in sealed containers at 1 to 3°C for up to 10 years.

**Pre-treatment of seed:** Warm stratify for 90 to 120 days, cool stratify for 90 days. Gibberellic acid and mechanical

**How to Grow:** Seed: Standard conditions.
Vegetative: Softwood stem cuttings.

## General

**Plant Description:** A deciduous shrub, 0.5 to 2m tall [1]. Leaves are opposite, with a general appearance like a maple leaf with 3-lobes and pointed tips, rounded at the base, 5 to 10cm long. Leaves are toothed on the margins. Flowers and berries occur in the leaf axils, from a stalk. Flowers are small, white, with 5 petals. Berries are red at maturity

**Field Identification:** Squashberry can be recognized by its bright red fruit at maturity, 3-lobed leaves (newly formed leaves are not lobed) and red-orange dots on the underside. **Similar species:** High bush cranberry (*Viburnum trilobum*) has very similar appearance of leaves and fruit, but its leaves are not dotted with reddish dots on the underside and it has several large showy flowers in comparison.

**Life Form:** Deciduous shrub; buds are 0.5 to 3m above ground.

**Reproduction:** Squashberry reproduces by seeds beginning at about 5 years of age [2]. Reproduces vegetatively by layering, following major disturbance such as fire or ice scour it will regenerate from the root crown [2]. This species is rhizomatous, but apparently does not sprout from rhizomes for regeneration.

**Continental Range:** Squashberry is present in all Canadian provinces except Prince Edward Island [3]. Present in Alaska and in northern United States.

**HBL regional Range:** Widespread and abundant in the Hudson Bay Lowlands [4].

**Habitat:** Found in forests, stream margins, gravel and rocky shores [2]. Grows best on well-drained soils, tolerant of a variety of soil texture classes.

## Reclamation value

**Nitrogen fixing:** No.

**Symbioses:** Other *Viburnum* ssp. associate with arbuscular mycorrhiza [5,6].

**Growth rate:** Rapid [7].

**Successional stage:** Found in all stages of forest succession [2]. Tolerant of full sun and moderate shade, regenerates from root crowns following fire.


*Photo 2:Squashberry ripe fruit.*

# squashberry

## Seed and fruit properties

**Fruit description:** A red, soft and juicy berry at maturity.
**Dispersal:** Animals eat the fruit [2].
**Fruit weight:** (whole dried, fruit) 46.8mg [8].
**Seeds/ fruit:** One seed/berry.
**Seed size and description:** Seeds hard, heart-shaped, flattened, about 6mm long and 6mm wide.
**Average seed weight:** (cleaned, dry seed) 20.6 mg [8].
**Seeds/kg:** 48 500 seeds/kg [8].

*Photo 3: Collecting ripe squashberry fruit into a bucket wrapped around the collectors neck.*

## Seed collection

**Timing collections:** Berries ripen in September. Berries are bright red, soft and juicy at maturity. All berries ripen at one time. Berries will persist if not consumed by wildlife.
**Collection protocols:** Berries can be collected using berry rakes or hand collected into plastic buckets wrapped around the collector. Berries occur in clumps, ripening all at once, and at chest height, making this species easy to collect. See processing protocols for post-harvest handling.
**Collection effort:** One collector harvested 97g (40g to 170g) of pure dried seed in one hour. Or 0.6 to 2.9kg of fresh fruit.
**Potential density:** Not determined.
**Cautions:** None known, berries edible.

*Photo 4: The reserved seed material following blending. A quick thresh and winnowing will purify this seed.*

*Photo 5: Cleaned squashberry seed. (inset photo) Sectioned squashberry seed, exposing embryo.*

## Propagule processing

**Processing protocols:** Berries may be dried whole or processed in a blender. One study found that more seedlings emerged when whole berries were planted compared to seeds [9]. 1. To clean squashberry fruit, place berries in a blender that has dulled blades, with 3:1, water:berry. 2. Pulse blades at 3 second intervals until berries are crushed. 3. Pour off pulp, some seeds may be stuck to the skins causing them to float. 4. Pour material into a sieve and rinse. One author recommends keeping this seed moist if you are placing into pre-treatments, because drying seed may reduce germination success [10]. However for seed sales and to quantify your seed, proceed with drying on paper towels. 5. Once dry, seed can be threshed to remove any remaining pieces of fruit skins and winnowed.
**Cautions:** None known, berries edible.

## Storage

**Storage behaviour:** Orthodox [11].
**Storage requirements and longevity:** Seeds can be dried and stored in cool conditions for many years [12]. Dried seeds stored in sealed containers at 1 to 3°C can remain viable up to 10 years [13].

## Seed propagation

**Dormancy classification:** Morpho-physiological dormancy [14].
**Potential viability**: Our cleaned seed lots had 98.5% viability on average.

**Pre-treatments:** Due to the complicated dormancy of squashberry seeds, pre-treatment requirements are complex. First seeds can be placed in warm stratification at 21°C for 90 to 120 days [10,15]. This will allow the radicle (root) to penetrate the seed, but in order for the seed to continue growing beyond the root (epicotyl emergence) the plant will need to be cool-moist stratified at about 5°C for 90 days. Following cool-moist stratification seeds can be returned to warm conditions for full emergence [10,15]. Gibberellic acid may replace the need for cool stratification with this species [14]. In place of these pre-treatments, seed may be scarified mechanically in combination with 250mg/L of gibberellic acid [11]. In one seed lot, seedlings fully emerged after 252 days in just cool-moist stratification at 5°C.
**Germination protocols:** For full seedling emergence, follow pre-treatments described above. High seedling emergence rates in standard greenhouse conditions [10] or at 30/20°C and 8/16 hours of light/dark [11].
**Other propagation methods:** Collect softwood stem cuttings collected in mid-June after flowering. Cuttings are 20 cm long and 0.5 cm in diameter and treated with 3000ppm Hormonex rooting hormone. 100% rooting reported [13].
**Field planting:** Whole fruits planted in the spring or fall had much higher emergence rates that cleaned seed sown in fall or spring [9]. Seed emergence will occur in the second season after sowing.

## Other

**Canadian commercial sources:** None found.
**Useful links and further reading:**
https://gobotany.newenglandwild.org/species/viburnum/edule/
https://www.fs.fed.us/database/feis/plants/shrub/vibedu/all.html
http://www.northernontarioflora.ca/description.cfm?speciesid=1001276
http://www.wildflower.org/plants/result.php?id_plant=VIED
http://arcadianabe.blogspot.ca/2013/08/highbush-cranberry-de-befuddled.html

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15. Walck, J. L., Karlsson, L. M., Milberg, P., Hidayati, S. N. & Kondo, T. Seed germination and seedling development ecology in world-wide populations of a circumboreal tertiary relict. *AoB Plants* **12,** 1–15 (2012).

# American vetch

Family: Fabaceae

Scientific name: *Vicia americana* Muhl. ex Willd.

Cree Name: ___________

Synonyms: *3 recognized subspecies*

*Photo 1: Flowering American vetch plant growing on an eroded slope.*

## Quick Seed Guide

**When and what to collect**: Seeds ripen in August. Collect pods when they are plump, yellow to light brown and contain several plump seeds. Collect by hand or using scissors.

**Seed Processing**: Dry. Thresh. Sieve and winnow.

**Storage:** Seed is not sensitive. Dry and store cool in sealed containers for several years.

**Pre-treatment of seed:**

**How to Grow:** Seed: Germinate at 25/15°C with equal light/ dark.

## General

**Plant Description:** A perennial climbing herb that grows 40 to 100cm tall [1]. Rhizomatous, producing single stems. Stems are smooth, not winged, not hairy. Leaves are compound, 4 to 8 pairs of leaflets and tendrils at the tip. Leaflets are short, 1 to 3cm long, rounded or slightly pointed at the tip. Stipules at the base of the leaves are toothed. Flowering heads are made up of 2 to 9 bluish-purple flowers. Flowers are tube-shaped, 3 to 5.5mm long. Fruit is a 2 to 4cm long pod, with several pea-like seeds, brown to dark brown at maturity.

**Field Identification:** American vetch's smooth stem, the number of leaflets and number and appearance of the flowers are important for identifying this species from other legumes in the *Vicia* and *Lathyrus* genus. **Similar species:** The non-native species, Cow vetch (*Vicia cracca*) often has 10 to 40 flowers per flowering head and its stems are covered in fine hairs. *Lathyrus* ssp. often have stipules over 10mm long and fewer leaflets, or if the same number of leaflets have winged stems [2]. Refer to further reading below for an online identification key.

**Life Form:** Perennial forb; stems die back during unfavourable conditions, regenerating from rhizomes.

**Reproduction:** Reproduces by seeds and rhizomes [3]. Flowers from May to August [4].

**Continental Range:** American vetch is secure in western Canada; populations become imperiled in Quebec and are absent in provinces further east [5]. Present but imperiled in the Yukon and Alaska. Found throughout much of the United States, not present in southeastern states.

**HBL regional Range:** Widespread and abundant in the Hudson Bay Lowlands [6].

**Habitat:** Found in a wide variety of habitats, moist soils, mixed forests, clearings, arid lands [3]. Tolerant of a range of soil types, including coarse, fine and medium textured soils from acid to basic soils.

*Photo 2: Cow vetch (left) and American vetch (right). Note the*

*to American vetch plants.*

## Reclamation value

A drought tolerant herb, capable of nitrogen fixation may be highly valued in reclamation of disturbed sites such as roadsides and mining areas [3]. Tolerates mildly saline soils [7].

**Nitrogen fixing:** Yes [3].

**Symbioses:** Vesicular arbuscular mycorrhiza [8]. Fixes nitrogen due to a symbiotic relationship with *Rhizobium* bacteria.

**Growth rate:** Moderate [9].

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# American vetch

**Successional stage:** Found in all stages of succession [3]. Colonizes recently disturbed sites following fire, but tolerates shade, common in quacking aspen forests.

*Photo 3: Mature American vetch pods.*

## Seed and propagule properties

**Propagule description:** A pea-like pod, turns brown at maturity, 2 to 4cm long [1].
**Dispersal:** Pods burst open after drying and launch seed short distances.
**Propagule weight:** (whole dried pod) 11.58mg [10].
**Seeds/ propagule:** Two or more seeds/ pod.
**Seed size and description:** Seeds are dark brown to black at maturity, round about 3mm in diameter.
**Average seed weight:** (cleaned, dried seed) 11.20mg [10].
**Seeds/kg:** Approximately 89 000 seeds/kg [10].

## Seed collection

**Timing collections:** Seeds mature about one month after flowering [4]. Pods are plump and yellow to brown at maturity usually by mid to late August. Seeds disperse quickly once mature [11] especially during dry, hot weather. Pods can be collected when they are green in colour as long as seeds inside are plump, brown and hard.
**Collection protocols:** Collect the pod from the plants by hand or scissors if plants are highly productive. Place pods in paper bags to dry following collection, they may burst open and launch seed so it is best to keep them contained in a breathable container or bag.
**Collection effort:** Seed abundance was low in wild populations, so we spent most of our time searching for productive plants rather than collecting pods. One person collected between 1.5 to 41g of pure, dry seed in one hour.
**Potential density:** No information found.
**Cautions:** None known.

*Photo 4: American vetch pods following threshing have all released their seed.*

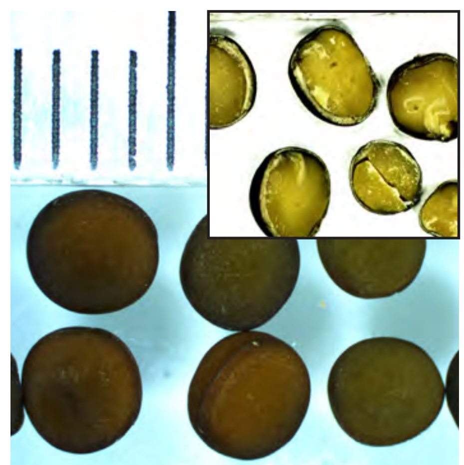

*Photo 5: American vetch seed.*

## Propagule processing

**Processing protocols:** When material is dry, many pods will have opened and released seeds. Thresh dried pods on a corrugated rubber surface, to open any pods that have not split open. Sieve then winnow material to remove chaff.
**Cautions:** None known.

## Storage

**Storage behaviour:** Probably orthodox [12].
**Storage requirements and longevity:** Seed longevity is not described, however American vetch seed is likely long lived like other legumes with a hard seed coat [11]. For best practices of orthodox seed, dry well and store cool (1 to 5°C) or at -20°C.

## Seed propagation

**Dormancy classification:** Physical dormancy [13].
**Potential viability:** Our cleaned seed lots had over 98% seed viability.
**Pre-treatments:** Seeds germinate best after mechanical scarification of the seed coat [14], however seed will germinate without pre-treatments, but will be delayed.
**Germination protocols:** Untreated seed germinates to 85% at 30/20°C and slightly better at 25/15°C [11]. Other temperate or arctic vetches (*Vicia* ssp.) germinate after seed coat scarification at 20/15°C or 20/10°C with 12/12 hours of light/dark [13].

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**Other propagation methods:** Rhizome cuttings (cited in [14]).
**Field planting:** Seeding rates of approximately 37kg /hectare to a depth of 1cm in moist clay soil [11]. Seed emergence was best at 4% and did not differ for spring or fall plantings [15].

## Other

**Canadian commercial sources:**
https://www.brettyoung.ca/professional-turf-and-reclamation/seed/native-grasses
**Useful links and further reading:**
Online dichotomous key to Fabaceae family: http://michiganflora.net/family.aspx?id=Fabaceae
http://www.borealforest.org/herbs/herb39.htm

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