Starting a Native Plant Business in Southcentral Alaska

July, 2024

Homer Soil & Water Conservation District

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Acronyms and Abbreviations

AK DOF	Alaska Department of Forestry
AKNPC	Alaska Native Plant Collaborative
BLM	Bureau of Land Management
CSP	Conservation Stewardship Program
DOT	Department of Transportation
e.g.	exempli gratia – for example
EQIP	Environmental Quality Incentives Program
IDIQ	indefinite delivery, indefinite quantity
IPM	integrated pest management
n.d.	no date
NRCS	Natural Resource Conservation Service
PLANT	Partnership for Landscape Action with Native Terrestrials
PMC	Plant Materials Center
RBDG	Rural Business Development Grant
SWCD	Soil and Water Conservation District
TCD	Tribal Conservation District
USDA	United States Department of Agriculture
USFS	United State Forest Service

Cover photos, left to right: *Geranium erianthum* (wooly geranium, C. Greenstein), *Sanguisorba canadensis* (Canadian burnet, C. Greenstein), *Lupinus nootkatensis* (Nootka lupine, B. Bernard).

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(3) Email: OASCR.Program-Intake

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-Propagation profiles literature review methodologies, results, discussion, and recommendations

-Vegetation mats literature review, filling data gaps

-Partnerships, coordination, and collaboration</td><td>Body of report:

-Ecological and biological considerations (why local plants are important, seed transfer zones, integrated pest management)

-Business considerations (choosing production type, scalability, ensuring demand)

-Best Management Practices by taxon and material type (seed collection, grow out, woody cuttings, salvage, ancillary/support services; graminoid, forb, shrub, tree)

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1 INTRODUCTION

The current state of native plant production in Alaska is often compared to a chicken-and-egg situation. Without native plant materials available, land managers can't require their use in restoration and reclamation projects. But until projects start mandating native plant material use, there isn't enough demand to grow the native plant industry. Which comes first?

With the current influx of federal funding (e.g., Bipartisan Infrastructure Law), government agencies are uniquely poised to support business development in the native plant sector. In this way, we can aim to produce so many eggs that the chicken must follow. In this analogy, native plant materials are the egg, and the chicken is regulations requiring and enforcing the use of native plant materials in restoration and reclamation projects.

Our chickens and eggs can happily coexist here and now. There are federal funds presently to break the stalemate, but these funds will run out. If we want a native plant industry to be sustainable, it needs to exist outside the boom-and-bust cycle of federal funding. Incentivizing non-government organizations and individuals to produce native plant materials is needed to guarantee a sustainable industry. However, potential growers see the volatility in the market, question the profitability, and hesitate to get involved. This document aims to address these issues by providing prospective growers with guidance and tools to get started collecting, growing, propagating, and selling native plant materials, as well as ensuring there is demand for these products.

To keep the analogy rolling, this report celebrates our favorite yard birds by sharing research conducted 2023-2024 by the Homer Soil and Water Conservation District (SWCD). This report incorporates a few lessons learned from surveys and interviews (see Appendix D – Survey/Interview Questions) of 43 individuals and organizations from diverse perspectives: state and federal agencies, non-profits, botanists, foresters, farmers, and anyone with an interest in native plant production. We conducted extensive literature reviews to compile *Propagation Profiles* (Appendix A) on 40 high-priority species, each detailing biological descriptors, and best management practices for collecting, cleaning, storing, propagating, and planting. Lastly, a literature review allowed for summarizing categories of native plant business types, providing recommendations unique to taxonomic groups, and exploring scalability of endeavors, to encourage inclusivity and reduce barriers to implementation for those interested in starting a native plant business.

Additionally, Homer SWCD's Agriculture Program and Native Plants Program are available to support growers with technical guidance throughout the business development and implementation process.

The literature review and interviews that inform this guidance document dovetail with a larger statewide effort (the Alaska Native Plant Collaborative [AKNPC]) to gather baseline information on native plant supply, demand, and available expertise. Both this project and the AKNPC are working toward the same goal of providing education, outreach, and support to growers/collectors, as well as help identifying and connecting growers to markets.

The geographic scope of this project focuses on Southcentral Alaska, but much of the work is applicable throughout the state. We hope that this report is useful for anyone interested in starting a native plant business, as well as the diverse and talented team participating in the AKNPC.

Acknowledgements

Thanks to the United States Department of Agriculture (USDA) Rural Business Development Grant (RBDG), Alaska State Office, for funding this project. Additional funding for background research culminating in the included appendices was provided by the Bureau of Land Management and Chugach National Forest. Homer SWCD's District Manager, Kyra Wagner, never fails to remind us that *a rising tide lifts all boats*, and the work we put into this report elevates the work done across the state to develop a viable native plants sector. I'm extremely grateful to the Homer SWCD Native Plants team for creation of appendices: Kelly Sivy for the Propagation Profiles and Bonnie Bernard for the excellent guide to Collection Permits (and editing throughout); and both for contributing to the Recommended Reading list. Jake Egelhoff assisted in building the Network Diagram and conducted dozens of interviews with interested parties across the state. Lastly, thanks to all the interview participants who let us lob way too many questions at them in the name of science and industry.

2 BACKGROUND

2.1 Why Local is Important

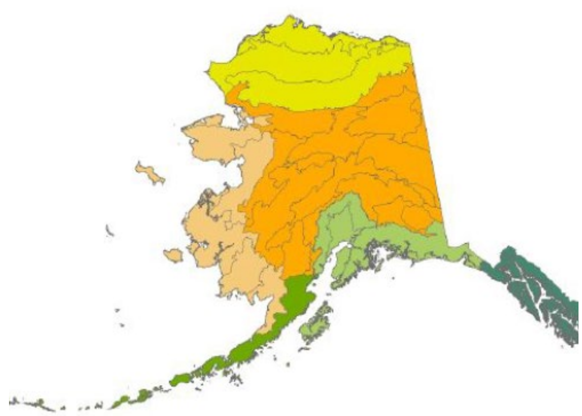
Many species have wide ranges throughout North America, but localized population genetics differ. For example, the same species growing in California and Alaska may share many traits, but Alaska populations have adapted to the shorter growing season. If you plant seeds or stems from a Californian population in Alaska, they may fail in their first year because they germinate too early in the spring and experience a killing freeze, or they may take too long to mature, and experience a killing freeze before producing seed in the fall.

Seed transfer zones are geographic ranges wherein seeds can be transferred and have a reasonable likelihood of success (see sidebar). As more seeds are collected from more seed transfer zones, these can be grown out as plugs, pots, flats, or bare root trees and shrubs, each generally adapted to the outplanting site. For this reason, regardless of the type of plant material produced, tracking the material's origin is important. A grower could end up producing three batches of white spruce, each genetically distinct enough to be tailored to different outplanting locations.

Seed Transfer Zones

Seed transfer zones are mapped regions in which transferring seeds should be reasonably successful. In the Lower 48, zones are based on defined ecoregions and climate data that include aridity and winter minimum temperatures, similar to US Department of Agriculture Plant Hardiness Zones. These are not a guarantee for seed transfer success but are a starting point that should be used alongside local knowledge, species-specific traits, and microsite types.

These data have not been fully assessed and mapped in Alaska, but our best resource at present is Preliminary Seed Zones (below) based on unpublished research from Brickley (2010) and described in a report by Duffy (2012). This uses the Alaska Unified Ecosystem units, with some modifications. At present these units are very large, so appropriate Transfer Zones still rely heavily on professional judgement.



Preliminary seed transfer zones (Duffy, 2012).

2.2 Native Plant Traits vs. Developed Varieties

There's a big difference between native plant traits and species that have been cultivated for agriculture or ornamental uses for generations (Figure 1). The latter have been selected for uniform characteristics, such as germination rates, fast growth, and predictable maturation. For agricultural seed crops, they are further selected for no seed dormancy, uniform flowering and maturity, and high seed retention. These traits all increase productivity when grown in a controlled environment. By contrast, native plants grown in the wild benefit from highly variable adaptations. For example, staggered germination and seed set times in wild populations allows them to survive across years, in changing environmental conditions, such as changing weather, predation, and fire regimes. For these reasons, native seeds do not behave the same as commercially available seed. The grower needs to be prepared for lower germination and survival rates.

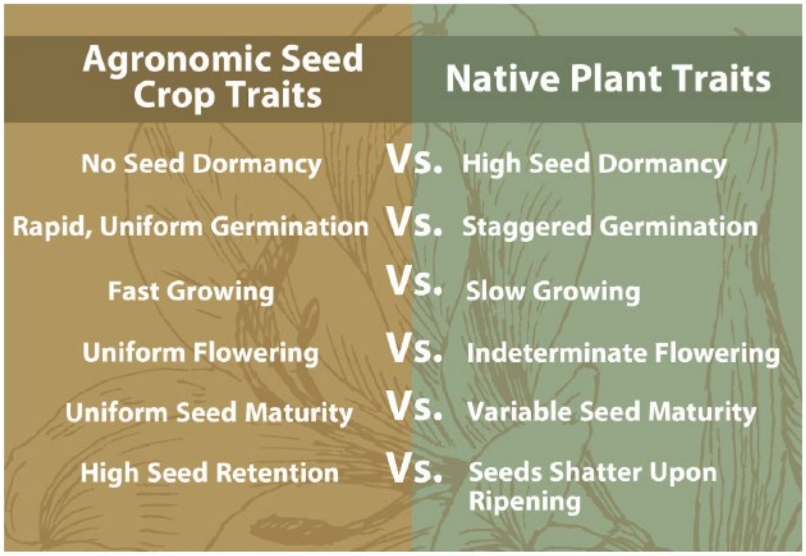


Figure 1. Comparison of plant traits, from Corvallis Plant Materials Center (PMC) (n.d.).

Additionally, cultivars developed from native species may have the benefit of increased production and more uniform growth. However, because they have been genetically selected for these traits, they may be less suitable for revegetation where high genetic diversity is preferred. More research is needed into the impacts of artificial selection on native seed's suitability for restoration.

2.3 Choosing Your Business Direction

Sections in this document outline the basic categories of native plant materials and production methods. Each section summarizes pros and cons, technical considerations, and potential profitability. The basic categories are:

- Grow Out
  - Containers
  - Fields
- Seed collection
- Woody cuttings
- Salvage

Figure 2 illustrates how each of these plant material types matches up with available resources. This can help the grower decide what type of plant production is most conducive to their resources, consequently having the lowest barriers to implementation. Alternatively, if a grower has an interest in a particular type of production, Figure 2 shows what basic infrastructure is needed.

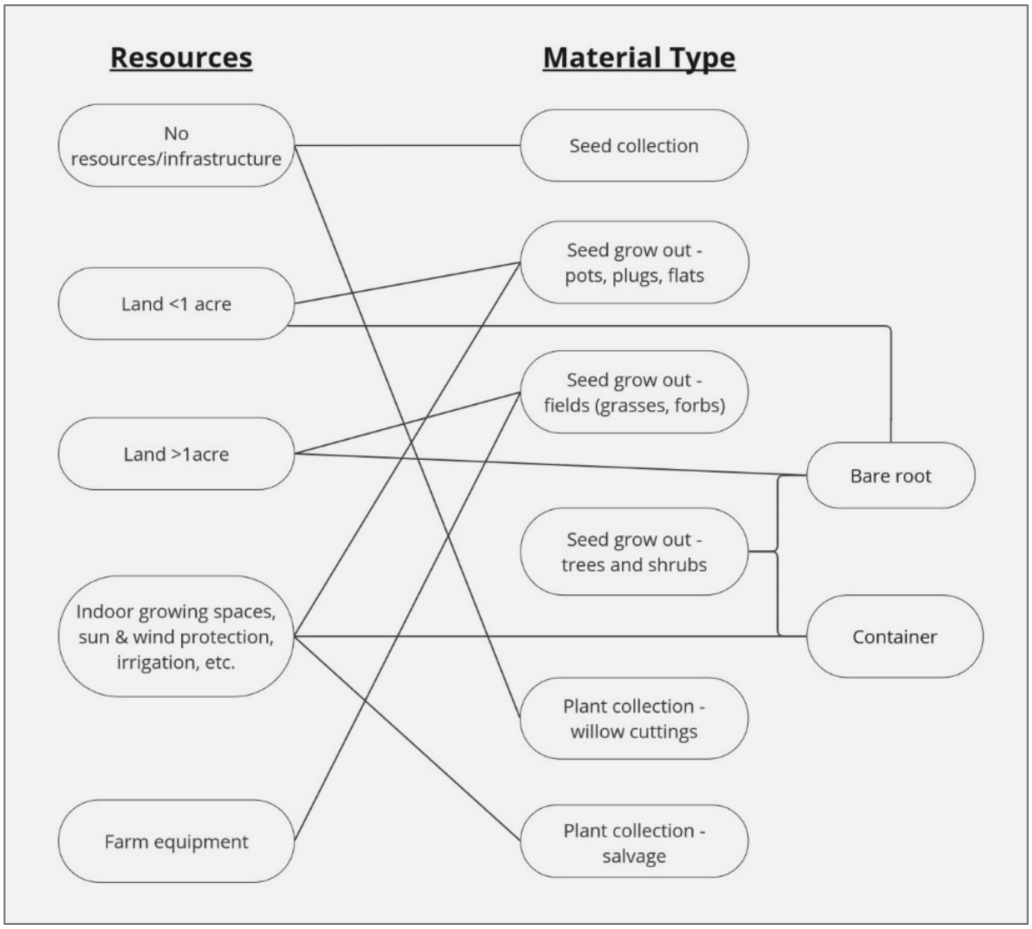


Figure 2. Diagram illustrating how to match available resources to different types of plant material production.

2.4 Ensuring Demand

Understanding market demand is crucial, but perhaps beyond the scope of interest of the average grower. The Homer SWCD is available to help connect growers to markets and recommend what types of materials are in high demand.

Knowing what projects are planned or in progress can help a grower select the right seed source and material type. For example, a large and ongoing wetland restoration project on federal lands will create high demand for wetland plugs and willow cuttings by the managing agency and will need seed collections from neighboring wetlands. By contrast, reforestation from spruce beetle kill in residential areas will create high demand for trees saplings from private buyers. Projects along highways and roads need grass seed for erosion control. As previously mentioned, these typically need materials from the same Seed Transfer Zone, but in some cases (e.g., roadside revegetation grass species), transfer zone requirements may be more lenient.

These considerations affect what type of plant materials are in high demand, and consequently will have a guaranteed market and yield a profit for the producer.

2.5 Sourcing Material

Regardless of avenue to plant production, it's important to realize that as of 2024 Alaska's native plant sector is in its infancy. A grower may want to produce a certain species or group of plants, only to find there are no seeds or other propagative parts available. The first thing Alaska needs is locally adapted seeds; from there plants can be grown out in fields for seed increase, or propagated into plugs, pots, saplings, etc., for sale and outplanting.

2.6 Integrated Pest Management (IPM)

Native plants are often used for the purpose of excluding invasive species establishment on restoration and remediation sites. As such, is extremely important to keep nonnative plants and seeds out of native plant materials using IPM methods; IPM is also used to control insect pests and fungal diseases, which may be a problem in nurseries or fields.

IPM is a strategy of controlling unwanted species through considering pest biology, management goals, and using a combination of control methods. The following are categories of pest management methods used in IPM and examples of each:

- Mechanical/physical – hand weeding, mowing, row cover, mouse traps.
- Cultural – sanitation, timing of planting and harvesting, crop rotation.
- Biological – using ladybugs in a greenhouse to control unwanted insects.
- Chemical – herbicide, fungicide, insecticide, repellents, disinfectants.
- Genetic – selecting species bred for pest or pathogen resistance, or coadapted to a pest, and consequently resistant to them.
- Regulatory – laws that restrict the sale of specific species, quarantines, inspections.

Examples of cultural control methods used by a native plant nursery in California (Young, n.d.) include:

- Drain plugs and pots completely between waterings (and use well-draining potting media); these avoid conditions that foster water-borne pathogens.
- Allowing enough space between plants to encourage air flow.
- Intermixing species to limit development of species-specific pest populations.
- Timing propagation to prevent plants becoming rootbound.
- Keep plants on benches and avoid contact with soil.
- Removing weeds in the vicinity of the nursery and within pots.
- Using compost-based plant media and compost teas.

Any native plant business will need to incorporate control with mechanical/physical and cultural methods. No biological control methods have been approved for use in Alaska but could be approved in the future. Chemical treatments are sometimes necessary but there are legal restrictions to applying pesticides on property that you don't own, as well as a number of human and environmental safety concerns. In the native plant context, genetic control methods relate to using species coadapted to pests of a particular region so that they have innate defense mechanisms. Regulatory control methods relevant to native plants include the required use of certified weed-free gravel at restoration sites, certified weed-free hay fed to horses for days prior to visiting the backcountry, and certified weed-free straw used for dog bedding along the Iditarod Trail. Regulations also prohibit the importation of certain plant and animal species into the state.

Quality control standards for weed-free native plant materials are not currently available but are expected to develop as the native plant sector grows.

2.7 Scalability

Considerations for scalability are addressed throughout the following sections. These are a starting point to think about the possible scope of a native plant business and are not intended to be a comprehensive list.

For example, a project could start out small with only modest seed collections that are sold rather than grown out. Hand tools can be used to salvage native plants at sites scheduled for ground disturbance and then sold to someone who will install them at sites in need of restoration. On a medium scale, someone may collect seed and grow it out to sell pots and plugs. Salvage jobs may occasionally rent/contract heavy equipment/operators to dig up small trees or scrape up sheets of native vegetation. On a large scale, hundreds or thousands of saplings could be provided to replant areas decimated by spruce bark beetles. The grower may also have their own equipment and trucks for transporting materials, and indoor and outdoor nursery space for propagation by seed, cuttings, and divisions. At the largest scale, a business may integrate all aspects, from wild harvest of seed and woody material to propagation, seed multiplication, landscaping/restoration, and provide a retail or wholesale nursery for direct sales.

In addition to being scalable, the proposed native plant nursery is highly adaptable in terms of centralization. For example, it could be a decentralized network of harvesters, growers, propagators, and planters; or could be run exclusively by SWCDs and Tribal Conservation Districts (TCDs).

In the following sections, under each business type there's a table summarizing considerations at small, medium, and large scales. Note that the larger scales still imply use of considerations listed at the smaller scales; they build on each other.

The following sections are not intended to be comprehensive but summarize how native plant production differs from vegetable or ornamental production.

3 GROW OUT – CONTAINERS OR FIELDS

3.1 Background

Native plant grow out can take place in outdoor fields or a nursery-type setting, though it doesn't necessarily require a greenhouse or high tunnel, like some vegetables or ornamentals do. Outdoor fields are used for seed multiplication of graminoids and forbs, and production of bareroot forbs, shrubs, and trees. Nurseries are used for containerized graminoids, forbs, shrubs, and trees.

Figure 3 presents a comparison of a container versus a bareroot nursery. This doesn't capture fields grown out for seed, but many of the factors for seed production are similar to a bareroot nursery, with a few exceptions.

Factor	Container Nursery	Bareroot Nursery
Land Requirement	Less land needed	More land needed
Soil Quality	Not important because artificial growing media are used	Critical—sandy loams are preferred
Water Quantity	Lesser amounts required	Greater amounts required
Water Quality	Good water is desirable but some problems can be chemically corrected	Good water is critical
Propagation Structures	Depends on location, size, and complexity of the nursery	None
Equipment	Depends on size and complexity of the nursery	Tractors and specialized equipment for sowing and harvesting
Duration of Crop Cycle	4 to 12 months to several years depending on container size	1 to 3 years
Crop Storage and Transportation	Greater volume required	Lesser volume required
Plant Handling	Roots are protected in plug	Roots are exposed and are often treated for additional protection
Season Seedlings Can Be Outplanted	Year-round if soil moisture is good	Spring or sometimes Fall

Figure 3. Considerations for starting a container or bareroot nursery. From Dumroese et al. (2021).

Additional differences include (Dumroese et al., 2021):

- Bareroot nursery has higher upfront costs (e.g., land and equipment) but lower operating costs compared to a container nursery.
- Higher elevations and altitudes decrease the growing season, making bareroot operations less practical.

- Container plants are grown at high densities and consequently use less land relative to bareroot seedlings.
- Controlled environments encourage faster growth rates if managed correctly.
- Both may require fencing, particularly if growing edible berries or other plants preferred by wildlife.

3.1.1 Genetic Diversity

A central objective of native plant production is maintaining genetic diversity. As conditions at an outplanting site change, there needs to be enough genetic diversity to adapt. There should be a balance between plants that are locally adapted but also retain as much genetic diversity as possible. There will be less genetic variability within a self-pollinating species, but increased variation between populations. By contrast, a fully outbreeding species has more variation in a single population and fewer genetic differences between populations (Young, n.d.).

Aggregating native plants into a controlled environment – be it field or nursery – can cause unintentional selection for genotypes that thrive in cultivation and the decrease in genotypes better able to thrive in the relatively harsh and competitive habitats of restoration sites.

Steps can be taken to protect genetic diversity: 1) To establish a cultivated stand, incorporate seed/plant material from diverse habitats and locations. 2) Encourage outcrossing between populations. 3) Make ongoing additions of wild seed/plant materials. 4) Save seed/plant material from all individuals, regardless of size or perceived inferiority; these may have genes that provide disease resistance, drought tolerance, etc. (Burton and Burton, 2003).

3.1.2 Obtaining Plant Materials

With a lack of native plant starter stock, you may need to collect your own seed or woody cuttings. In some situations, you may want to collect plant materials from near the intended outplanting location. Always know landownership and get permission to collect. see Appendix C – Collection Permits.

There are a few local seed sources, albeit with limited supply. Try reaching out to:

- Alaska Native Plant Society
- Alaska Plant Materials Center
- St. Isidore Farm
- Local garden club or Master Gardener group

Typically, seeds obtained through commercial retailers for ornamental or vegetable plants, or lawn mix, have no dormancy-breaking requirements. This is not the case for native species. Many Alaska species require, at a minimum, cold stratification. Some seeds are adapted to dispersal by wildlife and require mimicry of digestive acids to break their seed coat. Planting native seeds without stratification or scarification can yield little to no germination. For more information on species-specific needs, see Appendix A – Propagation Profiles or the Native Plant

Network database. For a discussion of dormancy types and methods for breaking dormancy, see Appendix B – Recommended Reading (in particular, Dumroese et al., 2021).

3.1.3 Outplanting Site Considerations

If growing for project-specific contracts, it's important to consider potential factors limiting growth at the outplanting site and adjust for them. For example, mine reclamation sites may have extreme soil pH, and may require a suite of species adapted to the site-specific pH. Both mining activities and forest fires can eliminate all soil microorganisms, including beneficial bacteria and fungi, and plants should be inoculated with the appropriate species before outplanting. By contrast, reforestation projects typically have plenty of naturally occurring mycorrhizae and beneficial organisms that will colonize the revegetation site, so plants don't require additional inoculations (Dumroese et al., 2022).

3.1.4 Scalability

A summary of scalability is provided in Table 1, which combines container and field operations.

Table 1. Scalability of container and field nurseries.

Scale Considerations	Small	Medium	Large
Geographic scale	<1 acre	<1 acre - a few acres	>5 acres
Time scale	1-2 year plants (grow and sell in single season, or over winter once)	1-5 year plants	1-5+ year plants
Infrastructure	-Potting shed -Outdoor grow space -Irrigation	-High tunnel -Low tunnel -Caterpillar tunnel -Greenhouse	-Fields for seed multiplication -Tree or shrub nursery
Tools	-Hand tools	-Small farming equipment	-Heavy equipment
Taxonomic groups	Graminoids, forbs	Graminoids, forbs, shrubs, trees	Graminoids, shrubs, trees (less emphasis on forbs)
Material types	Plugs, pots, flats	Plugs, pots, flats, bareroot trees and shrubs	-Seed production -Mature trees and shrubs
Target market	-Home gardeners -Landscaping companies -Local or state restoration projects	-Local, state, or federal restoration projects	-Home owners/Landscape contractors that need mature trees for privacy -Seed through brokerage* -State (particularly DOT) and federal agencies

*At present, large seed producers are part of the Alaska Seed Growers Association and use Alaska Mill and Feed as a brokerage service.

3.2 Container Grow Out

Pros: Ideal for someone already growing vegetables; easy to transition to native plant production because they already have most of the needed resources and expertise.
Cons: Learning curve for someone inexperienced with nursery management or crop production. Expect lower germination and higher mortality rate with native species.

As previously mentioned, native plants are more variable than plants specifically bred for ease of propagation. For a first-hand account of operations at a native plant nursery in Oregon, see Appendix B – Recommended Reading (specifically, Parks, 2023); they suggest starting by overplanting 30-50%, as this is the expected rate of loss. Similarly, anticipate additional staff time to thin failed plants and to replant, as needed.

3.2.1 Soil and Water Quality

Plants grown in containers are inherently limited in what they can take up from the small amount of soil they have access to; for this reason, they require some fertilization, which will vary by species. One nursery in California notes that little fertilization is needed. The primary nutrients they use are bonemeal (3-15-0) and cottonseed meal (6-2-1), which release slowly. They use only very low rates of nitrogen, as nitrogen can thin cell walls, making plants susceptible to harmful fungi. Nitrogen addition can also increase vegetative growth, at the expense of roots or seed production (Young, n.d.).

3.2.2 Infrastructure and Supplies

A native plant nursery requires different infrastructure compared to vegetable or ornamental plant production. The latter often need higher temperatures and season extension provided by a high tunnel or greenhouse. By contrast, native plants need growing conditions like what they experience in their native habitats. A greenhouse or high tunnel may be useful in the spring to artificially speed up germination and get a jump on summer growth. Otherwise, the types of structures suitable for native plants are primarily those that keep them protected from direct sun (as needed) and wind. Low tunnels and caterpillar tunnels require less financial investment and installation effort than greenhouses and high tunnels. A number of different coverings are available, depending on goals: bug protection, trap heat (seed starting), block wind, provide shade, and/or control watering. They can be used to keep plants dry in the fall rainy season, making seed collection from your plant stock easier. It's also entirely possible to grow native plants with no protective structure; however, a protected workspace can make the grower more comfortable.

Containers used for native plants may differ from what is commonly found in a typical retail nursery, which are intended to be single use. By contrast, when growing native plants for restoration, in some cases the plants can be removed from their containers and wrapped in biodegradable cellophane for transport, or the buyer can be required to return containers to the grower. Containers commonly used by native plant growers in the Lower 48 include the Ray Leach Cone-tainer™ and the Deepot™. Features that set these apart from the average Home

Depot flowerpot include internal ribs to prevent root spiraling, a reuse life expectancy of 5-7 years, ability to accommodate plants requiring a deeper root mass, and these come with a "block" that holds individual containers and allows them to be consolidated and rearranged, as needed. Additional container recommendations can be found Appendix B – Recommended Reading (specifically, Dumroese et al.,2022).

3.2.3 Storage and Overwintering

Native plants need to undergo a hardening phase, just like any other plant that needs to survive a winter. For more information see Appendix B – Recommended Reading.

It can be beneficial for the grower to unload all their plant materials in a single growing season, so they don't need to overwinter them. Plants that don't sell in the intended timeframe take up space, labor, and irrigation. However, some plant materials are intentionally grown over 2+ years to produce more mature plants. In this case, the goal is to keep plants below freezing to maintain dormancy but avoid exposure to rain or freeze-thaw cycles that can saturate – and then freeze – soils, consequently killing plants. The simplest yet riskiest method of storage is to keep plants outside, packed tightly together, protected from wind, and on a well-draining surface in preparation for spring melt. White or reflective tarps or other fabrics can be used to cover plants. Storage structures include cold frames, polyhouses, shadehouses, greenhouses, and refrigerated storage. One nursery in Oregon removes plants from their plastic containers, wraps them in biodegradable cellophane, and stores them either outdoors, in a protected space, or in a walk-in cooler (Parks, 2023).

3.2.4 Scheduling

Planting schedules are extremely useful and will differ from a single-year planning calendar that vegetable growers may be used to. They typically will span multiple years, and include all aspects from collection and processing, growing, hardening, and outplanting. Figure 4 provides an example of a native plant planning calendar.

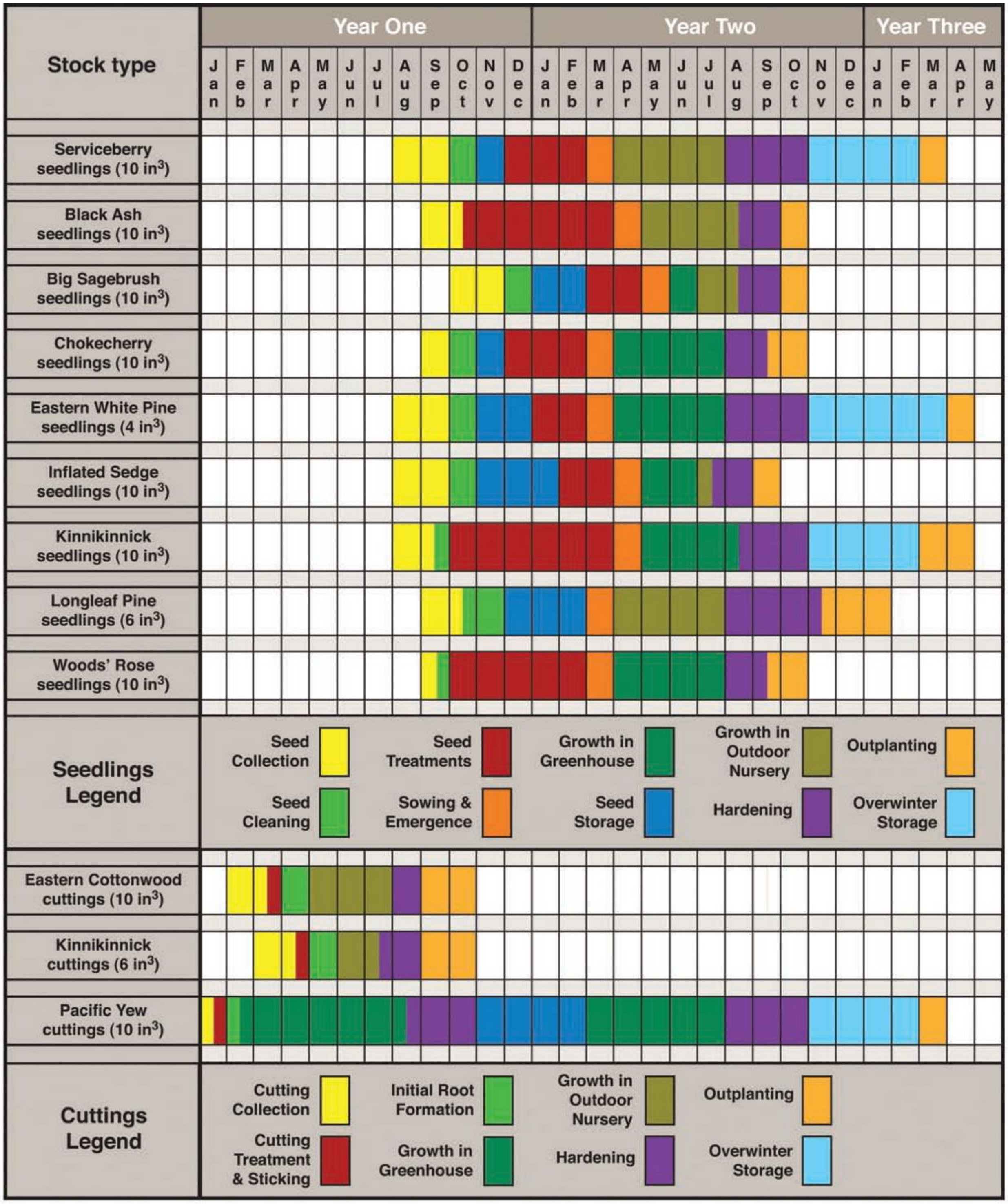


Figure 4. Example of a native plant nursery planning schedule, from Dumroese et al., 2021, 2022, illustration by Jim Marin.

3.2.5 Demand and Profitability

Demand for plugs, pots, and flats can be divided into two general categories: 1) restoration and revegetation projects that require hundreds to tens-of-thousands of plants, and 2) a smaller niche market for showy, edible, and ornamental native plants. Consequently, a government contract for 10,000 wetland plugs is going to have a larger pay out than selling a 6-pack of chocolate lilies to a gardener, though that latter will have higher unit price.

A wholesale native plant nursery in Oregon determines their prices based on average market rate, personnel time for each task in production, cost of soil and amendments per unit, and a standard per square foot of greenhouse space rate, which encompasses water, heat, etc. Their one-season plants average $1.85 each (Parks, 2023).

For a point of reference, Table 2 provides plant prices based on size, developed by the Anchorage SWCD. Given that the Alaska native plant sector is in its infancy, prices per unit are undergoing development and revision. These are only estimates, and subject to change, but can be useful as an initial point of reference.

Container size	Cost
Starter plug <2.5"	$1
50 cells of 5" plugs	$150-175
3" pot	$3
4-5" pot	$4
1 quart pot	$8
2 qt pot	$12
2 gallon – 2 years old	$20
2 gallon – 3 years old	$30
5 gallon – 3 years old	$50+
5" tree plug	$5
5" tree/shrub plug – 2 years old	$12

Table 2. Initial estimates of plant prices by container size, provided by the Anchorage SWCD, 2024.

3.3 Field Grow Out

Pros: High demand for workhorse grass species and mature trees and saplings. Guaranteed buyers.
Cons: Only suitable for someone with acreage and equipment.

The purpose of cultivating native plants in an agricultural field is to concentrate plants in a convenient area, rather than scout them in the wilderness. Fields can either be used to multiply seeds of graminoids and forbs, or to produce bareroot forbs, shrubs, and trees. Growing in a cultivated field can enhance seed and stem production by providing improved soil and eliminating competition from other species. Field preparation includes removing weeds, tilling, amending the soil as needed, and leveling the area for easy access.

For grass seed multiplication, fields are typically directly seeded with wild-harvested seed, and the cultivated seed is collected with farm equipment when the majority of seeds are ripe.

Forbs, shrubs, and trees grown for plants (rather than seed) are harvested when they reach the desired maturity, or in the case of some forbs, can be harvested by divisions. For those grown for seed, collection typically takes place by hand and occurs throughout the ripening window of the species. In either case, the initial seedstock is typically first grown out as plugs, then planted into the field; this is preferred over direct seeding when seeds are in short supply, or a species has unreliable germination. For this type of production, applying a weed barrier cloth to the cultivated field can help keep out unwanted species, and make seed harvest easier. Some operations will use a vacuum to collect seed that has dropped between rows.

3.3.1 Soil and Water Quality

Few studies have examined the effects of fertilization on native plants grown out in fields, and what data exists is often conflicting. One argument for limiting soil amendments is that in their natural habitats, many native species are adapted to poor soils. The counter argument is that for the sake of crop production, good soil fertility is better.

Burton and Burton (2003) describe the preferred site conditions as a flat site with deep loamy or sandy soils, weed-free, and with well-prepared and firm soil beds that are finely cultivated and smooth to accommodate the particularly small seeds of native species. They also recommend multiple fertilizer applications per year: for forbs, a balanced fertilizer applied annually; for grasses avoid nitrogen fertilizations, as this will increase vegetative growth and decrease seed production.

Field studies from the Corvallis PMC indicate most native forbs benefit from balanced fertilizer application in spring and that most native grasses don't benefit from fertilizer application in the fall but do benefit from nitrogen application in early spring (Corvallis PMC, n.d.).

Dumroese et al. (2022) note that some native plants prefer low fertilization, and that some beneficial organisms (e.g., mycorrhizae) need low fertility to establish.

Apart from conflicting nutrient recommendations, there is consensus that a field needs to be free of weeds prior to planting or seeding with natives, which can be accomplished with 1-2 years of mechanical or chemical treatments. Any site with aggressive invasives (e.g., quackgrass, Canada thistle, orange hawkweed, reed canarygrass) should not be considered for native plant production. Typical agronomic fields grow only annuals, and they are tilled under every year and replanted; this process helps to control weed species. However, cultivated natives are nearly always perennials, and consequently are not tilled annually, so weeds are not controlled by this means (Burton and Burton, 2003).

3.3.2 Harvesting and Equipment

Harvesting native species is more difficult than agricultural or agronomic species, since they don't mature uniformly. Native plants either require multiple seed harvests, or careful judgement of when the largest percentage of seeds are ripe. Using plastic between rows serves two purposes: providing weed control and making collection of dropped seeds easy, as they can be swept up or vacuumed. Vacuums can also be used to harvest fluffy seed heads right off the plant (Burton and Burton, 2003).

Grow out fields less than a half-acre can be harvested with hand tools, such as sickles. Anything over a half-acre will likely need equipment. Harvesting equipment can be species-specific and includes implements such as a combine, seed stripper, or swather. See Appendix B – Recommended Reading, subsection on Equipment.

3.3.3 Demand and Profitability

By some accounts, the largest demand for native plant materials in Alaska is for workhorse grass species to be seeded along roadsides after construction or maintenance. Consequently, there is a huge market for cost-competitive native seed. The PMC maintains cultivars of native species and encourages farmers to grow them out for seed multiplications; moreover, there is already an Alaska Seed Growers Association that partners with Alaska Mill and Feed to sell their products.

As a bonus, the byproduct of grass seed production is straw, which can be baled, sold (e.g., animal bedding, mulch) or used onsite as mulch.

Trees and shrubs are well suited to bareroot production in fields. Results from surveys conducted by Homer SWCD indicate high demand for trees, both small saplings and mature trees. Larger trees are expensive to ship from out of state, which may help locally grown plants be cost competitive. Nursery trees grown 3-5 years often sell for hundreds of dollars, which could make this a lucrative venture for someone willing to put in the time.

There is also a high demand for native edible berries. The target market for these is direct sale to homeowners, or sale through a farmers' market or local food hub.

4 SEED COLLECTION

4.1 Background

Pros: Little resources needed to start. High demand at this early stage of developing Alaska's native plant sector.
Cons: Time consuming, and probably not the most profitable. But with the industry quickly growing, name your price. Limited to late summer and fall when seeds are ripe.

There is an immediate need for seed collection. There is also a relatively small learning curve for successful seed collection.

The work requires excellent plant identification skills, as incorrect identification will lead to marketing the wrong plant, and potentially getting in trouble with buyers. When in doubt, collect a specimen and consult your local SWCD or Cooperative Extension office.

4.2 Species and Site Selection

Perhaps the most challenging component of seed collection is locating "workhorse species" (examples provided in Table 3) of plants in high demand from the appropriate seed transfer zone. The most sought-after species on a large scale are used for restoration and remediation and are often common species that establish easily in disturbed areas. However, there is also a smaller market for ornamental native species for use by homeowners seeking to plant pollinator gardens and improve wildlife habitat.

The challenge lies in finding seed source locations that 1) contain priority species and 2) priority species in high enough abundance to yield meaningful seed collection while practicing responsible harvesting techniques.

There are also species to be avoided, particularly rare, threatened, and endangered species, as well as those known to not reliably propagate from seed. Species that don't propagate from seed include willows, cottonwood, poplar, and aspen; these can be propagated from roots and shoots and are discussed below under Section 5 – Woody Cuttings.

Table 3. Example of a draft priority species list for Southcentral Alaska, from the Chugach National Forest, 2023.

Scientific Name	Common Name
Trees	
Betula papyrifera var. *kenaica*	Kenai birch
Picea glauca	white spruce
Picea × lutzii	Lutz spruce
Grasses and sedges	
Deschampsia cespitosa	tufted hairgrass
Calamagrostis canadensis	bluejoint
Hordeum brachyantherum	meadow barley
Agrostis scabra	rough bentgrass
Arctagrostis latifolia	wideleaf polargrass
Trisetum spicatum	spike trisetum
Festuca rubra	red fescue
Poa alpina	alpine bluegrass
Carex mertensii	Mertens' sedge
Carex aquatilis	water sedge
Carex canescens	silvery sedge
Carex lenticularis	lakeshore sedge
Juncus castaneus	chestnut rush
Luzula parviflora	smallflowered woodrush
Forbs	
Achillea millefolium	common yarrow
Angelica lucida	seacoast angelica
Artemisia tilesii	Tilesius' wormwood
Mertensia paniculata	tall bluebells
Lupinus nootkatensis	Nootka Lupine
Oxytropis campestris	field locoweed
Polemonium acutiflorum	tall Jacob's-ladder
Caltha palustris	yellow marsh marigold
Sanguisorba canadensis	Canadian burnet
Thalictrum sparsiflorum	fewflower meadow-rue
Rhinanthus minor	little yellow rattle
Geum macrophyllum	largeleaf avens
Shrubs	
Rosa acicularis	prickly rose

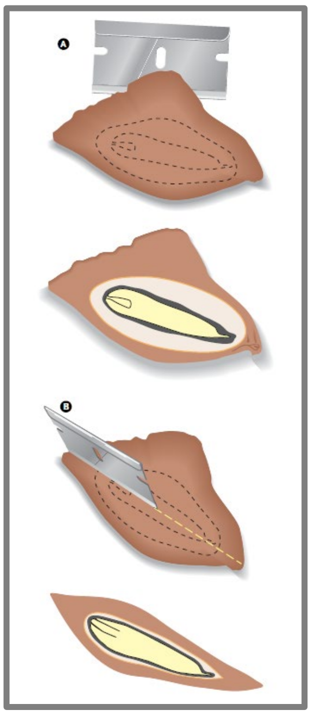
Geospatial data can assist in locating target habitat types; for example, if you know you need a species that prefers high elevation wetlands, and you're familiar with GIS systems, you can narrow down where to look. However, geospatial expertise is not required. If you like to hike and explore, you can scout locations and collect opportunistically. This may be the most cost-effective approach to seed collection, as the collector is not going out of their way or incurring travel costs strictly with the intent of seed collection.

4.3 Responsible and Effective Harvesting

To ensure adequate seed collection without damaging the native population, follow these guidelines:

Seed Viability – Cut Test

To test viability, cut a seed open with a razor blade or sharp knife, and use hand lens to see if the endosperm has a well-developed embryo and normal color. Seeds that appear shriveled, moldy, soft, milky, smell rancid, or have no embryo are not viable. For detailed instructions and photos see Kolotelo (1997).



A cutting test through the thinnest axis (A) or the wider axis (B). From Kolotelo (1997).

- Do not collect from populations of fewer than 50 individual plants.
- Before collection, inspect a few plants for empty seeds or insect damaged seeds (see sidebar).
- Collect up to 20% of viable seeds on any site visit, though a site can be visited throughout the seed maturation period. For outbreeding species, collect randomly and equally. Both these techniques increase genetic diversity.
- For rhizomatous or clonal species, collect seed at widely spaced intervals to ensure genetic diversity. For example, collect all seed on every fifth plant instead of a randomly selected 20%.
- Populations may be used for collections for two consecutive years, but no longer; leave populations unharvested for three years in between collection years.
- The collection location should not be from a planted or cultivated area. Wild populations only. For example, roadsides are often hydroseeded after maintenance, so are not suitable for grass seed collection.

Once a collection site that meets these criteria is identified, it may need to be visited later – or multiple times – to acquire ripe seed, as wild plants tend to have an extended maturation period relative to cultivated species. Also, collecting across a plant's maturation window maximizes genetic diversity. Avoid immature seed pods that are fleshy and green, and seeds that are soft, and white or green. A ripe seed pod is typically dry, and brown or white. Seeds should come out of the pod easily and be hard, and either black, brown, or yellow. However, as plants mature, ripe seed pods will open naturally to disperse seeds, and if pods are completely open the collection window has passed.

Also, it's crucial to know land ownership and get permission or permits, as needed. See Appendix C – Collection Permits.

4.4 Collection Tools

Collecting by hand requires paper or cloth collection bags, bag tags, work gloves, and in some cases, scissors or pruners. For large collections, it may be easier to collect into a bucket then transfer to cloth or paper bags. Collection of tree seeds may require climbing or felling of trees. Collections of fleshy fruits should use plastic bags rather than cloth or paper.

Some specialized equipment can allow for mechanized collection but is typically only useful for large areas of uniform grasses or sedges. A handheld seed harvester is a modified weed whacker that allows speedy collection of graminoid seeds. In large fields farm equipment may be appropriate if it doesn't otherwise damage the environment. For example, combines, flail-vacuum seed strippers, and threshers. Equipment recommendations can be found under Appendix B – Recommended Reading.

4.5 Seed Handling, Shipping, Processing, and Storage

Cleaning extends the seeds' viability. In Alaska, seed cleaning is typically done by the Plant Materials Center (PMC) in Palmer, Alaska. The PMC has specialized equipment to clean seeds, perform germination testing, and provide the right storage environment. For more information about their services visit the PMC website.

> There is a growing need for seed cleaning, as demand is outpacing current capacity. Consider starting a seed cleaning business! More information on this is below, in Section 7 – Ancillary Business Opportunities.

However, the PMC doesn't always have the capacity to support small collections. For in-house seed cleaning, there is equipment such as air-screen machines, clipper office tester, threshers, hammermills, and brush machines. Seed Appendix B – Recommended Reading for more on seed cleaning equipment. Another option is to send seeds to the Bend Seed Extractory in Bend, Oregon; however, the cost of shipping can be prohibitive.

Any large stems or woody debris should be removed from seed bags, but finer debris is left for the seed cleaning stage. Damp seeds should be allowed to air dry in front of a fan for several days before shipping or can be spread out on newspaper or screens. It's recommended that all non-fleshy seeds are placed in a bag with a No-Pest Strip (or similar product) for 48 hours to kill any insects or arthropods that may damage seeds, or a person handling seed. Follow instructions on the No-Pest Strip packaging. A tote bin with a No-Pest Strip can be used throughout a season, placing seed bags in the tote for 48 hours before sending out for cleaning.

Fleshy fruits need to be kept sealed and refrigerated prior to processing. Contact your seed processing facility for instructions for handling and shipping fleshy fruits. Cleaning fleshy fruits yourself typically requires a food processor or blender and sieves; for instructions, see Appendix B – Recommended Reading.


Figure 5. Volunteer collecting seed of *Geum macrophyllum* (largeleaf avens). Photo credit: C. Greenstein, 2023.

Both dry seed and fleshy fruit should be prevented from overheating or freezing and should be cleaned or shipped to a seed cleaning facility as soon as possible after treatment.

Price per ounce of seed varies by species. Some very small and difficult to clean seeds are more expensive. For example, the extremely small seeds of western columbine (*Aquilegia formosa*) may sell for around $100/ounce, while the relatively large seeds of wild iris (*Iris setosa*) may sell for around $60/ounce. By contrast, large scale production of workhorse grass species brings the price down. For example, a one-pound bag of native seed mix retails at Alaska Mill and Feed for $29.95. However, with the current status of low supply, high demand, and an emerging market, these prices are just a ballpark starting point.

4.6 Data Collection

Basic data should be recorded for every collection event. You can build your own data collection app with software such as Survey 123, or data can be tracked with handwritten field datasheets and organized in simple spreadsheets. Data tracking should include:

- Georeferenced locations (latitude and longitude)
- Description of location (this will assist in matching with a suitable outplanting site)
  - Elevation
  - Slope
  - Aspect
  - Soil type
  - Associated species
- Landowner
- Date
- Name of collector(s)
- Scientific name to species level, or subspecies/variety if applicable

4.7 Scalability

Seed collections at all scales have no infrastructure requirements, but as an operation gets bigger, there may be more equipment involved. A summary of scalability is provided in Table 4. This is intended only as a starting point for considering scale options and is in no way comprehensive. Additionally, once seeds are collected and cleaned, it's up to the individual to decide if they want to sell these as-is, grow them out in a field for seed multiplication, or grow them out as plugs, pots, and flats. Note that each increasing scale can also encompass considerations listed at the smaller scales.

If an individual or group would like to gain experience with seed collection prior to pursuing it as a business venture, anyone is welcome to volunteer with the Homer SWCD to learn how we survey, collect, handle seed, and track data.

Table 4. Scalability of seed collections.

Scale Considerations	Small	Medium	Large
Geographic scale	-Local -Opportunistic	-Regional -Tailor collection locations to meet demand	-Statewide
Time scale	August - September	July - October	July - October
Infrastructure	None	None	None
Tools	-Hand tools: shears, berry pickers, buckets, paper or cloth bags	-Weed whacker modified for seed collection -Tree seed may require felling or climbing	-Heavy equipment (e.g., combine) and truck/trailer to transport -Seed cleaning equipment
Taxonomic groups	Graminoids, forbs, shrubs	Graminoids, forbs, shrubs, trees	Graminoids, forbs, shrubs, trees
Material types	-Ounces of seed (<3000 seed per collection) -Small quantities of diverse species	-Ounces to pounds of seed (3000-10,000 seed per collection)	-Pounds to hundreds of pounds of seed
Target market	Seed packets sold to individuals or retailers	Contract with land managers to collect from target locations and target species	-Contract with land managers -Sell to growers for seed multiplication

5 WOODY CUTTINGS

Pros: less time-sensitive than other options. Collections can take place throughout the winter.
Cons: Some species are better suited to propagation by cuttings than other species, and winter identification can be challenging.

This method of collection and propagation is best for species that don't grow well from seed, which includes willows (*Salix* spp.); and cottonwood, poplar, and aspen (*Populus* spp.). Alaska has around 40 species of willows, and some are better suited to cuttings than others. Cottonwood can be propagated from cuttings, but each stem requires an apical bud. Poplar and aspen will grow from root cuttings, and not from stems. In all cases, collect only from dormant plants.

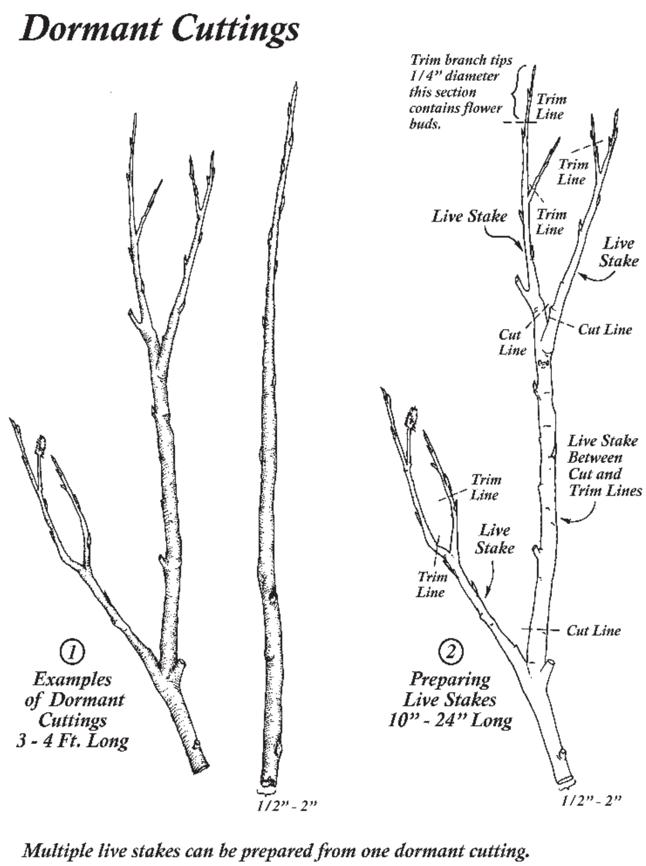


Figure 6. Illustration of appropriate dormant cuttings. From ADF&G (n.d.).

5.1 Root Cuttings

Root cuttings can be labor intensive but are the most effective way to grow aspen and poplar. A grower in Oregon recommends collecting when plants are dormant, in fall or spring when the ground is workable. Cut roots into two-inch pieces, lay in flats and cover with soil. Once they sprout, part of the root is cut out, dipped in rooting hormone, and transfer to tree tubes to grow out (Parks, 2023).

5.2 Stem Cuttings

Willow and cottonwood generally don't require rooting hormone. Willows naturally create their own rooting hormone, and water that has had willows soaking in it can act as a natural rooting hormone on other species. Willow cuttings are frequently planted directly at a restoration site and are referred to as direct staking or live staking. For more on successful staking, see Figure 6 and ADF&G (n.d.) guidance on willow staking. Alternatively, smaller cuttings of 2-6 inches can be grown out in the nursery to develop potted saplings.

5.3 Genetic Diversity

Willows, cottonwood, poplar, and aspen are all dioecious, meaning each plant either has female or male flowers. Consequently, if numerous cuttings are taken from a single plant – or coincidentally only from male or female individuals – and outplanted at a restoration site, this will limit their outbreeding abilities. One strategy to avoid harvesting from only male or female plants – and to aid in species identification – is to scout sites during the growing season, tag plants with genus, species, and sex, and return for stem collection when plants are dormant. (Tip: use aluminum tags that won't break down like paper or plastic tags do.)

Also, when collecting from wild populations, it's crucial to know landownership and ensure you have permission to collect. See Appendix C – Collection Permits. Responsible harvesting practices dictate not taking more than 30% of stems from a single plant, or 30% from a population.

5.4 Storage and Overwintering

Stems need to be kept cool and wet until outplanting. Throughout the winter and spring they can be stored in a snowbank. This can become challenging in the summer and may require a walk-in freezer. They must be planted the same year they are collected and soaked in water for a few days before outplanting.

5.5 Infrastructure and Supplies

Collection from easily accessible areas requires pruners, loppers, handsaws, and/or chainsaws to cut stems. For collections from more remote locations, it may be helpful to also have snowshoes, and a snow machine with sled to haul out materials. Tie stems into bundles of 25 for ease of transport, inventory management, and sale.

5.6 Demand and Profitability

Interviews with buyers clearly point to room in the market for an increase in willow stake production and ongoing demand for restoration sites. According to one estimate, at least 10,000 willow stakes are used per year, and this number is likely to increase as the native plant sector grows. As a point of reference, the Anchorage SWCD is selling whips and twigs for $2 each. One local contractor is reported to sell willow stakes for $1.75 each. Given that the Alaska native plant sector is in its infancy, prices per unit are undergoing development and revision. These are only estimates, and subject to change.

5.7 Scalability

Table 5 outlines options for scaling up production of woody cuttings.

Table 5. Scalability of woody cutting collections.

Scale Considerations	Small	Medium	Large
Geographic scale	Local	Regional	Statewide
Time scale	Collect October-April	Same	Same
Infrastructure	None	Access to cold storage	-Access to cold storage -Nursery space to grow out plants in containers
Tools	Handtools	Snowmachine with utility sled	Multiple snow machines with utility sleds
Taxonomic groups	Shrubs and trees	Same	Same
Material types	-Stem cuttings -Root cuttings	Same	Same
Target market	Individuals, contractors	Local and state restoration projects	State and federal restoration projects

6 SALVAGE

Pros: Resource that is often free for the taking.
Cons: Proper handling and storage between harvest and replanting can be challenging; expect losses. Matching available collection sites with suitable outplanting sites can be challenging.

Plant salvage involves harvesting plants from locations scheduled for ground disturbance, then either staging them and replanting them at the same site (after ground disturbance is complete) or rehoming them. It can include individual plants or sections of vegetated mat. One benefit is that collecting plants with their associated soil maintains beneficial bacteria and fungi associations. However, these soils may also include invasive species. It's recommended that salvage is not done at highly invaded sites and that good sanitation methods are used.

Once salvaged, plants need to be staged at a site out of direct sun and wind and with a water source. They don't necessarily need to be containerized but can be sandwiched on Typar® with soil and adequate water. They should be outplanted as soon as possible, to avoid unnecessary stress from being out of the ground. Overwintering is not recommended.

6.1 Infrastructure and Supplies

Salvage is strongly scalable and can be done with a few hand tools and a truck or scaled up to heavy equipment and multiple trucks with trailers. At a minimum, a staging area is needed to provide protection from the elements and herbivory. The plant salvager may also choose to harvest and sell plants, or to also provide installation service.

6.2 Demand and Profitability

Surveys conducted by Homer SWCD indicate this type of business is in high demand; there may also be no precedent. It's expected that plant material will be given up for free and can be sold at whatever prices are reasonable to compensate for the salvage and transport labor. These could operate as contract jobs where plants are removed then reinstalled after construction. Or it could operate as a wholesale/retail business, where donor sites are matched with buyers and/or sites in need of revegetation.

6.3 Salvage Scalability

Table 6 outlines options for scaling up production of plant salvage.

Table 6. Scalability of plant salvage.

Scale Considerations	Small	Medium	Large
Geographic scale	Local	Regional	Statewide
Time scale	Salvage and sell/plant in a single season	Salvage and sell/plant in a single season	Option to overwinter plants
Infrastructure	-Shaded staging area <half acre -Irrigation -Fencing	-Staging area 0.5-2 acres	-Staging area >2acres
Tools	-Truck -Hand tools	-Truck with trailer -Tree spade -Skid steer -Backhoe -Rental equipment and/or subcontract operators	-Own equipment
Taxonomic groups	Graminoids, forbs, small shrubs, saplings	Graminoids, forbs, shrubs, trees	-Graminoids, forbs, shrubs, trees -Less emphasis on smaller plants
Material types	-Vegetated mats small enough to hand carry -Pots or flats of graminoids and forbs -Bareroot or containerized shrubs or saplings	-Larger vegetated mats that can be moved with equipment -Larger shrubs and trees	-Vegetated mats and trees of increasing size and quantity
Target market	-Salvage and replant at the same site for a single client -Salvage and sell plants -Individuals, contractors	-Installation/landscape design services -Contractors, local and state restoration projects	-State and federal restoration projects

7 ANCILLARY BUSINESS OPPORTUNITIES

There are numerous business opportunities that are adjacent to, or directly support, native plant harvest and propagation. A few ideas are described below.

- Seed processing and storage – Cleaning requires specialized equipment, breaking dormancy can take specific chemicals, and storage requires temperature and humidity control. Currently the PMC in Palmer handles most of the seed cleaning; sometimes seeds are sent to the Bend Seed Extractory in Oregon. Through surveys and interviews we've determined there is a still a need for processing in Alaska – specifically for small seed lots – and storage (see Appendix B – Recommended Reading for more on seed cleaning equipment and techniques). Ideally, if Alaska had another seed cleaning facility, they would also be able to consolidate excess, unsold plants from growers; stage them overwinter; and provide consolidated lots for sale. This may also dovetail with providing emergency preparedness services regarding storing plants and seeds until they're needed.
- Heavy equipment operators and trucking – As noted throughout this report, as production scales up, so does demand for heavy equipment and transportation. There could be ample opportunities for equipment owners/operators to do contract work. For example, tree spades for salvaging larger trees, skid steers for harvesting vegetation mats, combines for collection from fields of grasses or sedges. Trucks will be needed for moving all types of material from harvest sites to outplanting sites.
- Vegetation mats – These are sheets of native plant material commonly used in restoration. This type of material is little understood and infrequently used in Alaska. However, they can be highly valuable for restoring sites where immediate ground coverage is needed, particularly on sites with poor soil where an instant matrix of established plants is beneficial. Research is underway to develop manufactured mats by several SWCDs. However, in the Lower 48 most producers are private, which might indicate this is well suited to a private venture. For more information see Greenstein et al. (2024).
- Landscaping – Provide landscaping and restoration services that focus on native plants.
- Soil amendment production – Ideally, local production of soil, mulch, compost, and fertilizer will grow alongside native plant production. For example, Homer's fish processing plants dump their carcasses back into Kachemak Bay, but these could be turned into fish fertilizer. A compost business could divert organic waste streams into a useful product, including animal manure, spruce chips, and commercial kitchen waste. A soil scientist or mycologist could breed mycorrhizae. A worm enthusiast (or professional helminthologist) could sell worm castings.
- Hydroseed – A product always in high demand, but not yet made from native species. There seems to be consensus, albeit anecdotal, that native species are not well suited to hydroseed. However, more research and testing could inform new strategies to make native hydroseed viable. Once native seed production reaches a critical mass, there may be opportunities to experiment.

- Tree climbers and planters – Through surveys and interviews, we learned that to do significant tree seed collection (by climbing) or planting of seedlings, at present, the only option is to hire contractors from out of state.
- Integrated pest management specialist – As the native plant sector grows, so will the need for regulations ensuring materials are free of nonnative species and pests. There may also be increasing opportunities for consultants who specialize in pest prevention, monitoring, and control of harmful species.
- Increase sustainability – An entrepreneur, researcher, or out-of-the-box thinker may be able to develop materials and methods that make growing practices – native plants or otherwise – more sustainable. For example, reducing the use of single-use plastics (e.g., pots, plugs, trays, landscape fabric). Also finding alternatives to peat, which is often recommended in planting media, but extraction is outpacing regeneration. Alternatives may include coconut coir instead of peat; multiple-use plastics, compostable containers, or soil blocking for plant starts; and burlap sheets for salvaging plants rather than relying on plastic pots and Typar®.
- Land clearing and weed control – Goats are often used to manage vegetation in the Lower 48 but have not been employed in Alaska (to the best of our knowledge). Chicken tractors can be used to clear a new garden bed down to bare ground. A study conducted in Homer, 2023, also found that species composition changed after application of chickens, with a significant reduction in invasive orange hawkweed (*Hieracium aurantiacum*) and increase in grasses (Greenstein, 2023). There may be an opportunity for someone with livestock to rent.
- Synergistic salvage – There may be opportunities to harvest plants where they would otherwise be trimmed, damaged, or removed. For example, in powerlines and other rights-of-way. A contractor could develop a relationship with a utility company to ensure an endless supply of plant materials to then sell.

More options are likely out there – this list only represents a snapshot of this nascent stage of the native plant sector.

8 UNDERSTANDING THE MARKET

To date, there is not adequate economic data association with native plant production and sales to know for certain the costs and profits of a native plant business. Comparisons can be made to locally operated traditional nurseries (imported plants), or local agricultural markets. However, these will differ from native plants for reasons described previously in Section 2.2 "Native Plant Traits vs. Developed Varieties." It will likely be necessary to operate a plant business for a few years, carefully track expenses, then adjust sale prices accordingly.

8.1 Working with Government Agencies

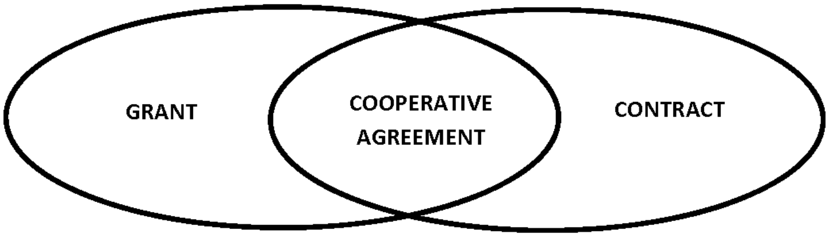
Federal agencies receive funding based on project proposal submittals, and then distribute funds through grants, agreements, or contracts; recipients are often state agencies, tribal entities, SWCDs, and other non-governmental organizations. As of 2024, funds available range in the hundreds of thousands.

The main limitations to grant and agreement funding are that federal funds are limited in their applications (by project type and geography), and typically can only be disbursed to state agencies, non-profits, university affiliates, etc., to the exclusion of private for-profit organizations. One way around this is to structure a business as a nonprofit; this would not limit a person's ability to make a living. For example, a nonprofit operating under a grant can write the budget to include their preferred salary. They can also receive donated items (e.g., salvaged plants) and sell goods and services (plants, seeds, landscaping). The main difference is that the purpose of a nonprofit is to serve the public good, rather than strictly turn a profit.

Alternatively, government agencies are allowed to establish contracts with for-profit businesses. Figure 7 summarizes the difference between grants, agreements, and contracts.

Homer Soil & Water Conservation District

Federal Funding (Grants vs Cooperative Agreements vs Contracts)



	Federal Grants	Federal Cooperative Agreement	Federal Contracts
Basic Purpose	A flexible instrument designed to provide money to support a public purpose. Assistance with few restrictions.	A flexible instrument designed to provide money to support a public purpose. Assistance with involvement between parties.	A binding agreement between a buyer and a seller to provide goods or services in return for consideration (usually monetary). Procures goods or services.
Terms & Conditions	Governed by the terms of the grant agreement	Governed by the terms of the cooperative agreement	Governed by Federal Acquisition Regulations
Scope	Conceived by PI. Flexible as to scope of work, budget, and other changes	Conceived by PI. Typically flexible as to scope of work, budget, and other changes	Conceived by sponsor. Relatively inflexible as to scope of work, budget, and other changes
Solicitation	Application kit or guidelines	Request for application	Request for proposal or quote
Effort	Diligent efforts are used in completing research and the delivery of results	Diligent efforts are used in completing research and the delivery of results	Significant emphasis placed on delivery of results, product, or performance
Sponsor Involvement	None	Substantial involvement	Approves activity, expects results
Payment	Payment awarded in annual lump sum	Payment awarded in annual lump sum unless otherwise specified in the cooperative agreement	Payment based on deliverables and milestones
Re-budgeting	Flexible	Usually flexible	More restrictive
Reporting	Annual reporting requirements	Reporting requirements determined by the cooperative agreement	Frequent reporting requirements
Flexibility	Principal Investigator has more freedom to adapt the project and less responsibility to produce results	Substantial involvement is expected between the executive agency and the State, local government, or other recipient when carrying out the activity contemplated in the agreement.	High level of responsibility to the sponsor for the conduct of the project and production of results

Figure 7. Summary of Grants vs. Agreements vs. Contracts. From the University of Pittsburgh, 2024.

In some cases, it may be possible to get indefinite delivery, indefinite quantity (IDIQ) contracts with the government. These are used when the exact quantity of materials needed is unclear. Instead, the contract is open for a fixed period and has minimum and maximum limits either in dollar values (for services) or unit quantities (for supplies). IDIQ contracts are often preferable to a standard contract, as they increase flexibility and can help streamline the contract process and delivery of services.

Ideally, government agencies (federal and state) will get better at planning ahead for projects, allowing contractors/grantees at least 1-2 years lead time to collect from the target seed transfer zone and grow out plants.

The following sections are not intended to be comprehensive but provide a few examples of pathways for prospective growers to partner with prospective buyers. Conversations between organizations are ongoing, and additional pathways may emerge in the future.

8.1.1 Example: USFS and Alaska DOF

The United States Forest Service (USFS) State, Private, and Tribal Forestry organization operates with grants, and eligible entities must be nonprofits; however, a recipient of a grant can hire contractors as they see fit. At the state level, their largest funding recipient is the Alaska Division of Forestry (DOF) & Fire Protection. Accordingly, this Alaska division can, in turn, directly procure tree seedlings via contracts, or provide subaward grants. If a private for-profit grower wanted to provide tree seedlings, the pathways to providing trees are:

- Directly selling already-grown tree seedlings to landowners/communities who have received USFS or DOF grant funding.
- Contracting with communities or community groups to grow tree seedlings using funding they've received from USFS or DOF.

8.1.2 Example: NRCS

By contrast to other federal agencies, the Natural Resource Conservation Service (NRCS) is specifically set up to work with private landowners to address resource concerns on their actively managed agricultural lands (both private lands and public lands in the case of a permit/land lease). Assistance from NRCS can be both technical and financial for individuals and private entities, and funding varies each year. As of 2024, they have significantly more funds to disburse than previous years. Their two primary pathways for distributing funds is through the Environmental Quality Incentives Program (EQIP) and Conservation Stewardship Program (CSP). While they don't directly fund native plant production, they can help offset the cost mulching, irrigation, cover crops, and site preparation; they provide financial incentives to plant shrubs, forbs, and grasses. For more information contact your local NRCS office.

8.2 Working with State Agencies

8.2.1 Example: ADF&G Cost-Share Program

At the state level, ADF&G runs a Cost Share Program, which provides financial support and incentives to private landowners to improve habitat along streambanks and shoreline. The limitations faced by the Cost Share Program are that it is grant funded, and consequently relies on staff to apply and win grant agreements, and it is limited in the scope of property owners it can assist.

8.2.2 Example: DOT

The Alaska Department of Transportation (DOT) is likely the largest user of grass seed in the state. Funding for their projects varies: those funded by the state are strapped for cash, while those funded at the federal level could potentially cover all costs for native plant revegetation.

8.2.3 Example: SWCDs

Homer SWCD is both a nonprofit and quasi-state agency. The combined knowledge and experience of our Native Plants Program and Agriculture Program leaves us well poised to assist growers with technical aspects of plant production and soil health. We are also able to act as liaison between government agencies and independent growers, to assist in connecting demand and supply, and connect salvage opportunities to projects in need of plants. Likewise, other SWCDs may be able to provide similar assistance. For an illustration of connections between SWCDs, funders, and native plant activities, see Appendix E – Network Diagram.

8.3 Working with Private Entities

If you want to be involved with native plants but prefer to keep the government out of it, there are options. For example, grow and sell directly to landscaping contractors and restoration specialists. Start your own landscaping or salvage business to serve the private sector. Start your own retail nursery. Additional platforms include selling plants or seeds at your local farmers' market or the Alaska Food Hub.

8.4 Working with the Alaska Native Plant Collaborative

Staff at the Fairbanks Fish and Wildlife Service office spearheaded establishment of the Alaska Native Plant Collaborative (AKNPC). They also secured funding to start multiple native plants nurseries, through a project called Partnership for Landscape Action with Native Terrestrials, aptly acronymized PLANT.

The AKNPC now has subgroups focused on developing the following:

- Outreach and education
- Brokerage services
- Website
- Production, planting, and collecting considerations

- Data repository clearinghouse
- Plant species lists by region

Once a preliminary website is launched, this will be publicly available and include resources and contact information that interested parties can utilize.

8.5 Examples of Potential Funding Sources

This is not an exhaustive list and is only provided as a starting point to investigate what opportunities may be available in the future. Links provided in this section may be to application windows that have already closed. Also, many grants have restrictions on who can apply, e.g., are only open to non-profits, university affiliates, state agencies, tribal entities. Some opportunities require match, while others don't. Some specify they only service "disadvantaged" communities, and these are delineated by the mapping application Climate and Economic Justice Screening Tool.

A state database is maintained cooperatively by multiple agencies and can be found at Alaska Federal Funding, Active Grants for Alaska.

8.5.1 Good Neighbor Authority

Funding source: USFS and Bureau of Land Management (BLM) Good Neighbor Authority
Who can apply: States, counties, federally recognized Indian tribes
Type: Agreement or contract
Activity summary: "Restore or improve forest, rangeland, and watershed health"
Link: https://www.fs.usda.gov/managing-land/farm-bill/gna
https://www.blm.gov/policy/im-2022-023

8.5.2 Community Forestry Grants

Funding source: The USFS and the Alaska Department of Natural Resources, Division of Forestry and Fire Protection, Community Forestry Program (CFP)
Who can apply: "disadvantaged or distressed" communities; federal organizations, state agencies, local governments, cooperative weed management areas, SWCDs, registered non-profits, local communities, public and state-controlled institutions of higher education, Alaska Native organizations, federally recognized Tribes, Alaska Native Corporations and villages, and tribal organizations as defined in 25 USC 5304 (l).
Type: Grant
Activity summary: "Green infrastructure projects, streambank stability/restoration projects…community forestry management plans"
Link: https://forestry.alaska.gov/community/grants

8.5.3 Alaska Native Community Forest Program

Funding source: Alaska Village Initiatives
Who can apply: Alaska Native Villages
Type: unclear
Activity summary: Highly flexible and varied
Link: https://usfs.akvillage.org/

8.5.4 Neighborhood Forest Grant and Community Challenge Grants

Funding source: Anchorage Park Foundation
Who can apply: Anyone
Type: Grants
Activity summary: "…Improve the well-being of the community and urban environment in Anchorage."
Link: https://anchorageparkfoundation.org/grants/

8.5.5 Orchards and Food Forests GROW-OFF Grant Program

Funding source: Rural Alaska Community Action Program, Inc. (RurAL CAP)
Who can apply: Disadvantaged communities; federally recognized Tribes, non-profit organization, school, or public organization.
Type: Grant
Activity summary: "Establishing and maintaining community orchards and food forests." The tree component is for non-native fruit trees, but it also includes native edible shrubs and plants.
Link: https://ruralcap.org/connect/news/rfq/grow-off-rfp/

8.5.6 Rural Business Development Grants

Funding source: USDA, Rural Development Program
Who can apply: Public body/government entity, Indian Tribe, or nonprofit entity primarily serving rural areas. Includes location restrictions.
Type: Grant
Activity summary: "Promote economic development and job creation projects through the awarding of grant funds."
Link: https://www.rd.usda.gov/programs-services/business-programs/rural-business-development-grants/ak

8.5.7 Specialty Crop Block Grants

Funding source: USDA Agricultural Marketing Service (AMS); Alaska Department of Natural Resources, Division of Agriculture
Who can apply: Producers, universities, extension services, SWCDs, or schools working in cooperation with a business or non-profit.
Type: Grant

Activity summary: "Increase production, consumption, access, knowledge, and sustainability of Alaska Grown specialty crops, sustain farmers' livelihoods, and strengthen local communities."
Link: https://dnr.alaska.gov/ag/ag_grants/specialty_crop_block_grant.htm

8.5.8 Reimbursement Transportation Cost Payment

Funding Source: USDA Farm Service Agency
Who can apply: Geographically disadvantaged farmers
Type: Reimbursement
Activity summary: "Reimburse producers for a portion of the cost to transport agricultural commodities or inputs used to produce an agricultural commodity." Includes floriculture, horticulture, and trees.
Link: https://www.fsa.usda.gov/programs-and-services/price-support/RTCP-Program/index

9 CLOSING THOUGHTS

An indispensable resource for anyone interested in growing native plants is Dumroese et al. (2021) *Raising Native Plants in Nurseries: Basic Concepts*. A copy can be downloaded for free at https://doi.org/10.2737/RMRS-GTR-274.

Here at Homer SWCD our education and outreach efforts are always ongoing. Both our Agriculture Program and Native Plants Program can provide technical expertise, resources, support, and market connections for anyone interested in getting involved with native plants. We also have volunteer opportunities if you'd like to help with plant salvage or seed collection. Stop by our office in the Frontier Building at 432 E. Pioneer, or email casey@homerswcd.org.

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Appendix A – Propagation Profiles

Written by Kelly Sivy, Homer Soil and Water Conservation District

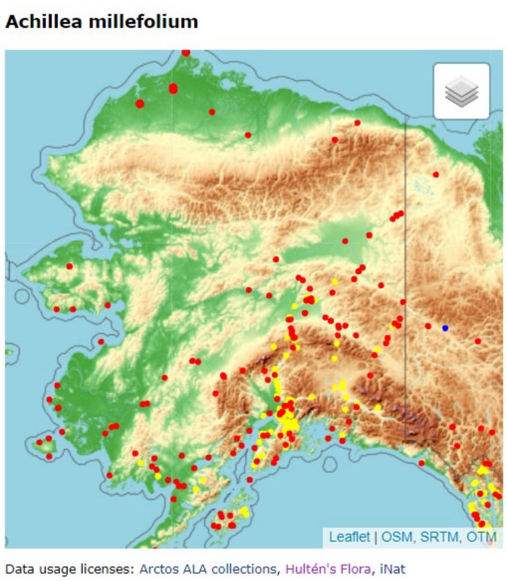
Scientific Name	Common Name
Achillea millefolium	common yarrow
Achillea sibirica	Siberian yarrow
Agrostis scabra	rough bentgrass
Agrostis sp.	bentgrass
Alnus incana ssp. *tenuifolia*	thinleaf alder
Alnus viridis ssp. *crispa*	mountain alder
Alnus viridis ssp. *sinuata*	Sitka alder
Aquilegia formosa	western columbine
Arnica angustifolia	narrowleaf arnica
Artemisia tilesii	Tilesius' wormwood
Aruncus dioicus	goatsbeard
Betula papyrifera var. *kenaica*	Kenai birch
Calamagrostis canadensis	bluejoint
Carex aquatilis	water sedge
Carex canescens	silvery sedge
Carex mertensii	Mertens' sedge
Carex pachystachya	starry broomsedge
Chamerion angustifolium	fireweed
Dryas drummondii	Drummond's mountain-avens
Eriophorum angustifolium	common cottongrass
Erythranthe guttata	seep monkeyflower
Eurybia sibirica	Siberian aster
Geum macrophyllum	largeleaf avens
Hedysarum alpinum	alpine sweet vetch
Hordeum brachyantherum	meadow barley
Juncus mertensianus	Merten's rush
Lathyrus japonicus	beach pea
Leymus mollis	beach rye
Lupinus arcticus	arctic lupine
Lupinus nootkatensis	Nootka lupine
Luzula parviflora	smallflowered woodrush
Papaver radicatum	rooted poppy
Picea glauca	white spruce

Polemonium acutiflorum	tall Jacob's-ladder
Polemonium pulcherrimum	showy Jacob's-ladder
Pyrola asarifolia	liverleaf wintergreen
Rhinanthus minor	little yellow rattle
Salix sp.	willows
Sanguisorba canadensis	Canadian burnet
Spiraea stevenii	Alaska spirea
Tripleurospermum maritimum	arctic chamomile

Propagation Profiles

Scientific name: *Achillea millefolium*
Synonyms: n/a
Common name (s): common yarrow
Family: Asteraceae
USDA PLANTS code: ACMI2

Duration: Perennial
Growth habit: Forb/herb
Wetland indicator status: FACU



WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
Bulkley Valley, Northwestern British Columbia (Burton & Burton, 2003) - USDA Zone equivalent 4b
https://www.for.gov.bc.ca/hfd/library/documents/bib107640.pdf

Pullman, Washington (Skinner, 2003) - USDA Zone 6a
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=asteraceae-achillea-2148

Seed collected in Glacier National Park, propagated in Bridger, MT (Winslow, 2002) - USDA Zone 5a
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=asteraceae-achillea-1362

Habitat description:
Dry and moist meadows, pastures, edges of streams and wooded areas (Mann et al., 2022; Rose et al., 1998).

Elevation range:
1200-3350 meters (Rose et al., 1998).

Soil preferences and adaptations:
Medium textured soils (USDA & NRCS, 2023). Tolerates a wide range of soil types in addition to being adapted to poor soils and acidic or alkaline conditions (Mann et al., 2022). Dry to moist or mesic sites, provided they are well-drained (Burton & Burton, 2003).

Created 2024, Kelly Sivy
Last updated: n/a

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CONSERVATION DISTRICT

Shade tolerance:
Variable and likely dependent on population distribution. The USDA lists common yarrow as having intermediate drought tolerance (USDA & NRCS, 2023); Mann et al. (2022) describes that it thrives in open sun but can tolerate shade, which may affect flowering and seed production; Burton and Burton's (2003) review indicates shade intolerance.

Drought tolerance:
Medium to high drought tolerance (Rose et al., 1998; USDA & NRCS, 2023).

Disturbance tolerance:
High. Hardy and thrives in disturbed areas, resilient to grazing, and recovers from light fire (Aleksoff, 1999; Burton & Burton, 2003; Mann et al., 2022).

Community interactions:
Tolerant of competition, can become weedy if not regularly managed (Mann et al., 2022).

Wildlife associations:
Beneficial to insects, and to some extent provides forage for snowshoe hares and deer (Mann et al., 2022).

Restoration value:
Used for revegetation of disturbed sites and erosion control, as rhizomes can bind the soil (Downing, 1996; Mann et al., 2022). Greenstein (2023) observed yarrow maintaining a population within a site heavily infested with the extremely invasive species, orange hawkweed (*Hieracium aurantiacum*), indicating it may provide competition to unwanted species.

Primary reproductive mode:
Sexual and asexual. Regenerates from rhizome fragments, and colonizes within 1-2 meter range through wind dispersed seed (Aleksoff, 1999).

Seed type:
Orthodox (SER, INSR, RBGK, 2023).

Ease of growing:
Excellent germination from seed (Burton & Burton, 2003). Mann et al. (2022) warns that once established, *A. millefolium* should be closely monitored to keep from becoming weedy or invasive, as it forms colonies with extensive rhizomes that can form monocultures. However, Burton and Burton (2003) write that where *A. millefolium* is newly established it is not typically an aggressive plant, despite its rhizome growth.

SEED

- **Collection recommendations**
  Yarrow flowers early in the season at low elevations, and later in the season at high elevations (Rose et al., 1998). Holloway (2024) writes "high degree of self-incompatibility, so insect pollination improves seed set. *A. alpina* has up to 25 heads per flower cluster, and the plant

usually consists of a single upright flowering stem. *A. millefolium* is much more robust, consisting of one or multiple stems from a large crown and as many as 100+ heads in a flower cluster."

Entire heads change from greenish to tan to brown; seeds are ready for harvest when flower heads turn brown and hard. Rub heads between fingers, and harvest when individual heads begin to break apart. Harvest entire seed heads, by hand or with a combine. By hand, cut heads from the plant. Seed loss can be minimized by clipping over a bin or inside a bag (Burton & Burton, 2003). Store in paper bags or on screens at room temperature for a minimum of 1 week, until ready for cleaning (Mann et al., 2022; Skinner, 2003). Winslow (2002) notes average seed collection by hand of 138.3 grams (4.9 oz) of clean seed per person-hour.

- **Seeds per/lb**
  8,105 seeds per gram from British Columbia (Burton & Burton, 2003); 2.8 million seeds per pound reported from the Pullman, WA ecotype (Skinner, 2003); 6.6 million seed per kilogram reported from Glacier National Park (Winslow, 2002).

- **Processing techniques, recommended equipment**
  Holloway (2024) advises: "Separate achenes from chaff by rubbing against screens with an air/screen cleaner or seed blower. Some that don't break apart easily may require processing with a hammermill." Rose et al. (1998) advises that once dried, seed heads can be crushed with a rolling pin or similar to remove nutlets, then run through a sieve to separate chaff from seed. Skinner (2003) rubbed seed heads to separate and cleaned with air column separator.

  Winslow (2002) describes their seed processing as follows:
  "Seed is spread out on a tarp in a dry, sheltered environment and turned daily for approximately 3-5 days, until no moisture or warmth is detected. After drying, material is processed with a Wintersteiger plot combine at concave closed, speed 700 rpm, and no wind. Seed is threshed with a hammermill through a 4/64" round hole screen, air-screen processed on a Clipper M2B or Eclipse cleaner over a 1-21" round hole screen with low wind, and then over a 6x30 wire mesh screen (0.0203" x 0.1471") to remove very fine debris. Due to tiny seed, abundance of floral chaff, and moderate seed flow, this species is moderately easy to clean. Larger seed lots are processed most efficiently with mechanized cleaning equipment and smaller seed lots usually require more hand labor."

  Burton and Burton (2003) describes their cleaning process (dried seed):
  "Fanning mill (no air flow), followed by vacuum separator. Fanning mill screen sizes: prescreen 1.8 x 12.5 mm slot; top screen 1.2 x 7.1 mm slot; bottom screen blank or 1.40 mm square. Then use vacuum separator with speed and suction set low to remove dust and <5% of seeds. Hand sieve using a #14 (1.40 mm) screen for small quantities or for finishing."

- **Storage**
  Seed germination declines gradually over time, but > 50% of seeds usually remain viable for at least 5 years when frozen (Holloway, 2024). Store seeds in cold, dry storage in a sealed container (Rose et al., 1998). Seed can remain viable for 5 to 7 years when stored in cool (40-50° F) dry conditions (Mann et al., 2022). Burton and Burton (2003) report storing at 0.6-7.2C (33-45F). Winslow (2002) stored seed in Ziploc bags punctured for aeration, then placed punctured Ziplocs in cloth or plastic seed sacks and left them in cool, dry storage. The Pullman Plant

Materials Center reports maintaining stored seed at 40°F and 40% relative humidity (Skinner, 2003).

- **Scarification requirements**
  Lab and greenhouse trials indicate seed priming with gibberellic acid (400 ppm), potassium nitrate (either 2 or 4%), or polyethylene glycol (either 12 or 24 hour exposure) yielded significant increases in germination rate and seedling emergence in soil (Kanatas et al., 2020).

- **Stratification requirements**
  The USDA reports in its plant guide that seeds require one month of cold stratification and direct sunlight for germination (Mann et al., 2022). However, Burton and Burton (2003), working with seed collected from northwestern British Columbia, found little difference during incubator trials between germination rates of stratified (86-95%) and unstratified (86-96%) seed. Winslow (2002), germinating seed collected from Glacier National Park, reported implementing a 10-day cold stratification at 0-1°C, with subsequent exposure to 22-25°C.

- **Germination rates and techniques**
  Burton and Burton (2003) report mean germination of untreated seed at 81.4%, under a 30/20°C thermocycle. Germination improved under warmer temperatures. Under 25/15°C thermocycle germination was 91.5% for untreated seed and 90.5% for stratified seed. These results were from germination tests under an incubator. Seed began germinating after 5 days and reached 50% in 6 days (Burton & Burton, 2003). For outdoor planting, they note that *A. millefolium* germinated best on cooler soils, on a weed free site consisting of loamy, well-prepared soil.

  The Seed Information Database reports 94-98% germination by trials conducted in Canada, achieved under an 8/16 photoperiod at 15 -25°C, and required 35 days to germinate. This rate was reduced to 60% germination under the same 8/16 photoperiod when grown at 10°C, and time to germinate increased to 168 days (SER, INSR, RBGK, 2023).

  Holloway (2024) writes:
  "Seeds are easy to germinate outdoors or indoors. Direct sow in autumn or spring by scattering seeds on the soil surface. Germination is best and fastest in light and alternating temperatures. Indoors press seeds into the surface of a sterile seed starting mix, and do not cover. Keep moist. Germination begins in 7-10 days 25/10°C with 16 hr light at the high temperature or 10- 14 days at 21°C (70F) 16/8 light/dark. Germination percentages are higher outdoors in cultivated seed nurseries with ample soil fertility and moisture as opposed to wild harvested seeds."

- **Establishment phase**
  Following cold stratification, Winslow (2002) direct seeded into a firm, weed-free soil bed with field moisture to 4" depth. For each row, 25-30 seeds/ft were planted to a 0.25" deep using a 2-row double disk planter. They recommend keeping soil moist and prevent soil from crusting with 3-4 light water applications per week.

  The USDA recommends planting seed in a sunny location, in soil that has been loosened to a depth of 12-15". Seed can be sown at 1-2 pounds per acre at ¼" depth and 3 feet apart; for broadcast seeding, they recommend doubling the seeding rate. Germination occurs in 1-2 weeks (Mann et al., 2022).

Skinner (2003) reports:
"In January, seeds are sown directly into 10 cu. in. Ray Leach Super Cell containers filled with Sunshine #4 planting media and covered lightly. A thin layer of pea gravel is used to prevent seed and media from floating during initial watering. Media is kept moist during germination. Germination is usually 6-7 days and is complete in 2 weeks."

For bareroot production, Mann et al., (2022) recommend keeping yarrow plots weeded until the plant is well established, and/or seeding yarrow in a contained area or with other competitive plants to minimize weeds. They also note that, though yarrow does not require fertilizer, plants may benefit from a 5N:4P:2K fertilizer when transplanted. For seed crops, flower production can be facilitated by cutting dead, brown flower heads (Mann et al., 2022). Winslow (2002) does not recommend applying fertilizer during the first year as it can favor weeds and consequently enhance competition.

- **Active growth phase**
  Skinner (2003) reports an active growth phase of 60 days. Plants grew quickly after germination, when watered every other day and fertilized weekly using a complete, water soluble fertilizer containing micronutrients.

  Winslow (2002) advised:
  "Plateau herbicide is recommended for control of broadleaf weeds and application must occur pre-emergence or post-emergence prior to bolting, budding, or bloomset of wildflower crop; soil moisture is critical during budding stage, after anthesis, and post harvest to pre-freezeup -no irrigation is applied during flowering (pollination); fertilizer is broadcast at 100 lbs actual N/40 lbs actual P/acre in mid-September."

- **Hardening phase**
  Skinner (2003) moved plants to a cold frame, and the hardening phase was 3-4 weeks.

- **Harvest, storage & shipping**
  Plants at the Bridger Plant Materials Center (Montana) were harvested late summer (mid July-late August). Plants were harvested with a John Deere swather and a diaper (heavy plastic or canvas under belt draper) to minimize seed loss (Winslow, 2002).

VEGETATIVE PROPAGATION

- **Cuttings**
  Heger et al. (2011) provides some generalized guidelines for propagation by basal or stem cuttings from mature individuals of any *Achillea* spp.: "Cut off the tips of the stems in spring before the plant sets flower buds or in summer after flowering. Take cuttings with three sets of leaves in early morning when plants are minimally stressed. Each cutting should have several sets of leaves. Cut about ¼" below leaf node, and remove all but top set of leaves." Plant immediately after collection, in moist rooting medium and high humidity. Stem cuttings should root in 4-6 weeks (Heger et al., 2011). Once young plants have formed an adequate root ball,

transplant into pots or a protected garden location. Water regularly until well established (Heger et al., 2011).

- **Division**
  Holloway (2024) writes: "Divide during non-flowering times (spring or autumn), but best to divide in spring just as crown growth begins. *A. millefolium* spreads by rhizomes and forms tight fibrous root clumps that can be pulled apart. Yarrow may also be propagated through division of mature plants featuring clusters of basal rosettes." Lift mature plants in early spring to divide; cut back leaves to minimize moisture loss (Rose et al., 1998). Mann et al. (2022) suggest "patches of common yarrow should be divided every 3 to 4 years to encourage growth."

- **Rhizomes**
  Yarrow may be propagated from strong white rhizomes collected and planted in spring or early fall (Downing, 1996). Rhizome fragments should produce shoots in 2-3 weeks. In one study, fragments 4 cm long (with 1-6 nodes) were planted 5 cm deep (Rose et al., 1998). In another study, rhizome cuttings were planted 6-12" apart and 0.5" deep (Downing, 1996). Planting in rich soil can positively affect leaf production, but may reduce flower production (Downing, 1996).

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Propagation Profiles

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Propagation Profiles

Scientific name: *Achillea sibirica*
Synonyms: *Achillea multiflora*
Common name (s): Siberian yarrow
Family: Asteraceae
USDA PLANTS code: ACSI (syn. ACMU3)

Duration: Perennial
Growth habit: Forb/herb
Wetland indicator status: unavailable

Note: Many data gaps exist regarding propagation and autecology specific to *A. sibirica*. Please see propagation notes for *A. millefolium* for additional information.

WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
No protocol specific to *A. sibirica* was found. However see *A. millefolium* for propagation details that may be applicable.

Habitat description:
Meadows and woods (Hultén, 1968). Mesic to moist riverbanks and lakeshores in montane zones, tolerant of maritime exposure (Klinkenberg, 2020; PFAF, 2023).

Elevation range:
Up to 600 meters (Hultén, 1968; Klinkenberg, 2020).

Soil preferences and adaptations:
Sandy, loamy, and clay soils, provided they are well-drained. Tolerant of nutrient poor soil with mention of being longer lived where soil quality is low (PFAF, 2023).

Shade tolerance:
Low (PFAF, 2023).

Created 2024, Kelly Sivy
Last updated: n/a

Homer Soil & Water
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Propagation Profiles

Drought tolerance:
High (Missouri Botanical Garden, 2018).

Disturbance tolerance:
No information available.

Community interactions:
No information available.

Wildlife associations:
Attracts and benefits butterflies and other pollinators (Alaska Native Plant Society, 2023).

Restoration value:
Indicated as having restoration value (Alaska Native Plant Society, 2023); no other information available.

Primary reproductive mode:
Sexual.

Seed type:
Orthodox (SER, INSR, RBGK, 2023).

Ease of growing:
Easy to germinate both indoors and outdoors (Holloway, 2024).

SEED

- **Collection recommendations**
  Holloway (2024) writes "High degree of self-incompatibility, so insect pollination improves seed set. *A. alpina* has up to 25 heads per flower cluster, and the plant usually consists of a single upright flowering stem. *A. millefolium* is much more robust, consisting of one or multiple stems from a large crown and as many as 100+ heads in a flower cluster."

- **Seeds per/lb**
  No information available.

- **Processing techniques, recommended equipment**
  Holloway (2024) writes:
  "Entire heads change from greenish to tan to brown. Rub heads between fingers, and harvest when individual heads begin to break apart. Harvest entire heads, and dry in paper bags or on screens. Separate achenes from chaff by rubbing against screens with an air/screen cleaner or seed blower. Some that don't break apart easily may require processing with a hammermill."

- **Storage**
  Germination reduces with storage time, but > 50% of seeds usually remain viable for at least 5 years when frozen (Holloway, 2024). Storing seeds at 15% relative humidity and freezing for 74 days at -20°C retained 100% viability of seeds (SER, INSR, RBGK, 2023).

- **Scarification requirements**
  No information available.

- **Stratification requirements**
  No information available.

- **Germination rates and techniques**
  Of the germination trials on record with the Society for Ecological Restoration, a 100% germination rate within 7-14 days is reported for *A. sibirica* seeds germinated in 1% agar under an 8/16 photoperiod at 20°C or an alternating thermoperiod of 25/10°C; 95% germination occurred in 28 days at temperature of 15°C (SER, INSR, RBGK, 2023).

  Holloway (2024) writes:
  "Direct sow in autumn or spring by scattering seeds on the soil surface. Germination is best and fastest in light and alternating temperatures. Indoors press seeds into the surface of a sterile seed starting mix, and do not cover. Keep moist. Germination begins in 7-10 days 25/10°C with 16 hr light at the high temperature or 10-14 days at 21°C (70°F), 16/8 light/dark. Germination percentages are higher outdoors in cultivated seed nurseries with ample soil fertility and moisture as opposed to wild harvested seeds."

- **Establishment phase**
  No information available.

- **Active growth phase**
  No information available.

- **Hardening phase**
  No information available.

- **Harvest, storage & shipping**
  No information available.

VEGETATIVE PROPAGATION

- **Cuttings**
  Heger et al. (2011) provides some generalized guidelines for propagation by basal or stem cuttings from mature individuals of any *Achillea* spp.: "Cut off the tips of the stems in spring before the plant sets flower buds or in summer after flowering. Take cuttings with three sets of leaves in early morning when plants are minimally stressed. Each cutting should have several sets of leaves. Cut about ¼" below leaf node, and remove all but the top set of leaves." Collected cuttings should be planted immediately in a moist rooting medium at high humidity; stem cuttings should root in 4-6 weeks (Heger et al., 2011). Once young plants have formed an adequate root ball, transplant into pots or a protected garden location and water regularly until well established (Heger et al., 2011).

- **Division**

Propagation Profiles

Achillea spp. plants can be propagated by division, in spring or autumn and then planted directly into final permanent locations (PFAF, 2023). Holloway (2024) advises: "Division during non-flowering times (spring or autumn). Best in spring just as crown growth begins. *A. millefolium* spreads by rhizomes and forms tight clumps that can be pulled apart, *A. sibirica* has a smaller crown and is a bit harder to cut apart. Both have fibrous root clumps."

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Propagation Profiles

Scientific name: *Agrostis scabra*
Synonyms: Numerous, see USDA Plants Database
Common name (s): rough bentgrass, winter bent
USDA PLANTS code: AGSC5
Family: Poaceae

Duration: Perennial
Growth habit: Graminoid
Wetland indicator status: FAC

Webb & Ickert-Bond, 2022

Nearest propagation protocol:
Seeds collected in Yosemite National Park - USDA Zone 3b-5a; propagated in Bridger, Montana - USDA Zone 5a (Winslow, 2002).
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=poaceae-agrostis-1372

Habitat description:
Dry, open slopes and alluvial flats (Hultén, 1968); also occurs in disturbed areas (e.g., roadsides, clear cuts), and occasionally occurs in open forests or dry tundra (Skinner et al., 2012).

Elevation range:
Sea level to alpine elevations (Matthews, 1992).

Soil preferences and adaptations:
Fine to medium soils, sandy loam, loam, and clay; tolerant of nutrient poor soils and/or soils with low pH (Matthews, 1992; USDA & NRCS, 2023).

Shade tolerance:
Low (USDA & NRCS, 2023).

Created 2024, Kelly Sivy
Last updated: n/a

Homer Soil & Water
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Drought tolerance:
Low (USDA & NRCS, 2023).

Disturbance tolerance:
Mildly fire intolerant (USDA & NRCS, 2023), and increases in response to grazing pressure (Matthews, 1992).

Community interactions:
No information available.

Wildlife associations:
Provides forage and cover for small mammals and waterfowl, and forage to deer and to some extent moose (Matthews, 1992).

Restoration value:
Shows highly successful results for both long- and short-term revegetation programs, especially for alpine and disturbed sites, and in northern regions. In particular, *A. scabra* has been effective for stabilizing soil due to its fibrous root system, and when used in restoration of mining sites with high sulfur, copper, and/or nickel concentration (Matthews, 1992).

Primary reproductive mode:
Sexual, but may spread laterally via stolons (Matthews, 1992).

Seed type:
Orthodox. The Society for Ecological Restoration notes that although *A. scabra* seeds are known to form a short-term, persistent soil seed bank viable for 1-5 years, it also remains possible that seeds surviving less than 2 years in the soil exhibit intermediate or recalcitrant behavior (SER, INSR, RBGK, 2023).

Ease of growing:
Readily sprouts from seed and is noted to be highly effective at seed dispersal by wind, with little planting necessary where there is already a nearby population (Matthews, 1992). Revegetation trials in the Yukon documented seedling emergence on 100% of plots in the first growing season, with 86% of plants producing seed in the second season (Matthews, 1992).

SEED

- **Collection recommendations**
  Holloway (2024) writes:
  "Flowers are an open panicle with single-flowered spikelets at the tips of thin, wiry stems. Fruit is a caryopsis, seed is fused to pericarp and harvested together. Harvesting can be difficult since the entire open, airy panicle can break off and blow away at maturity. Individual caryopses within a spikelet are enclosed by brown or purple glumes that expand when dried. The caryopsis falls to the ground at maturity leaving the glumes behind persisting on the stalk. Harvesting must be done before caryopsis release. Seeds are extremely small and easily shatter. Cut entire panicle of seed heads with knives or clippers and collect in paper or cloth bags. Spread onto a tarp (covered with newspaper or another tarp in breezy areas) to dry for one week."

Winslow (2002) hand harvested seeds in fall when caryopses were a tan-brown color, and the inflorescence was nearly mature (i.e., hard dough stage) but fruits were not freely falling from the open panicle. This collection method is reported to yield an average of 77g (range: 23-168g) of clean seed, per hour, per person, but varies with stand density and collector experience. Matthews (1992) reports an average of 3.3oz (93.6 g) per hour.

- **Seeds per/lb**
  Seeds per pound reported between 4.3-5 million (USDA & NRCS, 2023; Winslow, 2002).

- **Processing techniques, recommended equipment**
  Holloway (2024) writes:
  "Some growers follow with a debearding machine to remove the awn which helps with handling and sowing. If the spikelet is intact, sometimes seeds are run through a hammermill to break up the spikelet and remove the glumes. Clean seeds with an air/screen cleaner. In some seasons, there will be a lot of unfilled seeds. Because of their tiny size, it is hard to separate filled from unfilled seeds. They can be examined microscopically or by germination test to obtain percent filled/unfilled seeds."

  Winslow (2002) describes the seed processing workflow at the Bridger PMC as follows:
  "Spread seed on tarp in a dry sheltered environment, turn daily for 3-5 days until seeds are completely dry and no warmth is detected. *A. scrabra* seeds are small with presence of fluff and other debris and therefore difficult to clean in small batches which require more hand labor. For larger batches, use mechanized cleaning to increase efficiency. Process dried seed on Wintersteiger plot at concave closed, 700 rpm, and no wind. Thresh seed with hammermill through 4/64" round hole screen, and air-screened processed on a Clipper M2B or Eclipse cleaner over a 1-24" round hole screen."

- **Storage**
  Store seeds in plastic seed bags in a cool, dry environment. Winslow (2002) reports 5-7 years viability.

- **Scarification requirements**
  None.

- **Stratification requirements**
  Seeds may benefit from cold stratification (Holloway, 2024). Winslow (2002) exposed seeds to 0-1°C for a 10-day cold stratification period, followed by exposure to 22-25°C.

- **Germination rates and techniques**
  Holloway (2024) writes:
  "Outdoors, seeds may be sown in autumn or spring. Press seeds into the soil, but do not cover. Well drained, loamy soils are best. Indoors, surface-sow the seeds onto a well drained, sterile seed starting mix, a combination of sand/peat. Do not cover. Keep barely moist. Seeds are susceptible to fungal attacks especially if seeds are germinated on filter paper. Experiment with different seed lots. Some seeds benefit from a prechilling cold stratification treatment, 2-4°C for 10 days, before sowing at 22-25°C (72-77°F). Germination begins in 7–10 days."

Winslow (2002) reports 98% germination. For field production at the Bridger PMC, seeds are direct-sown at a depth of 0.6cm (0.25”) using a two-row double-disk planter with depth bands, at a seeding rate of 25-30 seeds per foot. Irrigated rows are spaced at 91 cm (36”). Seeding occurs in a firm seedbed with good field moisture to 4” depth and may take place during spring or fall. Matthews (1992) recommends fall planting in alpine environments to avoid breaking dormancy and to optimize spring growth.

Trials in US and Canada indicate 89-90% germination in 49-70 days in 1% agar under an 8h/16h photoperiod in conjunction with a 25°C/10°C (8h/16h) thermoperiod (SER, INSR, RBGK, 2023).

- **Establishment phase**
  Winslow (2002) recommends keeping soil surface moist throughout the 14-16 day germination and emergence period; this also helps prevent soil crusting. Low (but unspecified) rates of Buctril M™ (bromoxynil; a selective postemergence herbicide) were applied during the 3-5 leaf stage to control broadleaf weeds. Fertilizer application may stimulate weed growth (i.e., competition) and is therefore not recommended during the first year.

- **Active growth phase**
  The active growth phase lasts from spring to fall, for 2-3 growing seasons. Winslow (2002) advises using broadleaf-specific herbicides for weed control during stem extension phase (i.e., before boot stage), and reports that soil moisture is critical during seed head development (i.e., boot, heading, and ripening stages).

- **Hardening phase**
  At the Bridger (Montana) Plant Materials Center, irrigation was suspended during flowering and resumed between harvest and freeze-up; broadcast fertilizers were applied in mid-September at 100 lbs N/acre and 40 lbs of P/acre (Winslow, 2002).

- **Harvest, storage & shipping**
  At the Bridger, Montana, propagation site (USDA Zone 5a), cultivated harvest occurs late July to late August. They use a John Deer swather to cut stems into windrows for direct combining, and it’s fitted with a temporary diaper (heavy piece of plastic or canvas clipped under belt draper) for direct catchment to minimize seed loss. Yields vary based on stand age and local weather, but averages 142 kg/ha (127 lbs/ac) annually (Winslow, 2002).

VEGETATIVE PROPAGATION

- **Division**
  Division is not recommended, as bentgrasses are tufted, non-rhizomatous grasses that are difficult to divide (Holloway, 2024).

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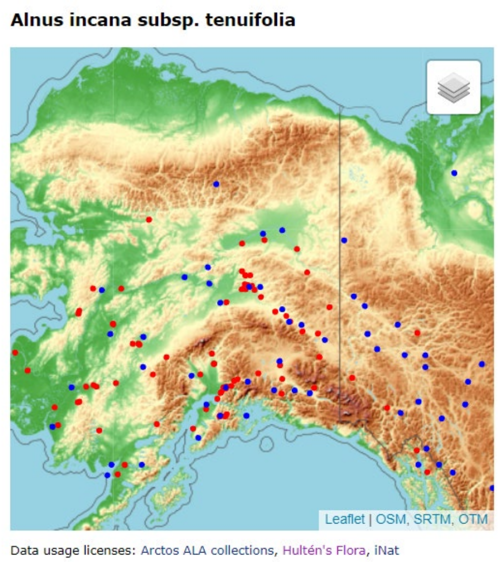
Propagation Profiles

Scientific name: *Alnus incana* ssp. *tenuifolia*
Synonyms: *A. tenuifolia*
Common name(s): thinleaf alder
Family: Betulaceae
USDA PLANTS code: ALINT
Duration: Perennial
Growth habit: Shrub, tree
Wetland indicator status: Unavailable

Some taxonomic ambiguity exists for this species. The parent species *Alnus incana* is divided into sub-species *A. incana* ssp. *rugosa* (or synonym *A. rugosa,* speckled alder), primarily occurring in eastern North America, and *Alnus incana ssp. tenuifolia* (or synonym *A. tenuifolia,* thinleaf alder), primarily occurring in western North America, including Alaska. The information presented here represents findings specific to *Alnus incana ssp. tenuifolia* or western distributed *A. incana* when sub-species was not identified.



WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
Seeds collected in Glacier National Park and propagated in West Glacier, MT (Luna et al., 2008) - USDA Zone 5a
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=betulaceae-alnus-40

Stem-cuttings from parent species *A. incana* harvested in Yellowstone National Park, propagated in Bridger, MT (Scianna, 2003) - USDA Zone 5a
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=betulaceae-alnus-2795

Habitat description:
Occurs in moist forests, streamsides, and bogs in montane zones (Klinkenberg, 2020).

Elevation range:
Sea level to high elevation sites throughout Alaska (Fryer, 2011); observations in British Columbia indicate range of 7-2,060 meters (Klinkenberg, 2020).

Soil preferences and adaptations:
Coarse and medium soils (USDA & NRCS, 2023). Grows in a wide range of soil conditions and pH levels, including poor soils, but does best in heavy moist soils (Favorite, 2002). Also known to grow in sand and along sandbars (Fryer, 2011).

Shade tolerance:
Intermediate/moderately shade tolerant; sprouts possibly having higher shade tolerance than seedlings (Fryer, 2011).

Drought tolerance:
Low (USDA & NRCS, 2023).

Disturbance tolerance:
Adapted to almost all disturbance types, including fire and flood (Favorite, 2002; Fryer, 2011; Rose et al., 1998).

Community interactions:
Alnus spp. are nitrogen fixers capable of affecting soil nutrient dynamics throughout a successional gradient, especially during the first 5 years of stand establishment (Fryer, 2011). Although *A. incana* ssp. *tenuifolia* may facilitate establishment of other early species such as balsam poplar and feltleaf willow, facilitative effects may dissipate as a result of root crowding and root competition from *Alnus* (Fryer, 2011).

Wildlife associations:
Generally considered unpalatable to wildlife (Fryer, 2011). However, leaves and twigs do provide forage for moose and snowshoe hares, while catkins and buds are used by a variety of songbirds (Favorite, 2002). Beavers use bark for forage, and stems for building dams and lodges (Rose et al., 1998).

Restoration value:
Excellent candidate for revegetation of disturbed riparian areas and erosion control; also well suited for for natural screening or windbreaks (Favorite, 2002). Luna et al. (2008) reports rapid growth following outplanting which quickly stabilizes streambanks.

Primary reproductive mode:
Primarily reproduces from seed, and will also regenerate after damage from disturbances or wildlife (i.e., beavers) by sprouting from the stump, root collar, or root crown (Favorite, 2002). Asexual reproduction may be more characteristic of established populations (Fryer, 2011).

Seed type:
Orthodox (SER, INSR, RBGK, 2023).

Ease of growing:
Easy to grow. Luna et al. (2008) report container trees in 3L pots reaching 40 cm height by the end of the second growth season; container trees in 9L pots reached 1.1 meters height from seed in 3 years.

Inoculation can improve establishment, early growth and outplanting of *Alnus* spp. in general (Harrington et al., 2008). As a nitrogen fixing plant, root inoculations are an important component of plant propagation. Darris (2011) summarizes details for inoculation options of similar *Alnus* sp., using isolated cultures (commercially sourced), fresh nodules harvested from donor plants, or from soil beneath existing stands or inoculated seedlings, advising that the latter may yield the best results. Quoreshi et al. (2007) describes the implementation of a successful inoculation protocol for propagating *A. viridis* ssp. *crispa* using a culture of *Frankia* sp. collected from root nodules of wild *A. viridis* ssp. *crispa* stands. Overall, inoculation improved seedling growth and biomass, nodule lobes quantity and weight, nitrogen content, and overall seedling production, without compromising other aspects of nursery operations (Quoreshi et al., 2007).

SEED

- **Collection recommendations**
  Thinleaf alder is produces abundant, but low viability seed every 1-4 years (Rose et al., 1998). Seeds are small nuts, present in pairs on the bracts of the strobiles (Harrington et al., 2008). Once seed matures, dry weather is considered to contribute to opening of the scales to release seeds; wet weather after a dry spell may cause strobiles to close and end seed dispersal (Harrington et al., 2008). Seeds can continue to be dispersed on snow (Densmore, 1979).

  Luna et al. (2008) describes collection of seed during late fall in Glacier National Park:
  "Seeds are collected in late fall when catkins have turned woody and scales begin to open. Branches are flailed over a canvas tarp and seeds are swept into collection bags and kept in a well-ventilated drying shed prior to cleaning."

  Regarding collection of wild inoculate, Densmore (2000) writes in their protocol for propagation of similar species *A. viridis* ssp. *crispa* in Denali National Park, Alaska:
  "Every seed lot should be accompanied by 1-4 L of alder root nodules and soil from the collection site. The alder root nodules and soil surrounding the roots are used to inoculate the alder seedlings in the nursery."

- **Seeds per/lb**
  675,000 seeds per pound (USDA & NRCS, 2023). Mid-elevation collections in Oregon report 589,090-720,000 seeds per pound (Barner, 2008, 2009). Mean annual seed rain in interior Alaska was 745 seeds/m^2 (Zasada, 1986).

- **Processing techniques, recommended equipment**
  Seed processing guidelines generalized across *Alnus* spp. are described by Harrington et al. (2008). Dry alder cones on screens or in fine mesh bags in a well-ventilated area for several weeks to encourage cones to open, or use a kiln set to 16-27°C to expedite the drying process to 2-7 days (Harrington et al., 2008). Excessive heat can cause strobiles to dry too quickly, so use caution. The majority of seeds generally fall from strobiles during drying, any stubborn seed can be loosened with gentle shaking or the tumbling of catkins (Harrington et al., 2008; Luna et al., 2008). Luna et al. (2008) report difficulty separating empty seeds. For stubborn seed, re-wet cones, place in cooler for 24 hours, and repeat drying process (Harrington et al., 2008). Clean seeds with screening for trash removal, followed by air column separator for smaller material.

Barner (2009) advises that cleaning of small seed lots can be challenging due to the need for specialized small-load equipment. He describes cleaning methods used on 2 separate occasions for small seed lots collected by hand into a paper bag:
"Seed is first processed using a hand tumbler to remove the seed from the woody cone. Lot was then air-screened using an office Clipper, with a top screen: 9 round and a bottom screen: 1/14 round, medium speed, low to medium air" (Barner, 2009). "Seeds are sized using Laboratory Test Sieves, mesh size 6. Lot was then air-screened using an office Clipper, with a top screen, 8 round and a bottom screen, 1/15 round, medium speed, low to medium air" (Barner, 2008).

- **Storage**
  Longevity of seed in the field for parent species *A. incana* is short, with viability unlikely after 2 years (Harrington et al., 2008). Long term storage may require drying to moisture contents below 10% by exposing seeds to 27°C with relative humidity below 25%, as is recommended for red alder *Alnus rubra* (Harrington et al., 2008). Barner (2008) reports storing seed at 33-38°F. Luna et. al (2008) stored seeds for 1 year in sealed containers under 3-5°C. Rose et al. (1998) reports that storing seed in sealed containers at 1-3°C can retain viability for up to 10 years. Hermetic air-dry storage is recommended at 2-5°C (SER, INSR, RBGK, 2023).

- **Scarification requirements**
  Luna et al. (2008) report exposing seed to a 24-hour running water soak prior to a 60-day cold moist stratification.

- **Stratification requirements**
  Stratification requirements vary, with successful germination occurring after no stratification (Baskin & Baskin, 2002). Stratification may not be necessary if seeds are sown in the fall, otherwise a 3-month cold stratification is needed (Favorite, 2002). Luna et al. (2008) exposed Montana-collected seed to a 60-day cold moist stratification. Seeds collected near Fairbanks, Alaska showed adequate germination without stratification at 25°C; seeds stratified for 72 days appeared to require lower temperatures (10-15°C) to germinate well (Densmore, 1979).

- **Germination rates and techniques**
  Seeds need light to germinate. The Society for Ecological Restoration reports 94% germination within 49 days under a 8/16 hour light cycle at 25°C (SER, INSR, RBGK, 2023). For thinleaf alder seeds collected near Fairbanks, germination averaged 90% for seeds cold-stratified in light and 5% for seeds cold-stratified in dark. Unstratified seed showed 100% germination in light and ≤13% germination in dark (Densmore, 1979; Fryer, 2011).

  To germinate, Holloway (1985) writes:
  "Sow in fall or spring. Seeds germinate readily in light when fresh at 25°C (77°F), but dry seeds may need stratification for 180 days at 4°C (40°F). Germination may be enhanced by following the scarification period with 3 days at -4°C. Alternating temperatures may increase germination (20/30°C; 68/86°F).

  Luna et al. (2008) used a direct seeding method in greenhouse and outdoor nursery grounds:
  "Seeds are surface sown for the light requirement. Growing medium used is 6:1:1 milled sphagnum peat, perlite, and vermiculite with Osmocote controlled release fertilizer ($13N:13P_2O_5:13K_2O$; 8 to 9 month release rate at 21C) and Micromax fertilizer (12%S, 0.1%B,

0.5%Cu, 12%Fe, 2.5%Mn, 0.05%Mo, 1%Zn) at the rate of 1 gram of Osmocote and 0.20 gram of Micromax per 172 ml conetainer. Plants are grown in the greenhouse with temperatures maintained at 21 -25°C day and 18°C at night for 12 weeks and are moved to outdoor nursery. Germination is uniform and is usually complete in 3 weeks. True leaves appear 2 weeks after germination and seedlings are thinned at this stage."

- **Establishment phase**
  Luna et al. (2008) reports a 4-week plant establishment period. Slow-release fertilizer is recommended (Favorite, 2002).

- **Active growth phase**
  Luna et al. (2008) report rapid growth over 16-week active growth period, and fertilization with 13-13-13 liquid NPK at 100 ppm. Plants were reportedly repotted into larger 3L containers 16 weeks post germination, and were "root tight" in 1 year (Luna et al., 2008).

- **Hardening phase**
  In the fall, Luna et al. (2008) report a 4 week hardening phase, and fertilizing with 10-20-20 liquid NPK at a concentration of 200 ppm, after which pots were leached with clear water; one final irrigation was done prior to overwintering period.

- **Harvest, storage & shipping**
  Stems are sensitive and brittle, handle carefully to avoid breaking stems, branches, or buds (Harrington et al., 2008). Store seedlings at low (-2 - +2°C) temperatures to prevent early budbreak and/or in plastic bags to prevent desiccation (Harrington et al., 2008). Luna et al. (2008) report total time to harvest as 16 weeks for 172 mL containers, and 1 year for 3L pots. Plants were harvested in September and overwintered in the outdoor nursery facility using foam insulation to cover and protect from snow (Luna et al., 2008). They further report formation of root nodules on nursery stock held for 1 year or more.

VEGETATIVE PROPAGATION

- **Cuttings**
  In general, *Alnus* spp. hardwood cuttings are notoriously unsuccessful at rooting (Darris & Gonzales, 2009; Holloway & Zasada, 1979; Java & Everett, 1992). Green stem cuttings of the similar species, *A. viridis sinuata* harvested from British Columbia and Oregon, were successfully rooted by Carpenter et. al (1984) with the following protocol: treat with 2000 ppm indole-3-butyric acid and dust with Rootone rooting powder and fungicide. Root into 1:1 medium of sterile perlite and vermiculite, mist intermittently for 10 weeks, for the last month fertilize weekly with liquid fertilizer, apply bottom heat (21°C) (Carpenter et al., 1984; Darris, 2011). Java and Everett (1992) similarly advise a 2000 ppm indole-3-butyric acid and 1000 ppm napthalene acetic acid followed by 1 month cold (1-3°C) storage to promote rooting (Java & Everett, 1992; Rose et al., 1998).

  Scianna (2003), also reports successful propagation from dormant hardwood stem-cuttings of parent species, *A. incana*, collected in late October from Sylvan Lake in Yellowstone National Park (USDA Zone 5a). Cuttings were taken from plants with evidence of repeated browsing, with bases promptly submerged in water inside a cooler, for 48 hours or less. He hypothesizes that the level of browsing on parent plants (similar to stimulation of root growth akin to "hedging") and submerging stems in water (stimulating root formation) prior to greenhouse transfer were important steps contributing to successful stem propagation. Once harvested, cuttings were transferred to greenhouse and trimmed to 6-10 inches in length, before recutting stem ends at an angle and wounding. Scianna (2003) further details the propagation procedure:

> "[Cut] Stems were treated with 8,000 ppm IBA; 20,000 ppm IBA; or a combination of 1,000 ppm IBA + 2,000 ppm NAA + 40,000 ppm Thiram. Prepared cuttings were stuck individually into a 1:1 sand:perlite mix in 10-cubic-inch containers and watered. The cuttings were then placed in a greenhouse under 16-hour photoperiods at 75 to 80°F days and 65 to 70°F nights. The cuttings were hand-watered twice per day (AM and PM) for the first 4 weeks and once per day thereafter."

During establishment Scianna (2003) reports:

> "After approximately 4 weeks in the greenhouse, bud break began to occur. By week 8, leaf growth advanced so a fertigation program was initiated. All cuttings were irrigated with a 350 ppm solution of 9-45-15, two to three times per week. By late January, the cuttings were rooted well enough to be transplanted into 40-cubic-inch DeepotsT in a 3:1, Fison's #3T:sand mix. The potted cuttings were returned to the greenhouse and grown on. Percent rooting ranged from 78 to 86% with a mean rooting of 82%. Based on the relatively uniform rooting, there does not appear to be any advantage to using high concentrations of IBA."

Scianna (2003) reports moving rooted stem cuttings to a ventilated, un-cooled outdoor hoophouse in late spring/early summer and exposing to full sun for 2-4 weeks early in growing season. During mid-summer, the hoophouse was covered with a 50% shade cloth; cloth was replaced with clear plastic once temperatures started to cool in late summer/early fall, during which plants were left to naturally harden for 30-60 days in a hoophouse (Scianna, 2003). Hoophouse was warmed with a small propane heater when necessary (e.g., early season frost). Cuttings in 40-cubic inch containers were reported to successfully overwinter in the unheated hoophouse (Scianna, 2003).

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Propagation Profiles

Scientific name: *Alnus viridis* ssp. *crispa*
Synonyms: *Alnus crispa*
Common name (s): mountain alder
Family: Betulaceae
USDA PLANTS code: ALVIC

Duration: Perennial
Growth habit: Tree, shrub
Wetland indicator status: unavailable

WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
Denali National Park, Alaska (Densmore et al., 2000) - USDA Zone 3b
https://apps.dtic.mil/sti/pdfs/ADA396156.pdf

Habitat description:
Alnus viridis ssp. *crispa* occurs in open forest, shrub tundra, and riparian areas, provided there is no dense overstory (Densmore, 1979; Matthews, 1992). Found on slopes, sand hills, and edges of wetlands and streams (Johnson et al., 1995). Within Alaska, it is further described to "Occupy a somewhat indistinct subalpine region, diminishing in height with increasing altitude, becoming, at its altitudinal limit, a prostrate dwarf shrub" (Hultén, 1968).

Elevation range:
Sea level to 2,000 meters (Matthews, 1992).

Soil preferences and adaptations:
Coarse to medium, sandy to gravelly to rocky soils (Matthews, 1992; USDA & NRCS, 2023). Prefers well-drained, coarse-textured soils; indicates seepage; widespread and common across boreal forest (Johnson et al., 1995). In interior Alaska, *Alnus* spp. are three times as likely to occur on bare mineral soils compared to organic surfaces (Zasada, 1986).

Shade tolerance:
Intermediate shade tolerance (USDA & NRCS, 2023).

Created 2024, Kelly Sivy
Last updated: n/a

Homer Soil & Water
CONSERVATION DISTRICT

Drought tolerance:
Alnus viridis ssp. *crispa* is listed as drought intolerant by the USDA; however, review by Matthews (1992) suggests that this taxon is better adapted to drier sites compared to other *Alnus* spp., as the increased moisture favors nitrogen fixation.

Disturbance tolerance:
As an early-seral/pioneer species, this species likely has a high disturbance tolerance. It is characterized in the Fire Effects Database as a "survivor species" due to its adaptability and rapid post-fire regenerative ability (Matthews, 1992).

Community interactions:
As a nitrogen fixer, *A. viridis* ssp. *crispa* affects the plant community by enhancing soil fertility, and in some instances may act as a nurse plant for *Picea* and *Pinus* spp.; however, this interaction may turn competitive as thicket forming *Alnus* spp. can shade out establishing conifers (Matthews, 1992). Nitrogen fixing capabilities can also facilitate willow growth, when planted in proximity (Densmore et al., 2000).

Wildlife associations:
Provides cover for a number of wildlife species, as well as forage for moose, caribou, small mammals, and birds (Matthews, 1992).

Restoration value:
Alnus viridis ssp. *crispa* is capable of fixing 18-55 pounds of nitrogen per year, and holds excellent restoration value through its ability to establish in sterile soils and improve organic matter and soil fertility (Matthews, 1992). This species can also stabilize soils to minimize erosion and has successfully colonized tailings at Alberta mine sites; it has also recovered following oil spills (Watson et al., 1980). Studies in Denali National Park suggest that this species may also hold value for revegetation programs seeking to accelerate the rate of succession, by facilitating the establishment of dominant woody species (Densmore, 2005).

Primary reproductive mode:
Primarily reproduces from seed on disturbed sites, and can also reproduce asexually by sprouting from the root crown following damage from natural disturbances or mechanical cutting (Matthews, 1992). On the Seward Peninsula, stands of *Alnus viridis* ssp. *crispa* appeared to be reproducing by seed on 8 out of 11 sites (Wilson et al., 1985).

Seed type:
Orthodox (SER, INSR, RBGK, 2023).

Ease of growing:
Will vigorously grow on harsh sites; however, direct seeding on disturbed or poor soil sites provides challenging conditions and plants may require 3-6 years to establish. Propagating container grown seedlings for transplant is therefore recommended (Densmore et al., 2000).

Propagation Profiles

SEED

- **Collection recommendations**
  Seeds are small nutlets found within conelike strobili, which open from mid-September to early October; the winged nutlets are dispersed by wind (Densmore, 1979). Collection of seed cones in Alaska is recommended from the last week of August through to the first week of September; cones should be placed in a warm, dry place to dry for 1 week (Densmore et al., 2000). Inoculation of soil is an important step for seedling establishment; Densmore (2000) writes:
  "Every seed lot should be accompanied by 1-4 L of alder root nodules and soil from the collection site. The alder root nodules and soil surrounding the roots are used to inoculate the alder seedlings in the nursery. Label the inoculant and store it in a cool place."

- **Seeds per/lb**
  1,280,000 seeds per pound (USDA & NRCS, 2023).

- **Processing techniques, recommended equipment**
  To remove seeds from cones, shake in an enclosed container (e.g., coffee can); separate seeds from cones using a screen or sieve/colander (Densmore et al., 2000).

- **Storage**
  Seeds should be stored in plastic bags in the freezer (Densmore et al., 2000). Alternatively, hermetic air-dry storage at 2-5°C is recommended (SER, INSR, RBGK, 2023).

- **Scarification requirements**
  Does not appear to benefit from scarification to break dormancy (Densmore, 1979).

- **Stratification requirements**
  Does not appear to benefit from stratification to break dormancy (Densmore, 1979). Similarly, no benefit of cold moist stratification (4°C) was found in more recent studies; however, stratification of anywhere from 2-12 weeks significantly reduced time to achieve 90% germination (7.9-11.5 days), compared to unstratified seeds (22.2 days) (Kaur et al., 2016). Stratification for 2 or 6 weeks is suggested for rapid, uniform germination in nursery settings, as these durations had the most pronounced effect compared to 12-week stratification or no stratification at all (Kaur et al., 2016).

- **Germination rates and techniques**
  Germination trials by Densmore (1979) of seeds collected outside of Fairbanks and sown in the Bonanza Creek floodplain indicate that seeds are conditionally dormant in response to temperature and require light for germination. Densmore monitored seed germination under temperatures from 5-25°C of a) unstratified seeds, b) seeds cold stratified at 2-5°C for 70 days under a 13-hour light cycle, and c) seeds cold stratified at 2-5°C for 107 days in the dark. One hundred percent germination was achieved by the 70-day light/cold stratified seeds at temperatures between 10-25°C. Unstratified seeds achieved 98% germination under light conditions at 25°C. Germination of seeds stratified and germinated in dark performed poorly (<12%). Overall, germination of stratified seeds in light was consistently high, provided temperatures of 10°C and above.

In general, P. Holloway (1985) of University of Alaska Fairbanks, advises:
"Sow in fall or spring. Seeds germinate readily in light when fresh at 25°C (77°F), but dry seeds may need stratification for 60 days at 4°C (40°F). Alternating temperatures may increase germination (20/30°C; 68/86F)."

Densmore (2000) provides a detailed propagation protocol based on successful greenhouse propagation of over 10,000 seedlings, with ≥95% survival rate after 5 years. Plants typically reached 1 meter after 3 years: Begin propagation in early March to allocate 3 months needed to achieve optimum seedling size of 15-25 cm tall, for outplanting. Plant seeds in a growing medium of 1:1 peat to vermiculite. For each m^3 of growing medium, mix in at least 2 L soil and nodule inoculant. Plant into 2.5 cm diameter tube containers 10 cm long. Because it is common for alder to produce 5-40% of nonviable seeds, it is advisable to plant 10-20 seeds per container/tube to ensure at least 1 seedling (Densmore et al., 2000).

As a nitrogen fixing plant, root inoculations are an important component of plant propagation. Darris (2011) summarizes details for inoculation options of similar *Alnus* spp., using isolated cultures (commercially sourced), fresh nodules harvested from donor plants, or from soil beneath existing stands or inoculated seedlings, advising that the latter may yield the best results. Quoreshi et al. (2007) describes the implementation of a successful inoculation protocol using a culture of *Frankia* sp. collected from root nodules of wild A. *viridis* ssp. *crispa* stands. Overall, inoculation improved seedling growth and biomass, nodule lobe quantity and weight, nitrogen content, and seedling production (Quoreshi et al., 2007).

- **Establishment phase**
  Densmore et al. (2000) describes that for onsite planting, install 0.5 meter apart, or in clumps where other species can colonize the open areas naturally. Alder may also be planted in bands along a floodplain, or along slope contours for stabilization. The planting hole should be deep enough to accommodate roots and a watering moat, and stems should be planted vertically (not angled into the hole). All parts of the roots should be covered. The preferred fertilizers are slow-release, low-nitrogen, mixed with backfill. Water with 1L fertilizer transplant solution at half strength of manufacturer recommendation to reduce transplant shock and stimulate growth. Seedlings can be watered with low nitrogen fertilizer, such as 7-40-11 NPK + micronutrient solution (Densmore et al., 2000).

- **Active growth phase**
  At approximately 6 weeks post sow, thin seedlings to 1 per container. Seedlings will take 3 months to reach plantable size (Densmore et al., 2000).

- **Hardening phase**
  To harden seedlings, set outdoors 2 weeks prior to outplanting (Densmore et al., 2000).

- **Harvest, storage & shipping**
  To transport seedlings, use waxed boxes; once destination is reached, remove plants from boxes into partial sun (e.g., under forest canopy). Monitor daily and provide plenty of water. Re-box plants for any additional transport, and do not expose to wind during transportation (Densmore et al., 2000). Stems are sensitive and brittle, handle carefully to avoid breaking stems, branches,

or buds (Harrington et al., 2008). Store seedlings at low (-2 - +2°C) temperatures to prevent early budbreak and/or in plastic bags to prevent desiccation (Harrington et al., 2008).

VEGETATIVE PROPAGATION

- **Cuttings**
  In general, rootings from *Alnus* spp. hardwood cuttings are notoriously unsuccessful (Darris & Gonzales, 2009; Java & Everett, 1992), with only 3 out of 1,000 *A. viridis* spp. *crispa* hardwood cuttings collected near Fairbanks taking root (Holloway & Zasada, 1979). However, green stem cuttings of the sister sub-species within *A. viridis,* Sitka alder (*A. viridis* ssp. *sinuata*), were successfully rooted by Carpenter et al. (1984) with the following protocol: treat with 2000 ppm indole-3-butyric acid and dust with Rootone rooting powder and fungicide. Root into 1:1 medium of sterile perlite and vermiculite, mist intermittently for 10 weeks, for the last month fertilize weekly with liquid fertilizer, apply bottom heat (21°C) (Carpenter et al., 1984; Darris, 2011).

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Propagation Profiles

Scientific name: *Alnus viridis* ssp. *sinuata*
Synonyms: *A. sitchensis*, *A. sinuata*, *A. crispa* ssp. *sinuata*
Common name (s): Sitka alder
Family: Betulaceae
USDA PLANTS code: ALVIS

Duration: Perennial
Growth habit: Tree, shrub
Wetland indicator status: unavailable

WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
Lake Macdonald, Glacier National Park, MT (Luna et al., 2008) - USDA Hardiness Zone 5a
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=betulaceae-alnus-39

Habitat description:
Alnus viridis ssp. *sinuata* is a seral shrub common to mountain slopes; avalanche chutes; stream banks; shores; deglaciated areas; north facing cool, moist sites or montane woods; rocky/sandy coastlines; anywhere with high surface moisture (Darris & Gonzales, 2009; Uchytil, 1989). Dominates avalanche chutes; snow slides over them without breaking (Pojar & MacKinnon, 1994; Uchytil, 1989).

Elevation range:
From sea level, or mid to high elevation up to 9000 feet (Darris & Gonzales, 2009; Uchytil, 1989).

Soil preferences and adaptations:
Occurs on mineral to rich soils, of coarse to medium texture, including silt and sand, loam, rock, gravel, and humus covered substrates. It has a tolerance for acidic (3.3-7.5 pH) soil and can also have an acidifying effect on surrounding soil (Darris, 2011). Sitka alder can also persist in heavy clay loam soil, provided there is adequate moisture (Darris, 2011). The ability to fix nitrogen allows this plant to establish on sterile mineral soils (Darris & Gonzales, 2009; Uchytil, 1989).

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Last updated: n/a

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Propagation Profiles

Shade tolerance:
Moderately shade tolerant; takes full sun to partial shade but does not tolerate dense overstory (Darris & Gonzales, 2009; Uchytil, 1989).

Drought tolerance:
Low (USDA & NRCS, 2023).

Disturbance tolerance:
High – readily establishes in avalanche chutes and streamsides (Uchytil, 1989).

Community interactions:
Alnus spp. are nitrogen fixers; Sitka alder is capable of fixing up to 18-55 pounds of nitrogen per acre per year, improving soil productivity (Uchytil, 1989). Sitka alder may facilitate succession through the establishment of conifers, and in particular seedlings (Chapin et al., 1994). However, this interaction may turn competitive due to shading and root competition. The overall effect of *Alnus* spp. on the plant community likely depends on overall nitrogen availability on a given site (Anderson, 2011; Chapin et al., 1994).

Wildlife associations:
Sitka alder provides cover and forage for bears, beavers, hares, birds, and moose (Darris & Gonzales, 2009; Uchytil, 1989).

Restoration value:
Sitka alder has a fibrous root system that makes it a good candidate for erosion control on disturbed slopes. It is well adapted to mineral soils and can improve soil productivity through nitrogen fixation, lending to its utility in mine reclamation (Darris, 2011; Densmore, 2005; Elliott et al., 1987). Seeds can be sown directly at disturbed sites with successful results (Uchytil, 1989).

Primary reproductive mode:
Propagation is primarily by seed (male and female flowers occur on the same plant). It can also revegetate from damaged root collars or stumps, typically where plants have been damaged by avalanche or fire (Uchytil, 1989). Can be propagated by seed, cuttings, suckers, and grafting (Downing, 1996).

Seed type:
Orthodox (SER, INSR, RBGK, 2023).

Ease of growing:
Reliable propagation from seed (Darris & Gonzales, 2009). Benowicz et. al (2000) evaluated germination, growth, and frost hardiness among 28 populations of *A. viridis* spp. *sinuata* throughout British Columbia to determine genetic and environmental-based differences. They found strong geographic variations in fall frost hardiness, shoot dry weight, summer (July) growth rate, and ratio of root dry weight to total dry weight, with latitude and distance from coast accounting for most of the variation (Benowicz et al., 2000). These findings underscore the importance of developing propagation techniques to match conditions present where plant material is collected from.

Propagation Profiles

SEED

- **Collection recommendations**
  Plants begin producing seed at 4-7 years old; however, cultivated stands may produce as early as 3 years old (Darris, 2011). Although plants produce seed annually, "bumper crops" may occur every 3-5 years (Darris, 2011). Seeds are mature and ready for collection when catkins turn woody and scales begin to open (Luna et al., 2008). Maturity can also be tested if scales easily separate when the cone is twisted from top and bottom (Darris, 2011; Hibbs & Ager, 1989). To harvest seed, "flail" branches over a tarp (Darris, 2011; Luna et al., 2008). Sweep seeds into paper bags and store in a well-ventilated drying shed before cleaning.

- **Seeds per/lb**
  Variable. 666,000 seeds per pound (USDA & NRCS, 2023); 1,700,000 seeds per pound (Darris, 2011); 14,700,000 seeds per kg (32,400,000 per pound) (Luna et al., 2008).

- **Processing techniques, recommended equipment**
  Dry cones at ambient temperatures on elevated screens, or hung in fine mesh bags. Once dry, any seed not fallen out can be removed by gently shaking or tumbling cones in a closed container (Hibbs & Ager, 1989; Luna et al., 2008). Cones may also be kiln dried at 16-27°C for 2-7 days. Clean seed with an air screen machine and process through an air column to remove particulates. (Darris, 2011; Hibbs & Ager, 1989). Luna et. al (2008) notes that empty seeds are difficult to separate from sound seeds.

- **Storage**
  Store seed in cool, dry storage to overwinter. Hermetic, air dry storage from 2-5°C is recommended (SER, INSR, RBGK, 2023). Store airtight at 1-3°C (Uchytil, 1989). Luna et. al (2008) report storing seeds for 1 year at 1-3°C inside sealed containers. Darris (2011) reports seeds stored in paper envelopes at 3-5°C for 3 years retained a 50% or greater germination rate.

- **Scarification requirements**
  Unknown. Some trials suggest soaking (see techniques, below); however, scarification has not been mentioned as a necessity.

- **Stratification requirements**
  Cold moist stratification for 1-3 months at 3°C is a general recommendation (Rose et al., 1998). Otherwise, stratification times are highly dependent on seed origin, seed moisture content, and planting season (Darris & Gonzales, 2009). For storage moisture below 10%, cold stratify for 60 days at 5°C for seeds to be sown in spring (Uchytil, 1989). Anywhere from 14 days to 3 months of cold moist stratification, at 34-38°F, has yielded success for spring sown seeds (Baskin & Baskin, 2002; Darris & Gonzales, 2009). Luna et. al (2008) reports germination to be most uniform with a 60-day cold moist stratification: soak seeds for 24 hours, after which place in fine mesh bags and bury in moist milled peat moss in a well-ventilated container in a 3°C refrigerator. If planting in fall, or using fresh seed, stratification may not be necessary (Darris & Gonzales, 2009; Uchytil, 1989).

Propagation Profiles

- **Germination rates and techniques**

  Darris (2011) writes that for spring planting, cold moist stratify seeds directly before planting. Pathogens present on seed coat may be eliminated by fungicide or peroxide treatment, but at the expense of the germination rate (Darris, 2011; Rose et al., 1998). Seed may also be soaked for 24 hours immediately prior to planting to bypass stratification requirements. Seeds require moist mineral soil to germinate (Uchytil, 1989). Seeds should germinate in 3 weeks. Repot into 1 gallon or larger pots within 12-18 weeks (Darris, 2011).

  For fall planting, plant dry, untreated seeds approximately 2-5 mm deep in moist mineral seed bed (Baskin & Baskin, 2002; Darris, 2011). As seeds require light to germinate, cover with only a thin layer of silica sand, mulch, soil, or peat. Surface sow or cover with thin layer of growing medium and inoculate roots with *Frankia* bacteria (Darris & Gonzales, 2009).

  Baskin and Baskin (2002) report germinating under an alternating temperature cycle of 20D/10N [*sic*] following a 14-day cold moist stratification (Propagation Profile authors interpret this as 20°C daytime/10°C nighttime).

  In their greenhouse propagation, Luna et. al (2008) reports 50-70% germination from fresh seed. Seeds were surface sown directly into a 6:1:1 milled sphagnum peat, perlite, and vermiculite growing medium with a controlled release fertilizer (Osmocote 13N:13P:13K with an 8-9 month release at 21°C) and fertilizer (Micromax 12%S, 0.1%B, 0.5%Cu, 12%Fe, 2.5%Mn, 0.05%Mo, 1%Zn). For each 172 mL container, they applied 1 gram of Osmocote and 0.20 gram of Micromax. They used 75-100% peat growing medium that was well drained and amended with these micronutrients and slow-release fertilizer (Luna et al., 2008).

  As a nitrogen fixing plant, root inoculations are an important component of plant propagation. Darris (2011) summarizes details for inoculation options using isolated cultures (commercially-sourced), fresh nodules harvested from donor plants, or from soil beneath existing stands. For the latter, collect a thin band of soil from beneath the existing stand, dry and sift soil, and incorporate it into the growing container before seed is sowed. Apply balanced liquid fertilizer periodically, and low to moderate application of nitrogen fertilizer to promote nodule growth.

  Assess seedling quality based on high root to shoot ratio, root nodule presence, and/or stem caliper as opposed to seedling height (Darris, 2011). It can take 4-7 years for plants to mature to produce seed (Lawrence, 1958; Uchytil, 1989). To cultivate seed producing stands, Darris (2011) suggests the following: "Seed orchards are best established in full sun on moist, well drained sites with coarse to medium textured soils that are mildly acidic." Keep isolated from other *Alnus* species, e.g., minimum distance 275 m. Stands should not need irrigation in subsequent years after establishment.

- **Establishment phase**

  Luna et al. (2008) report germination was completed in 3 weeks, with true leaves appearing 2 weeks post germination. Seedlings were thinned one true leaves appeared; they were hand watered inside the greenhouse until mid-May and moved outdoors afterwards.

- **Active growth phase**
  Luna et al. (2008) report seedlings grow rapidly over a period of 16-20 weeks, once established. A 13-13-13 liquid fertilizer was applied at 100 ppm throughout the growing season. In four months, seedlings averaged 5 mm caliper and 4 cm in height. They recommend plants are potted up to 3L (1 gallon) containers 16 weeks after germination; in one year their roots will fill out the container.

  Darris (2011) recommends plants are stored in a shade house, with periodic fertilizer and irrigation. A balanced soluble fertilizer may be applied in spring and early summer.

- **Hardening phase**
  Darris (2011) advises cease fertilization and irrigation as early as August, to harden. During a hardening phase of 8 weeks, Luna et al. (2008) report: "Plants are fertilized with 10-20-20 liquid NPK at 200 ppm in the fall, pots are leached with clear water, one final irrigation is applied before overwintering."

- **Harvest, storage & shipping**
  Luna et al. (2008) report total time until harvest as 9 months, with plants overwintered for 5 months in an outdoor nursery (Montana) under insulated foam coverings. Stems are sensitive and brittle, handle carefully to avoid breaking stems, branches, or buds (Harrington et al., 2008). Store seedlings at low (-2 - +2°C) temperatures to prevent early budbreak and/or in plastic bags to prevent desiccation (Harrington et al., 2008).

VEGETATIVE PROPAGATION

- **Cuttings**
  Rootings from hardwood cuttings are notoriously unsuccessful (Darris & Gonzales, 2009; Holloway & Zasada, 1979; Java & Everett, 1992); however, green stem cuttings of Sitka alder were successfully rooted by Carpenter et al. (1984) with the following protocol: treat with 2000 ppm indole-3-butyric acid and dust with Rootone rooting powder and fungicide. Root into 1:1 medium of sterile perlite and vermiculite, mist intermittently for 10 weeks, for the last month fertilize weekly with liquid fertilizer, apply bottom heat (21°C) (Carpenter et al., 1984; Darris, 2011).

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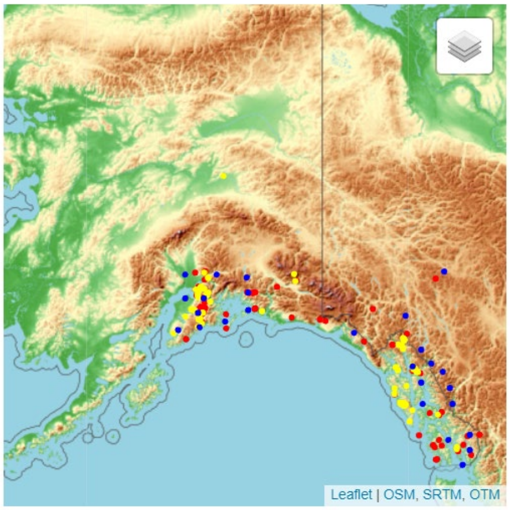
Propagation Profiles

Scientific name: *Aquilegia formosa*
Synonyms: Seven varieties are considered synonyms; see full list at USDA Plants Database
Common name (s): western columbine
Family: Ranunculaceae
USDA PLANTS code: AQFO

Duration: Perennial
Growth habit: Forb/herb
Wetland indicator status: FACU

Aquilegia formosa



Data usage licenses: Arctos ALA collections, Hultén's Flora, iNat

WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
Seeds collected in Crater Lake National Park - USDA Zone 6a-b; propagated in Corvallis, OR - USDA Zone 8b (Flessner & Trindle, 2003).
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=ranunculaceae-aquilegia-2362

Habitat description:
Moist woods, mountain slopes, and streamsides (Hultén, 1968; Rose et al., 1998); rocky slopes, thickets, clearings, roadsides, and open forests (Klinkenberg, 2020).

Elevation range:
Near sea level to 3100 meters.

Soil preferences and adaptations:
Coarse and medium soils.

Shade tolerance:
High (USDA & NRCS, 2023).

Drought tolerance:
Medium (USDA & NRCS, 2023).

Created 2024, Kelly Sivy
Last updated: n/a

Disturbance tolerance:
High fire tolerance (USDA & NRCS, 2023).

Community interactions:
Unavailable.

Wildlife associations:
An attractor for pollinating species such as butterflies, moths, and hummingbirds (Holloway, 2024).

Restoration value:
Unavailable.

Primary reproductive mode:
Seed.

Seed type:
Orthodox (SER, INSR, RBGK, 2023).

Ease of growing:
Easy to grow from seed, and will self-maintain stands from seed (Lady Bird Johnson Wildflower Center, 2023).

SEED

- **Collection recommendations**
  Holloway (2024) writes:
  "Considered a short-lived perennial with abundant regeneration from seed in the wild. Lasts longer in cultivated fields with ample nutrition. Will also easily hybridize with related species, especially commercially available cultivars, so plan to isolate plants when grown in nurseries. Fruit is an upright follicle that splits from the top. Black seeds drop to the bottom of the follicle and are shaken out when moved by wind, animals, human shaking."

  Flessner & Trindle (2003) note that seeds can be hand harvested and are easily identified from their uniquely shaped seed pod. In Oregon, follicles become dry and open in July through August (Rose et al., 1998).

- **Seeds per/lb**
  248,000 seeds per pound (USDA & NRCS, 2023).

- **Processing techniques, recommended equipment**
  Holloway (2024) writes:
  "Entire heads change from green to tan to light brown. Harvest entire follicle into paper bags just as the follicle begins to turn brown and crack open. Wait too long and a lot of seeds will be lost if the follicle is jostled. For small quantities, roll follicle between thumb and fingers after harvest to dislodge seeds, but be careful that you don't create a lot of broken trash that is hard to clean. For larger quantities, dry follicles in paper bags or on screens with a lower tray that will allow seeds

to drop through the screen while follicles remain on the screen. An air/screen cleaner or similar vibrating seed cleaner works well."

Follicles are inherently dry and will split open when mature. Remaining seeds can be separated with gentle crushing of dried seed heads and cleaned and scalped with an "office clipper" air-screen. Chaff is papery and light and will easily separate from seed. Alternatively, cut stalk into a bag before follicles open, and leave in the bag to dry for several days. Once dry, shake bag to release and separate seed from fruiting stalk (Flessner & Trindle, 2003; Rose et al., 1998).

Treatment with gibberellic acid can shorten or replace the period of after ripening of fresh seed (Holloway, 2011).

- **Storage**
  Seeds retained 80% viability after freezing for 116 days at -20°C and 15 % relative humidity (SER, INSR, RBGK, 2023). Seeds may be stored for 2 years at low temperature and humidity. Holloway (2024) advises refrigerating (4°C/40°F), or freeze; seed germination is good for at least 3 years when frozen. Seeds may remain viable longer if stored in sealed containers at low moisture (Rose et al., 1998). Seeds stored at the Corvallis Plant Materials Center remained viable for 3+ years when stored at low humidity and 34-38°F (Flessner & Trindle, 2003).

- **Scarification requirements**
  Krock et al. (2016) report a small but significant increase in germination rate following treatment with a 1:100 smoke-water imbibition. As plant-derived smoke-water is a known germination cue in fire-adapted ecosystems, heat and/or fire scarification may further improve germination rates for this species. No other scarification information was available.

- **Stratification requirements**
  Aquilegia formosa requires cold stratification or long moist pre-chill to improve germination (Flessner & Trindle, 2003; Russell, 2011).

  Krock et al. (2016) tested 6 cold stratification durations and of these, recommended a 60-day cold stratification to yield the highest germination percent (74%). Percent germination was further increased to 89% with a 1:100 smoke-water imbibition of 60 day cold-stratified seeds.

- **Germination rates and techniques**
  Germination trials from Canada report 96% germination in 1% agar under a 12/12 photoperiod and 12/12 thermoperiod of 26/16°C; seeds treated with 250 mg/liter of Gibberellic acid and exposed to an 8/16 light cycle and 8/16 thermoperiod of 25/10°C returned 80% germination over 84 days (SER, INSR, RBGK, 2023).

  Holloway (2024) advises:
  "Direct surface sow in autumn but protect from bird predation in open fields. Allow seeds to drop naturally from the follicles, then check for seedlings next spring. Can be quite prolific depending on the soil/moisture conditions. Indoors, cold stratify at least 30 days at 4°C. Some collections take longer, so experiment. Seeds respond well to a treatment with Gibberellic acid when seeds are soaked immediately after cold stratification. Do not allow seeds to dry between stratification and soaking. Soak 24 hours in 1000 ppm Gibberellic acid, then sow, again without drying. Press

seeds onto surface of propagation medium, and barely cover with fine vermiculite. Seeds germinate best in light. Seedlings will appear in 10-14 days at 70 - 75°F (21- 24°C)."

- **Establishment phase**
  Flessner & Trindle (2003) report moving cold stratified plugs outside to a shade house for mid-spring germination. "Initial germination was spotty, and initial growth is quite slow." Seedlings were subjected to light, frequent waterings to keep soil moist.

- **Active growth phase**
  At the Corvallis Plant Materials Center, Flessner & Trindle (2003) report the active growth phase as June through August, with slow and steady crown and root development throughout the season. They fertilized plants in July with half-strength Peters 9-45-15. Roots reached the bottoms of containers after about 3 months. Foliage development was robust, and watering was changed from overhead sprinklers to hand watering to reach the soil surface in plugs. Plants did not tolerate drying out.

- **Hardening phase**
  Time between waterings was lengthened upon adequate root development, fertilizer was not applied past August (Flessner & Trindle, 2003).

- **Harvest, storage & shipping**
  Flessner & Trindle (2003) shipped well-watered, year-old plugs in their containers via refrigerated van in August, from the Corvallis Plant Materials Center to Crater Lake National Park. Plugs were maintained in a park shade house for an additional 2 weeks, then outplanted in September.

VEGETATIVE PROPAGATION

- **Division**
  Plants of *A. formosa* may be divided in spring just as crown growth begins.

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Propagation Profiles

Scientific name: *Arnica angustifolia*
Synonyms: n/a
Common name (s): narrowleaf arnica
Family: Asteraceae
USDA PLANTS code: ARAN5

Duration: Perennial
Growth habit: Forb/herb
Wetland indicator status: unavailable

WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
Unavailable.

Habitat description:
Rocky slopes, mesic to dry sites in montane to alpine zones (Klinkenberg, 2020; Lady Bird Johnson Wildflower Center, 2023a).

Elevation range:
900-2400 meters (Klinkenberg, 2020). Flora of North America describes it ranging from 0-1500 meters.

Soil preferences and adaptations:
Dry, sandy, or rocky soils (Lady Bird Johnson Wildflower Center, 2023a).
Subspecies *angustifolia* is tolerant of alkaline soils (Lady Bird Johnson Wildflower Center, 2023b).

Shade tolerance:
The Lady Bird Johnson Wildflower Center (2023) reports that *A. angustifolia* thrives in full sun.

Drought tolerance:
Unavailable.

Disturbance tolerance:
Unavailable.

Created 2024, Kelly Sivy
Last updated: n/a

Homer Soil & Water
Conservation District

Community interactions:
Unavailable.

Wildlife associations:
Attracts and benefits pollinator species (Alaska Native Plant Society, 2023).

Restoration value:
Unavailable.

Primary reproductive mode:
Propagates by seed, division, or through rhizomatous growth (Lady Bird Johnson Wildflower Center, 2023a).

Seed type:
Unavailable.

Ease of growing:
Arnica angustifolia is sensitive to temperatures: high temperatures during previous years' growing season adversely affected rosette size and ramet survival (Jäkäläniemi, 2011).

SEED

- **Collection recommendations**
  From Pat Holloway (2024):
  "Entire heads change from yellow/green to tan to brown. The seeds are held tightly in the heads, but as they mature, the tufted hairs spread apart like dandelion fluff, and individual achenes can be pulled apart. It is easy to tell when seeds are mature because tugging on individual heads does nothing when seeds are immature. There is a short window when achenes and fluff can be pulled from the stem by hand or a vacuum harvester. Repeated harvest is required."

- **Seeds per/lb**
  Unavailable.

- **Processing techniques, recommended equipment**
  Although it is not necessary to remove hairs, seeds are more difficult to sow with the hairs attached. To remove, rub heads against a screen to dislodge hairs. A vacuum cleaner with nylon netting over the wand opening can be used to remove the hairs from small quantities of seed, or separate with a seed blower to bounce fluff off the seeds. Air/screen cleaners or air/gravity separators also work well to separate seeds from fluffy chaff (Holloway, 2024).

- **Storage**
  Seeds remain viable for at least 5 years when frozen (Holloway, 2024).

- **Scarification requirements**
  Unavailable.

- **Stratification requirements**
  Germination is reportedly improved through stratification by Lady Bird Johnson Wildflower Center (2023), but no details were provided and no other mention of stratification was found.

- **Germination rates and techniques**
  For outdoor propagation by seed, direct sow seeds in autumn or spring. For greenhouse propagation, press seeds gently into the propagation medium and cover lightly. Seedlings appear in 7-14 days at 70°F/21°C (Holloway, 2024).

  Another source suggested sowing seeds at 4°C for 3 weeks, then increase to 20°C (Ontario Rock Garden & Hardy Plant Society, 2023).

- **Establishment phase**
  Unavailable.

- **Active growth phase**
  Unavailable.

- **Hardening phase**
  Unavailable.

- **Harvest, storage & shipping**
  Unavailable.

VEGETATIVE PROPAGATION

- **Division**
  Plants often appear in clumps along a rhizome. They are easily divided, but growth and recovery is dependent on soil and moisture conditions and can be slow (Holloway, 2024).

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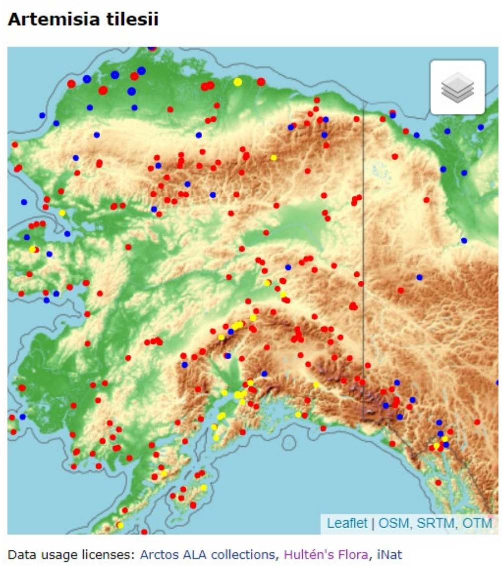
Propagation Profiles

Scientific name: *Artemisia tilesii*
Synonyms: n/a
Common name (s): Tilesius' wormwood
Family: Asteraceae
USDA PLANTS code: ARTI

Duration: Perennial
Growth habit: Forb/herb
Wetland indicator status: FACU



WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
Seeds collected from – and greenhouse propagated in – Denali National Park and Preserve (Densmore and Holmes, 1987) - USDA Zone 3b
https://www.tandfonline.com/doi/pdf/10.1080/00040851.1987.12002639

Information for the cultivar 'Caiggluk' Tilesius' wormwood developed by the Alaska Plant Materials Center (Hunt & Wright, 2007)
https://dnr.alaska.gov/ag/akpmc/pdf/plant-flyers/CaiggflukArtemisia.pdf

Habitat description:
Sandy areas, lowlands, moist to mesic meadows, streambanks and gravel bars, open forests, and rock slopes (Hultén, 1968; Klinkenberg, 2020).

Elevation range:
Lowland, montane, and alpine zones, reported up to 1845 meters in British Columbia (Klinkenberg, 2020).

Soil preferences and adaptations:
Adapted to coarse soil (USDA & NRCS, 2023). *Artemisia* spp. in general tolerate nutrient-poor soils, and prefer loose, aerated soil with good drainage. Persistently damp soils during their dormant season can lead to rotting of roots and crowns (Heger et al., 2011).

Shade tolerance:
Prefers sun, but is shade tolerant (Hunt & Wright, 2007; USDA & NRCS, 2023). In shady environments plants will become "lanky and sparse" (Heger et al., 2011).

Drought tolerance:
Low (USDA & NRCS, 2023). However, Wright & Czapla (2013) suggest high drought tolerance.

Disturbance tolerance:
Documented as one of the early colonizers of disturbed sites at drilling operations on the North Slope (McKendrick, 1987).

Community interactions:
A strong competitor (Wright & Czapla, 2013); allelopathic (USDA & NRCS, 2023).

Wildlife associations:
Provides cover and forage for birds and small mammals (Hunt & Wright, 2007).

Restoration value:
The 'Caiggluk' germplasm developed by the Alaska Plant Materials Center is noted as an excellent tool for revegetation of sandy, disturbed sites. It tolerates a pH range of 2-9, making it a good candidate for mine site reclamation and bioremediation (Hunt & Wright, 2007). The species is also known to tolerate petroleum hydrocarbon mixtures, atmospheric acidity, polluted areas, and may neutralize acid rain (Adams & Hutchinson, 1984; Freedman, 1990; Hunt & Wright, 2007).

Containerized seedlings of *A. tilesii* planted in alpine and sub-alpine zones showed 93-100% survival rate after one season among all treatments (variable amendments and watering regimes; Densmore & Holmes, 1987).

Primary reproductive mode:
Seed. Can also be propagated by cuttings (USDA & NRCS, 2023).

Seed type:
No information was available for *A. tilesii*, however the subspecies, *A. tilesii* ssp. *elatior*, is orthodox (SER, INSR, RBGK, 2023).

Ease of growing:
Easy to grow (Hunt & Wright, 2007). Propagation from 'Caiggluk' germplasm seed should result in seed-producing plants in 2 years (Hunt & Wright, 2007).

SEED

- **Collection recommendations**
  Seed of *A. tilesii* matures late in the season and can be easily shattered by fall weather (Carter, 2014).

Propagation Profiles

- **Seeds per/lb**
  Mean seed weight of 0.25 grams; 5,296,666 seeds per pound (SER, INSR, RBGK, 2023; USDA & NRCS, 2023).

- **Processing techniques, recommended equipment**
  Unavailable.

- **Storage**
  A. tilesii ssp. *elatior* is reported to maintain 100% viability after 159 days at -20°C and drying to moisture contents in equilibrium with 15% relative humidity (SER, INSR, RBGK, 2023)**.**

- **Scarification requirements**
  Not required.

- **Stratification requirements**
  In their greenhouse propagation for Denali National Park revegetation study, Densmore and Holmes (1987) cold stratified wild-collected seeds for 60 days and achieved successful germination. However, other sources suggest seeds don't exhibit dormancy and don't need stratification .

- **Germination rates and techniques**
  Denali National Park seeds were successfully germinated in petri dishes on lab tissue paper moistened with distilled water, under an alternating cycle of 16 hours light at 25°C/8 hours dark at 10°C (Densmore & Holmes, 1987).

  The Society for Ecological Restoration reports germination in 1% agar under an 8/16 photoperiod yielded 100% success in 35 days. Baskin and Baskin (2002) report germination at 28°C. Two other trials report 70-74% germination over 28 days under a 8/16 photoperiod at 15-20°C (SER, INSR, RBGK, 2023).

  Plant into a sterile, moist growing medium; germinate at 60-65°F and do not cover as seeds require light for germination. Seedlings should emerge in 30 days (Heger et al., 2011). For field planting, seed at ¼" depth via broadcast seeding or light raking into soil (Carter, 2014)

- **Establishment phase**
  Unavailable.

- **Active growth phase**
  Unavailable.

- **Hardening phase**
  In Densmore and Holmes's (1987) Denali greenhouse propagation, germinated seedlings were transferred to book-style containers filled with a sterilized peat/silt/sand growing medium, and moved outside one month prior to field planting.

- **Harvest, storage & shipping**
  Unavailable.

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Created 2024, Kelly Sivy
Last updated: n/a

Homer Soil & Water
CONSERVATION DISTRICT

Propagation Profiles

Scientific name: *Aruncus dioicus*
Synonyms: n/a
Common name (s): bride's feathers
Family: Rosaceae
USDA PLANTS code: ARDI8

Duration: Perennial
Growth habit: Forb/herb
Wetland indicator status: UPL

WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
Susitna Valley, Alaska (Moore & Ross, 2004) - USDA Zone 3b-5a
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=rosaceae-aruncus-2870

Habitat description:
Streamsides, meadows, riparian, white spruce-paper birch woodlands (Hultén, 1968; Moore & Ross, 2004).

Elevation range:
British Columbia populations occur up to 2750 meters, average of plants surveyed occurred 700-800 meters (Klinkenberg, 2020). Flora of North America describes elevation range of 10-1500 meters.

Soil preferences and adaptations:
Average to acidic (pH <6.8), nitrogen rich; although wetland status lists this plant as an upland species, it is indicated as growing in mesic to hydric conditions (Klinkenberg, 2020; Lady Bird Johnson Wildflower Center, 2023).

Shade tolerance:
Tolerates shade to full sun depending on latitude and temperature; in northern range *A. dioicus* can thrive in full sun, whereas more southern populations do better with more shade (Charnon, 2024; Lady Bird Johnson Wildflower Center, 2023).

Drought tolerance:
Low.

Disturbance tolerance:
Tolerant of seasonal flooding and commonly found near ephemeral waterways (Klinkenberg, 2020; Lady Bird Johnson Wildflower Center, 2023).

Community interactions:
Unavailable.

Wildlife associations:
Unavailable.

Restoration value:
Unavailable.

Primary reproductive mode:
Seeds, but can also be propagated by root divisions (Lady Bird Johnson Wildflower Center, 2023).

Seed type:
Orthodox (SER, INSR, RBGK, 2023).

Ease of growing:
May be difficult to sprout from seed (Holloway, 2024). Easily transplanted.

SEED

- **Collection recommendations**
  Male and female flowers are on separate plants (Holloway, 2024). Seeds develop only on female plants and ripen approximately one month after blooming (Lady Bird Johnson Wildflower Center, 2023). The fruit is a tiny follicle that opens at the top; harvest follicles when seed heads begin to turn brown. Shake the feathery heads onto paper to see if seeds are being released. Take care to harvest before follicles become too dry as seeds are more easily lost (Holloway, 2024).

- **Seeds per/lb**
  Mean seed weight per 1000 seed is 0.10 grams (SER, INSR, RBGK, 2023).

- **Processing techniques, recommended equipment**
  Dry entire seed heads on screens with a tray placed underneath to collect seeds (Holloway, 2024).

- **Storage**
  Seeds retain 100% viability after drying to moisture contents in equilibrium with 15% relative humidity and freezing at -20°C for 115 days (SER, INSR, RBGK, 2023). Holloway (2024) indicates that seeds may remain viable for 3 years or more when frozen.

- **Scarification requirements**
  Tests in European populations found no improvement to germination (see germination rates and techniques below).

- **Stratification requirements**
  See germination rates and techniques section.

- **Germination rates and techniques**
  Moore and Ross (2004) reported germination >80% after 6 weeks, when processed as follows: "Cold-stored seed is washed in running water for 24 hours. After washing, the seed is fall-sown in 10.5 in^3 Spencer-Lemaire rootrainers with a well-drained upland soil mix. These are stored in a cooler exposed to outside winter temperatures. In the spring, the trays are moved to the greenhouse for germination. Total time for cold moist stratification is 5 months."

  Holloway (2024) advises:
  "Direct sow in autumn, but results are not great – seeds are tiny and get lost easily or washed away. You can sometimes find seedlings beneath female plants that can be dug and re-planted. Cold stratify seeds 30 - 60 days (2-4°C). Sprinkle seeds onto the sterile potting mix. Do not cover. Germinate at 55 - 65°F (13-18°C). Germination begins in 7-10 days at 25/10°C or 21°C (70°F) with 16 hours of light during the warm period, but may take 2-8 weeks. Not always successful."

  Germination trials on Italian populations of *A. diocius* were conducted to determine optimum requirements for the purposes of cultivation. Among 6 accessions they determined that 2°C cold stratification returned significant improvements to germination rate and time: a 45-day cold stratification resulted in 90.1% germination in 7.7 days. Neither chemical nor mechanical scarification were found to improve germination. They additionally determined that cold stratified seeds did not germinate in the dark, and an artificial light was necessary to break dormancy (Gianni, 2019).

  A recent study of seed priming on seed from Korea populations found that pre-treating seed with polyethylene glycol (PEG) for 24 hours resulted in a 1.9-fold increase in percent germination, compared to untreated seeds. Seeds were air dried after priming and germinated in petri dishes under a 16-hour photoperiod at 25°C and 60% humidity (Kim et al., 2022).

- **Establishment phase**
  Known for slow growth and establishment during first several years.

- **Active growth phase**
  Unavailable.

- **Hardening phase**
  Move trays from greenhouse in June (Moore & Ross, 2004).

- **Harvest, storage & shipping**
  Unavailable.

Propagation Profiles

VEGETATIVE PROPAGATION

- **Division**
  As a clump-forming plant with rhizomes, plants may be propagated by division. Holloway (2024) recommends dividing in the spring, right as new growth is initiating. “Can be a tangled mess, so prune off top before dividing.”

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Propagation Profiles

Scientific name: *Betula papyrifera* var. *kenaica*
Synonyms: *B. kenaica, B. neoalaskana* var. *kenaica*
Common name (s): Kenai birch
Family: Betulaceae
USDA PLANTS code: BEPAK

Duration: Perennial
Growth habit: Tree
Wetland indicator status: FACU

Information on this variety is lacking. Where noted, information for *B. papyrifera* is provided.

WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
Seeds collected near Tyonek, Alaska - USDA Zone 5a, germinated in Durham, NC - USDA Zone 8a Densmore (1979)

Glacier National Park, MT - USDA Zone 5a (Luna et al., 2008)
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=betulaceae-betula-42

Habitat description:
Birches are pioneer species in boreal ecosystems. They thrive in open areas of disturbed sites and tend to occur on cool, moist aspects (Uchytil, 1991). *B. papyrifera* var. *kenaica* occurs in subalpine habitat often among alders or at the edge of treeless tundra (Hultén, 1968).

Elevation range:
Sea level to 300 meters (Flora of North America, 1993).

Soil preferences and adaptations:
B. papyrifera will grow on gravel, silt, bog and peat soils, with preference to well-drained sandy loam, or sandy or silty soils characteristic of glacial deposits (Rose et al., 1998; Uchytil, 1991). The variety *kenaica* prefers moist and well-drained sites but can tolerate heavy clay. Also tolerates nutritionally poor soils (PFAF).

Shade tolerance:
Low (PFAF); shade intolerant (Uchytil, 1991).

Created 2024, Kelly Sivy
Last updated: n/a

Homer Soil & Water
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Drought tolerance:
High (Smreciu et al., 2013).

Disturbance tolerance:
The tendency of *B. papyrifera* to readily regenerate and colonize after clearcutting and fires, wind, drought, avalanche and mild salinity indicates a high tolerance for disturbances (Smreciu et al., 2013; Uchytil, 1991). The high moisture content of birch canopies makes it one of the least flammable trees (Uchytil, 1991). Though regularly used for restoration of disturbed sites, *B. papyrifera* can be rapidly shaded out by shade-tolerant tree species (Uchytil, 1991). Direct seeding may not be advised on mine reclamation sites with compromised soils (heavy metals or low soil pH), or sites with air pollution, as these factors can inhibit germination of some birch species (Brinkman, 1974).

Community interactions:
In other parts of its continental range, leaf litter can inhibit germination of certain pine species (Uchytil, 1991).

Wildlife associations:
B. papyrifera provides important winter forage for moose, it is also regularly consumed by snowshoe hares, porcupines, and other small mammals and birds (Uchytil, 1991).

Restoration value:
B. papyrifera is regularly used in revegetation, soil stabilization and mine reclamation, as well as being a desirable tree for landscaping (Uchytil, 1991).

Primary reproductive mode:
B. papyrifera can be propagated by seed and vegetatively through grafting, air layering, tissue cultures and cuttings (Uchytil, 1991).

Seed type:
Orthodox (SER, INSR, RBGK, 2023).

Ease of growing:
In revegetation programs, transplanting 2 year old stock or use of containerized plants (as opposed to direct seeding) is recommended (Uchytil, 1991).

SEED

- **Collection recommendations**
  In general, *B. papyrifera* produces abundant seed every other year, starting when trees mature to 15 years of age, with peak seed production from 40-70 years old (Uchytil, 1991). Seeds are wind dispersed, with peak viability co-occurring with peak seed crop years. Flowering occurs in May-June, with seed dispersal initiating August-September into November (Bjorkbom, 1971; Viereck & Little, 1972). Early dispersed seeds are considered more likely to have low seed quality (Karrfalt, 2008). Birch species hybridize easily, so keep in mind when identifying stands for seed harvest (Karrfalt, 2008).

Both male and female catkins occur near tips of branchlets, on the same tree, and fruits are drooping strobiles with many scales that enclose a small winged seed (Rose et al., 1998). Ripe strobiles shatter easily, so pick or strip drooping strobiles when they are still green and will hold together, and place directly into bags (Karrfalt, 2008). Luna et al. (2008) report the majority of seed shed to occur from September to November, in Glacier National Park, MT; collection is done Sept-Oct "when catkins have turned papery but are still somewhat green and holding together." Luna et al. (2008) report spreading a canvas tarp beneath trees and using a pole pruner to cut branches with catkins and let them fall onto tarp; seeds are then swept from tarp into paper bags and stored in a shed to dry before further processing.

- **Seeds per/lb**
  610,000-4,120,000 seeds per pound (Brinkman, 1974; Karrfalt, 2008).

- **Processing techniques, recommended equipment**
  Dry strobiles until they begin to disintegrate (may take up to several weeks), then flail and shake to shatter (Rose et al., 1998). Heat can be safely applied to fresh, green strobiles, but keeping humidity low can facilitate seed release at temperatures ranging from -14 to 16°C (Karrfalt, 2008).

  Use screens or fanning to separate, (eg, for paper birch 3.2mm round hole screen); an indent cylinder can be used to remove stems; a column blower or specific gravity table can further "upgrade the seedlot" (Karrfalt, 2008).

  Luna et al. (2008) report extracting seeds by tumbling catkins and then running through screens, noting that empty seeds were difficult to sort from filled seeds.

- **Storage**
  Hermetic storage at -25° to 3°C is recommended with seeds dried to 1-3% moisture content (SER, INSR, RBGK, 2023). In general birch seeds store best at 2.2-3°C (Karrfalt, 2008). Seeds of paper birch will keep at room temperature 1.5-2 years provided they are dried to 1-5% moisture content, higher moisture contents can reduce germination capacity unless seeds are frozen (Brinkman, 1974). Seeds of paper birch have been kept as long as 15 years at 5-9% at 8°C (Karrfalt, 2008). Luna et al. (2008) stored seed for 1 year in sealed containers at 1-3°C.

- **Scarification requirements**
  Not required.

- **Stratification requirements**
  Stratification is a known requirement for germination of *Betula* spp. – regardless of ecoregion – to maximize germination speed and rate; photoperiod during germination can be introduced to shorten the stratification requirement, depending on species (Karrfalt, 2008). Cold stratification of 30-60 days is recommended for northern seedlots to achieve germination of 60% or more (Holloway, 1985; Smreciu et al., 2013). Karrfalt (2008) advises stratification at 2-3°C.

  For Alaska populations, germination is sensitive to photoperiod and temperature, of which both dependencies can be manipulated through cold stratification (Densmore, 1979). Germination of unstratified seed was highest with long day (22 hours light/2 hours dark) photoperiods, provided temperature was 15-25°C; for shorter days (13 hrs light/11 hours dark), germination rates were highest only at warmer temperatures (20-25°C) (Densmore, 1979). Stratification (74 days) removed this sensitivity of *B. papyrifera* to photoperiod and temperature, with seeds reaching 88-100% germination, irrespective of photoperiod, over a wide range of temperatures (5-25°C) (Densmore, 1979).

Testing a seed lot can help determine light requirements and prechilling conditions to maximize germination (Karrfalt, 2008). In general, northern seed populations seem to tolerate a wider range of germination temperatures, with longer stratification periods likely to increase light sensitivity during germination (Bevington, 1986).

- **Germination rates and techniques**

  Holloway (1985) advises cold stratification for 60 days at 4°C and germinate at 10-25°C; alternatively, fall sow or germinate on filter paper or sand at 21-24°C and under continuous light. Mineral and mixed mineral organic soils are best for germination; however, humus provides a better medium for seedling survival (Uchytil, 1991). Shade is important for germination as seeds are sensitive to moisture and temperature (Uchytil, 1991).

  Sow in late summer or fall, or cold stratify 4-8 weeks and sow in spring (Rose et al., 1998). Cover seeds lightly with 3 mm of soil, or no covering at all provided there is adequate irrigation (Brinkman, 1974; Karrfalt, 2008). Keep seedlings shaded for 2-3 months during the first summer (Karrfalt, 2008). Seedlings are sensitive to use of herbicide and insecticide (Karrfalt, 2008).

  Luna et al. (2008) soaked seed in water for 24 hrs, followed by a 60-day cold moist stratification. Seed was then placed in fine mesh bags and buried in moistened milled sphagnum peat moss and stored in a refrigerator at 1-3°C. They report 47-87% germination with this method. Seeds were then directly surface sown into 172 mL cone-tainers filled with a growing medium comprised of 6:1:1 milled sphagnum peat, perlite, and vermiculite. Within each cone-tainer, the growing medium was mixed with 1 gram Osmocote controlled release fertilizer (13N:13P2O5:13K2O; 8 to 9 month release rate at 21°C) and 0.20 gram Micromax fertilizer (12%S, 0.1%B, 0.5%Cu, 12%Fe, 2.5%Mn, 0.05%Mo, 1%Zn).

- **Establishment phase**

  Luna et al. (2008) report a 4 week total establishment period. They describe "uniform" germination over a period of 3 weeks, with true leaves appearing at 2 weeks, upon which seedlings were thinned.

- **Active growth phase**

  Luna et al. (2008) report a 16 week active growth period, during which seedlings grew rapidly. They fertilized growing plants with 100 ppm of 20-20-20 liquid NPK. After 16 weeks, plants were potted up into 3L containers.

- **Hardening phase**

  Luna et al. (2008) report fertilizing plants for a 4 week hardening period in fall with a 10-20-20 liquid NPK at 200 ppm, leaching pots with clear water, and one final irrigation prior to overwintering. Protocols compiled for use in Alberta suggest that plants may be overwintered for use in spring or early fall (Smreciu et al., 2013).

- **Harvest, storage & shipping**
  Tend in greenhouse for 16 weeks prior to outplanting, or harvest after growing period of 120 days (Smreciu et al., 2013). Luna et al. (2008) report total time to harvest as 8 months. For overwintering plants, Luna et al. (2008) left in an outdoor nursery under foam insulation covers and snow.

VEGETATIVE PROPAGATION

- **Cuttings –** *B. papyrifera* can be propagated vegetatively through grafting, air layering, tissue cultures and cuttings (Uchytil, 1991). For cuttings, Rose et al. (1998) advises harvesting when shoots are still active, and base of cutting is just starting to be firm; nodal cuttings 15-20 cm long are preferable. Inspect cuttings for terminal buds, if they are visible, then poor rooting is likely (Rose et al., 1998). Dip cutting in 8000 ppm IBA talc rooting hormone, and plant in peat-sand mixture. Transplant cuttings into pots only once rooted; long, warm dry days with good air circulation are best (Rose et al., 1998). Cuttings from older trees are less vigorous in sprouting (Uchytil, 1991). For collections in Montana, Luna et al. (2008) advises harvesting semi-hardwood cuttings in summer, as timing with active growth period is critical to ensure development of a terminal bud. They report high rooting success with harvested cuttings, 10-20 cm in length and with a "long shallow wound at the base," treated with 8000 ppm IBA talc rooting hormone, with bottom heat and mist.

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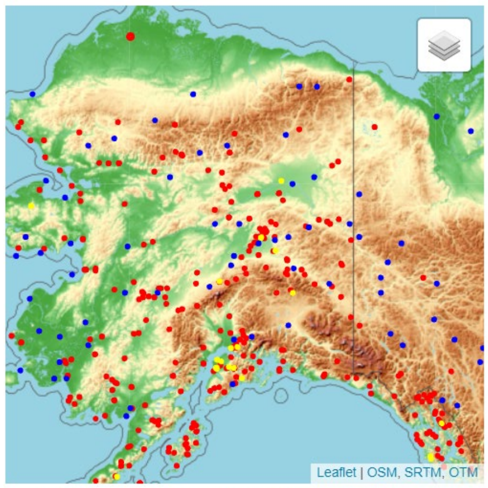
Propagation Profiles

Scientific name: *Calamagrostis canadensis*
Synonyms: n/a
Common name (s): bluejoint
Family: Poaceae
USDA PLANTS code: CACA4

Duration: Perennial
Growth habit: Graminoid
Wetland indicator status: FAC

Calamagrostis canadensis



Data usage licenses: Arctos ALA collections, Hultén's Flora, iNat

WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
'Sourdough' cultivar, developed and described by the Alaska Plant Materials Center in Palmer, Alaska (Hunt and Wright 2007)
https://dnr.alaska.gov/ag/akpmc/pdf/plant-flyers/SourdoughBluejoint.pdf

Bulkley Valley, Northwestern British Columbia (Burton & Burton, 2003) - USDA Zone equivalent 4b
https://www.for.gov.bc.ca/hfd/library/documents/bib107640.pdf

Seed collected from Rocky Mountains, western WY and propagated in Aberdeen, Idaho (Tilley, 2010) - USDA Zone 5b
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=poaceae-calamagrostis-3865

Habitat description:
Throughout its range, *C. canadensis* occurs in meadows, open woods, and wet areas such as bogs, thickets, swamps, and lake margins (Darris, 2006). Throughout Alaska, occurs in meadows and wet areas (Hultén, 1968).

Elevation range:
Sea level to 2,420 meters (Klinkenberg, 2020).

Soil preferences and adaptations:
Adapted to fine and medium soils, with high $CaCO_3$ tolerance (USDA & NRCS, 2023). It can be found growing in highly organic peat and clay and tolerates a broad range of soil pH (3.5-8). *C. canadensis*

tolerates fresh to brackish water and thrives in moist to saturated soils, provided they are not water-logged. Can tolerate standing water associated with spring flooding (Darris, 2006; Wynia, 2006).

Shade tolerance:
Shade tolerant to shade intolerant (Burton & Burton, 2003; USDA & NRCS, 2023).

Drought tolerance:
The USDA Plants Database reports low drought tolerance; however, populations throughout British Columbia are reported to be drought tolerant once established (Burton & Burton, 2003; USDA & NRCS, 2023).

Disturbance tolerance:
C. canadensis can form dense stands after fire or clear-cut disturbances, and has rebounded after oil spills (Tesky, 1992; Wynia, 2006). As high value forage to livestock, *C. canadensis* is sensitive to being overgrazed, and unfertilized stands do not tolerate heavy grazing (Klebesadel & Laughlin, 1964; Tesky, 1992; Wynia, 2006).

Community interactions:
C. canadensis is a dominant understory species of boreal forest communities, and co-dominant species in early seral riparian and forest communities (Tesky, 1992). It can become weedy and persistent in some areas, including cranberry bogs and agricultural fields in Alaska, and may suppress woody plants and inhibit seedling establishment of conifers, in particular white spruce (*Picea glauca*) (Darris, 2006; Helm, 1995; Wynia, 2006).

Wildlife associations:
Provides forage and cover for small mammals and birds. Early season growth provides palatable forage for livestock and wildlife (Klebesadel & Laughlin, 1964; Quinlan & Cuccarese, 2004).

Restoration value:
C. canadensis has creeping underground rhizomes that facilitate binding of soil, and is commonly used for wetland restoration, and stabilization of streambanks and shorelines (Darris, 2006; Tesky, 1992). *C. canadensis* is an especially good candidate for restoration of high gradient streams subject to seasonal flooding (Burton & Burton, 2003). This cold hardy grass has rhizomes that are tolerant of low soil temperatures, which can be advantageous for revegetation of cold sites (Hardy BBT Limited, 1989; Hunt & Wright, 2007). It will quickly colonize areas that have been disturbed by fire or logging (Darris, 2006), and has been known to colonize oil spill sites (Hardy BBT Limited, 1989; Tesky, 1992).

The 'Soughdough' cultivar developed by Alaska Plant Materials Center in Palmer is a result of combining 30+ collections made throughout the state (Hunt & Wright, 2007). It is not recommended as a monoculture (Hunt & Wright, 2007); a number of case studies featuring its use in seed mixes for revegetation projects is described by (Wright & Czapla, 2013).

Primary reproductive mode:
Propagated by seed, sprigs and rhizomes (Tesky, 1992; USDA & NRCS, 2023).

Seed type:
Unavailable.
Ease of growing:

C. canadensis is an aggressive colonizer and can dominate plant communities (Hunt & Wright, 2007). Monitor carefully, as it can become invasive in some areas, but can be controlled with glyphosate and hexazinone herbicide, especially when applied during late stages (Wynia, 2006). Seed is expensive, so it may be more economical to establish stands by rhizome for large projects, especially in northern ecosystems (Burton & Burton, 2003; Darris, 2006; Wright & Hunt, 2008). Densmore et al. (2000) report mixed/poor results for in-situ revegetation in Denali National Park by direct seeding, and vigorous growth in areas revegetated by transplants (Densmore et al., 2000).

SEED

- **Collection recommendations**
  C. canadensis flowers in late June-July, with seeds maturing by August (Darris, 2006). Flowering is prolific in wetlands and areas of recent disturbances (Tesky, 1992). Seeds are wind dispersed and can remain viable for 5-7 years in the soil (Darris, 2006). Seed heads, 4-10 inches long, show a purplish color when they start emerging; color later transitions to tan (Klebesadel & Laughlin, 1964). Ripe seeds will be hard and brown (Tilley, 2010). Burton and Burton (2003) point out that because of this species' tendency to form dense, pure stands, opportunities for wild seed harvest are good. Collect before seeds shatter. On wet sites, collect pannicles by hand cutting with shears or a hand scythe; a combine may be used for drier sites (Tilley, 2010; Wynia, 2006).

  Burton and Burton (2003) advise harvesting with a hand sickle or clippers; dry seeds in the sun or inside in a warm, dry environment. For seed harvested from cultivated stands, laying plastic between rows can help mitigate seed loss during harvest. Seed may also be harvested with the use of a seed stripper fitted with a soft-threaded harvesting head or a combine/thresher can be used set to 1548 rpm and 5 mm gap (Burton & Burton, 2003).

- **Seeds per/lb**
  3,837,472 seed per pound (USDA & NRCS, 2023).

- **Processing techniques, recommended equipment**
  Seed can be difficult to clean. Tufts of hair, attached to lemma bracts, can be cleaned by threshing panicles with a hammermill, or with use of a debearder to remove the basal hairs; any loss of hulls in the process is not important to germination (Darris, 2006; Wynia, 2006).

  Burton and Burton (2003) report cleaning seed with a rotary flail, if seed is harvested with long stalks intact. A fanning mill is then used for subsequent cleaning, set to 4 x 19 mm slot prescreen, 4.98 mm round top, and a blank bottom; manually clear any seed that has balled together (Burton & Burton, 2003).

  Tilley (2010) report air drying seed for several weeks in paper bags. Before processing:
  "Seed is removed from stem using a hammer mill with a 0.6 cm (0.25 in) screen. Seed is cleaned using an airscreen cleaner with a 1.55 mm screen and light air. Purities of over 95% are typical…A kerosene heater "pop test" is used for quick estimates of seed fill. Lots with poor viability are re-cleaned with increased air" (Tilley et al 2010).

Barner (2009) describes the seed cleaning process for a 0.85 pound seed lot harvested near Boise, Idaho:
"Seed lot is first processed using a Westrup Model LA-H laboratory brush machine, with a #14 mantel with pins, (to move material along and prevent clogging), at a speed of 3, to remove seed from stems and de-awn. Seeds are then finished by air-screening, to remove chaff and inert material, using an office Clipper, with a top screen: 1st run, 1/18 round, next runs, (1/16, and 1/20 round) and a bottom screen: 50 x 50 wire mesh, low speed, and low to medium air" (Barner, 2009).

- **Storage**
Tilley (2010) reports storing seed at 10°C under relative humidity of 20-30%. Seed may retain 80% or more viability after two years of storage (Wynia, 2006). Burton and Burton (2003) report successful germination of seed that was 4-6 years old, and advise storing at 0.6-7.2°C. Experimental field trials of seed buried near Fairbanks, AK, showed total loss of seed viability by 10 years, with viability declines estimated to be 26-45% per year, depending on depth of burial; within the 10 year period, seed buried 15 cm below ground surface was estimated to have fared better than seed buried 2 cm below ground surface (Conn et al., 2006). The 'Sourdough' cultivar developed by the Alaska Plant Materials Center is reported to have long storage capacity (Hunt & Wright, 2007).

- **Scarification requirements**
Not required.

- **Stratification requirements**
No pre-treatments appear to increase germination (Wynia, 2006). Germination trials of seed collected in northern British Columbia also suggest no advantage to cold stratification, especially for seeds germinating in warmer soil (Burton & Burton, 2003).

- **Germination rates and techniques**
Germination trials in the US report 72% germination over 35 days when germinated in 1% agar under an 8/16 hour light cycle and thermocycle of 25/10°C (SER, INSR, RBGK, 2023). Germination rate of seed from Inuvik in the Northwest Territories was 90%, under 20°C temperature (Tesky, 1992). Germination capacity of British Columbia seed was highest (42.5%) when germinated under a 30/20°C thermocycle; seedlings began to emerge after 15.4 days and reached 50% potential after 22 days (Burton & Burton, 2003).

  The Alaska Plant Materials Center recommends planting seed of the 'Sourdough' cultivar between May 20-and July 10 in Southcentral Alaska; seed planted outside of this window can have poor germination rates or be subject to fungus or winter kill (Hunt & Wright, 2007).

- **Establishment phase**
Tilley (2010) reports planting seed into an unfertilized growing medium mix of 1:1:1 coconut fiber, compost, and perlite; seed not covered, but is lightly pressed into medium to ensure seed to soil contact. Seeds were watered with overhead mister 2 minutes/hour from 9am – 5pm for 30 days, with grow lights on at night. Greenhouse temperatures ranged from 32-43°C during the day and 30°C at night (Tilley, 2010). Seedling emergence occurred after 3-5 days, with full stands in 12 days.

Burton and Burton (2003) advise that for field planting, plant seeds in spring into a weed-free site, with moist to saturated (but not inundated) soil.

- **Active growth phase**
  Tilley (2010) reports a 3 month active growth phase, during which plants were fertilized once/week with Miracle Grow 15-30-15 All Purpose Plant Food, with irrigation increased to 3 minutes/hour, and no nighttime grow lights.

  For field plantings, annual fertilization may promote stand establishment, but may not be necessary given this species' tendency for long term persistence (Burton & Burton, 2003).

- **Hardening phase**
  To harden, Tilley (2010) reports removing supplemental greenhouse heat and discontinuing watering for 3 days before plants are shipped.

- **Harvest, storage & shipping**
  Unavailable.

VEGETATIVE PROPAGATION

C. canadensis may establish best by rhizome, which may be more economical for large revegetation projects in northern ecosystems (Burton & Burton, 2003; Darris, 2006; Wright & Hunt, 2008). It is also mentioned as a good candidate for revegetation in the form of grass rolls (Walter et al., 2005).

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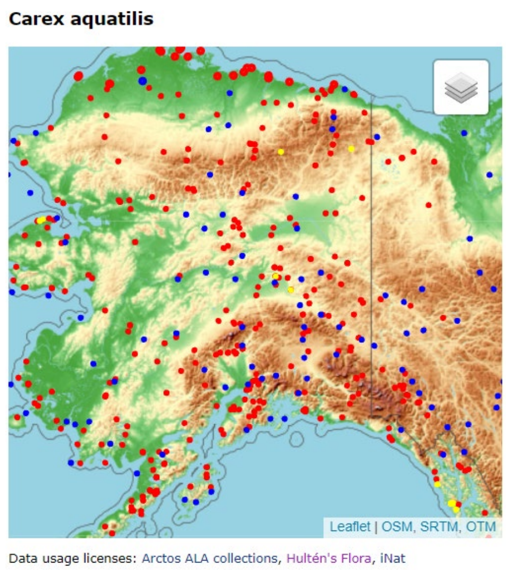
Propagation Profiles

Wynia, R. (2006). Plant Guide for Bluejoint Reedgrass Calamagrostis canadensis (NRCS Plant Guide). USDA NRCS Plant Materials Center

Propagation Profiles

Scientific name: *Carex aquatilis*
Synonyms: n/a
Common name (s): water sedge
Family: Cyperaceae
USDA PLANTS code: CAAQ

Duration: Perennial
Growth habit: Graminoid
Wetland indicator status: OBL



WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
Seed collected from bogs and marshes throughout Alaska, germinated at Alaska Plant Materials Center (Moore & Hunt, 2003) - USDA Zone 4b
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=cyperaceae-carex-2753

Aberdeen, Idaho (Tilley et al., 2011) - USDA Zone 5b
https://plants.usda.gov/DocumentLibrary/plantguide/pdf/pg_caaq.pdf

Habitat description:
Mountains, arctic and subarctic habitats (Hauser, 2006). Shallow water, marshes, bogs, floodplains, ponds, and lakes (Hultén, 1968).

Elevation range:
Sea level to alpine habitats; up to 1,800 feet in Alaska (Hauser, 2006; Tande & Lipkin, 2003).

Soil preferences and adaptations:
Cold, moist soils; fine to sandy (Hauser, 2006).

Shade tolerance:
Intolerant (USDA & NRCS, 2023).

Drought tolerance:
Low (USDA & NRCS, 2023).

Created 2024, Kelly Sivy
Last updated: n/a

Homer Soil & Water
CONSERVATION DISTRICT

Disturbance tolerance:
High – thrives on disturbed sites (Hauser, 2006).

Community interactions:
Unavailable.

Wildlife associations:
This sedge is an important component of wetland communities, especially in shallow streams and lentic habitats. It's an important source of forage for waterfowl, small mammals, musk ox, and caribou, particularly in arctic Alaska (Tande & Lipkin, 2003).

Restoration value:
Carex aquatilis is documented as a pioneer species in areas of thermokarst and floodplains in Alaska (Cargill & Chapin, 1987). Due to its rhizomatous growth, it's also an excellent candidate for restoration of disturbed sites and stabilization of streambanks (Hauser, 2006). It has been a successful component in tundra restoration efforts using "tundra sodding," a practice based on indigenous traditional ecological knowledge (Cater et al., 2015).

Primary reproductive mode:
Asexual. Sod-forming clonal plant with complex rhizomatous growth patterns comprised of spreading and clumping rhizomes; reproduction by seed is infrequent and only occurs during "favorable years," with a small proportion of plants within a population producing viable seeds (Hauser, 2006).

Seed type:
Orthodox (probable). Known to form long-term persistent soil seed banks, with seeds remaining viable 5 years or more; however, because the upper time limit to longevity has yet to be empirically documented this species has been conservatively classified as "Orthodox (probable)," meaning "better than likely, but not absolutely certain" (SER, INSR, RBGK Seed Information Database, 2023).

Ease of growing:
In the wild, *C. aquatilis* primarily reproduces from rhizomes and rarely reproduces from seeds, which are produced irregularly only during favorable years (Hauser, 2006; Tilley et al., 2011). Germination and pre-treatment success may be highly dependent on location (Holloway et al., 2013).

SEED

- **Collection recommendations**
  Holloway (2024) writes:
  "Plants are monoecious with multiple flower spikes, the terminal spike is staminate; lower spikes are pistillate and seed bearing. Individual spikes may be composed of >50 flowers. Wind pollination is essential. Fruits are achenes with a single seed surrounded by a perigynium (inflated sac). This covering is thought to be involved in the light requirement in seed germination.

  Fruiting heads are ripe just before shattering, and seeds are brown and hard (Moore & Hunt, 2003). Hand strip multiple heads or clip multiple heads when they turn from green to tan to brown; green seeds do not loosen from the head easily and will not germinate (Holloway, 2024). Moore and Hunt (2003) recommend collecting seed with gloved hands, as stems are sharp; collectors should take care when harvesting to avoid perigynia smut (fungal disease). Seeds can also be collected by cutting the fruiting heads from stems with shears or hand scythe (Moore & Hunt, 2003; Tilley et al., 2011). Place heads or stalks into a paper bag then onto screens to dry for a few days and allow seeds to be more easily removed.

Seed maturity can be assessed by crushing a seed sample to test for firmness. Yields from wild-harvested seed heads are less than 50 seeds/per head (Holloway et al., 2013).

- **Seeds per/lb**
  The Idaho Plant Materials Center reports 450,000 seeds/lb when the perigynium is left intact, and 900,000 seeds/lb when the perigynium is removed (Tilley et al., 2011).

- **Processing techniques, recommended equipment**
  Use screens or air/screen separators to remove and clean seeds (Holloway, 2024). Air dry seed for several weeks prior to processing. Remove seed from stem using a hammer mill with 0.6 cm (0.25 in) screen. Seed can be pre-cleaned with a small-lot air screen cleaner with a 1.80 mm (0.07 in) screen to remove stems and other debris. The perigynium is then removed from the seed using a corrugated rubbing board or hammer mill and then re-cleaned with a 1.55 mm (0.06 in) screen and light air. Seed can also be cleaned by hand, or with brush cleaner, or sandpaper box; take care not to damage seed when removing perigynia (Hoag et al., 2001; Moore & Hunt, 2003; Tilley et al., 2011).

- **Storage**
  Store seeds in freezer until processing (Tilley et al., 2011).

- **Scarification requirements**
  There was no effect on germination with either gibberellic acid or potassium nitrate under constant temperatures (Holloway et al., 2013). No other scarification recommendations are available.

- **Stratification requirements**
  Both light and temperature are critical for germination (Holloway, 2024). Seeds germinate readily with 30-day cold moist stratification; however, trials from the Idaho PMC suggest that this may not be necessary at high temperatures and high moisture levels (Tilley et al., 2011). Koropchak (2010) determined the best stratification treatment among greenhouse propagation treatments in Northern Alberta was to store seeds moist at 4°C for 30 days (Koropchak, 2010).

  Moore and Hunt's (2003) Alaska-specific protocol includes the following cold stratification:
  "Pack cloth bags with 1 gram of seed/bag and run cold water over them for 24 hours. Sandwich bags between layers of wet peat, or plant directly into standard no-hole flats of 18 3x3" cells with obligate soil mixture. Over winter seeds in a cooler (not turned on) to simulate sheltered cold moist stratification."

  Alternatively, wet pre-chilled seed in distilled water and sphagnum moss mixture and leave in a cooler for 30 days at 34-38°F (Hoag et al., 2001).

- **Germination rates and techniques**
  Germination rates of seeds generally ranges from 20-60% (Hauser, 2006). Controlled experiments of wild seed harvested at Prudhoe Bay, Alaska, suggested the most important factor influencing successful germination of either fresh or stored seed was exposure to light and alternating temperatures; exposure to 25/13°C for 15/9hr cycles were optimal germination conditions (Holloway et al., 2013).

  Holloway (2024) further writes:
  "Optimum germination in containers involves 25/10°C, 18/6 hrs temperatures with light being provided during the high temperature. The perigynium can be removed with difficulty, and that relieves the requirement for light, but it is easier just to add light. Outdoors, press seeds onto a moist, peaty substrate, and do not cover. Keep moist. Some growers make raised beds with plastic liners to emulate wetland conditions, then spread seeds on the surface. Indoors, seeds may be sown on an acid/peaty substrate (watch out for fungus gnats). Some seed lots benefit from up to 6 months cold stratification (4°C, 40°F) before sowing, but it is not always necessary. Try without cold stratification first."

  The Alaska Plant Materials Center advises bringing seeds that have overwintered in peat sandwiches into the greenhouse in spring, planting them into cells filled with obligate soil mixture, and then placing them either in the greenhouse or planting them directly onto outside coir mats topped with obligate soil mix (Moore & Hunt, 2003).

  Koropchak's Alberta greenhouse study documented the most effective germination treatment of 4 tested was to plant seeds just below the substrate surface and maintain water levels at 1 cm below the substrate surface; however, only 9% of all sown seeds germinated (Koropchak, 2010).

  The Idaho PMC attained germination rates of 90-100% in 12 days with the following germination protocol:
  "For 10 in^3 containers, place 5-25 seeds on the soil surface and press the seed in or good seed-to-soil contact. Seed should not be covered with any soil or sand but kept moist with an overhead mist irrigation schedule of 2 minutes/hr from 9:00 to 5:00 pm for the first 30 days. Day time greenhouse temperatures range from 32 to 43°C (90 to 110°F). Nighttime temperatures average around 30° C (85° F). Grow lights are kept on during nighttime hours. First emergence occurs around 5 to 7 days after planting" (Tilley et al., 2011).

- **Establishment phase**
  During establishment, the Alaska PMC suggests using fishy peat as the peat source in an obligate soil mix and fertilizing with organic compost tea; or fertilizing with non-organic fertilizer if a soilless mixture is used (Moore & Hunt, 2003).

  The Idaho PMC advises to keep soil well saturated in up to 1-2 inches of standing water, until plants are established and approximately 12" tall; they suggest it may be possible to manipulate speed of establishment and extent of rhizome spread by fluctuating water levels (Tilley et al., 2011).

- **Active growth phase**
  The Alaska PMC suggests moving cells to a lath-house once temperatures outside remain above freezing, and planting *C. aquatilis* plugs before plants get root-bound. If plants become root-bound, it is advised to tease roots apart upon planting (Moore & Hunt, 2003).

  When planting in wetlands, plant at 15, 30 or 60 cm (0.5, 1.0, or 2.0 ft) spacing for uniform ground cover in 1, 2, and 3 years, respectively. Seedlings may also be planted by hand or use a dibble to plant into moist soil or standing water (Tilley et al., 2011).

- **Hardening phase**
  Unavailable.

- **Harvest, storage & shipping**
  Unavailable.

VEGETATIVE PROPAGATION

- **Division**
  Holloway (2024) writes: "Water sedge produces thin rhizomes that can spread widely in wet, peaty soils in their native wetlands. Propagation by rhizomes is fast and easy as long as there are vegetative buds or shoots already present. Bare rhizomes don't work."

- **Tundra sodding**
  This is an Inupiaq method of effectively revegetating disturbed wetland sites in the Arctic using transplanted sod consisting of *Carex aquatilis* and *Eriophorum angustifolium* (Cater et al., 2015). Sod can be harvested with serrated knives, or a sharpened steel disc (1m diameter) referred to as "nuna ulu"(land knife), mounted to an excavator bucket and rolled through tundra at a depth of 0.5 meter. Sod blocks can then be removed in layers with an excavator bucket or front-end loader. Harvest when soils have thawed to depths of 20-50 cm to remove sod blocks up to 60 cm in depth. Sod blocks can be broken up with serrated knives to facilitate transfer by a single person, keeping in mind that thicker pieces will minimize root shock. Sod can then be placed side by side in transplant area (Cater et al., 2015).

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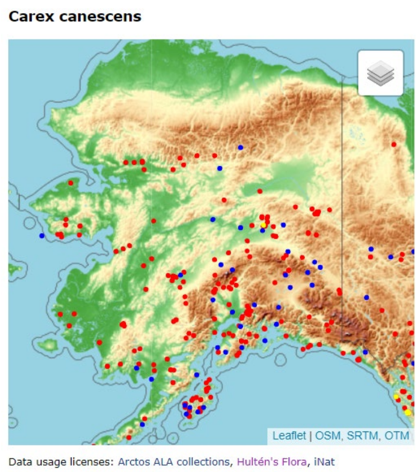
Propagation Profiles

Scientific name: *Carex canescens*
Synonyms: n/a
Common name (s): silvery sedge
Family: Cyperaceae
USDA PLANTS code: CACA11

Duration: Perennial
Growth habit: Graminoid
Wetland indicator status: FACW



Webb & Ickert-Bond, 2022

Nearest propagation protocol:
Lexington, KY (Baskin, 2003) - USDA Zone 7a
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=cyperaceae-carex-2502

Habitat description:
Carex canescens occurs in neutral to acidic conditions, including *Sphagnum* bogs and swamps (Hultén, 1968; Tande & Lipkin, 2003), but also in fens, wet meadows, streambanks, lake shores, and ditches (Hultén, 1968).

Elevation range:
Found up to 2200 meters (Klinkenberg, 2020).

Soil preferences and adaptations:
Coarse to medium soils (USDA & NRCS, 2023).

Shade tolerance:
Intermediate (USDA & NRCS, 2023).

Drought tolerance:
Intolerant (USDA & NRCS, 2023).

Disturbance tolerance:
Unavailable.

Community interactions:
Unavailable.

Created 2024, Kelly Sivy
Last updated: n/a

Homer Soil & Water
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Wildlife associations:
No information is available for this species. However, in general, *Carex* spp. are an important source of forage and cover for waterfowl, small mammals, musk ox, and caribou in Alaska (Tande & Lipkin, 2003).

Restoration value:
Carex canescens regularly occurs in disturbed habitats (e.g., ditches, wet clearings), but its restoration/ reclamation potential has not been formally investigated (Tande & Lipkin, 2003).

Primary reproductive mode:
Propagated by bare root, seed, and sprigs (USDA & NRCS, 2023).

Seed type:
Orthodox. Seeds remain 100% viable after drying to equilibrium moisture content at under 15% relative humidity, then storing at -20°C for 1 month (SER, INSR, RBGK, 2023).

Ease of growing:
Unavailable.

SEED

- **Collection recommendations**
  Holloway (2024) provides these guidelines for sedges, in general:
  "Hand strip multiple heads or clip multiple heads when they turn from green to tan to brown. Green seeds do not loosen from the head easily and will not germinate. Place heads or stalks into a paper bag then onto screens to dry for a few days and allow seeds to be more easily removed."

- **Seeds per/lb**
  Unavailable.

- **Processing techniques, recommended equipment**
  Seeds may be processed and cleaned with screens or an air/screen separator (Holloway, 2024).

- **Storage**
  No information available for this species. However, protocols for other sedge species advise to store seed in freezer until ready to process (Tilley et al., 2011).

- **Scarification requirements**
  Unavailable.

- **Stratification requirements**
  Cold stratification is required (USDA & NRCS, 2023). Experiments strongly indicate that *Carex* spp. in general require light and stratification for highest germination. Germination rate and probability of germination of *C. canescens* was found to be significantly higher following a 6-month cold stratification at 4°C, under a 12 hour light cycle, compared to unstratified seeds and unstratified seed germinated in the dark (Schütz & Rave, 1999). Seeds at University of Kentucky,

Lexington, were cold stratified for 30 days (Baskin, 2003). In a germination study among northern European seed populations, there was no relationship between winter severity at seed origin and length of cold stratification required; beyond 30 days, cold stratification had little additional effect on germination regardless of seed source (Schütz et al., 1997).

- **Germination rates and techniques**
  Germinate seeds under exposure to light and alternating temperature, e.g. 20/10°C (Baskin, 2003). Few North American protocols were available for this species, but may be similar to other *Carex* spp.

  In Northern European populations, a thermocycle of 22/10°C resulted in the highest germination rate (93-97%) across all seed storage conditions and treatments tested (Schütz et al., 1997). In a subsequent study, average germination under a 12-hour light cycle and across all temperatures tested (10-30°C) yield 81% for cold stratified seed; by contrast, fresh seed had a germination rate of 18% (Schütz & Rave, 1999).

- **Establishment phase**
  Unavailable.

- **Active growth phase**
  Unavailable.

- **Hardening phase**
  Unavailable.

- **Harvest, storage & shipping**
  Unavailable.

VEGETATIVE PROPAGATION

- **Division**
  Unavailable.

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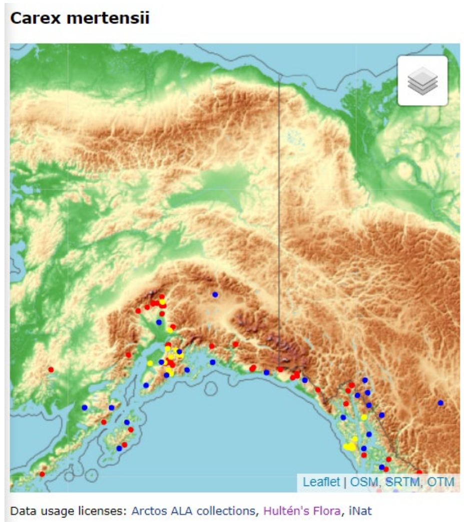
Propagation Profiles

Scientific name: *Carex mertensii*
Synonyms: n/a
Common name (s): Merten's sedge
Family: Cyperaceae
USDA PLANTS code: CAME6

Duration: Perennial
Growth habit: Graminoid
Wetland indicator status: FACW



WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
Collected from Hatcher Pass and cultivated at the Palmer PMC – Zones 4b-5a (Moore & Hunt, 2003)
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=cyperaceae-carex-2757

Bulkley Valley, Northern Interior British Columbia – USDA Zone equivalent 4a-5b (Burton & Burton, 2003)
https://www.for.gov.bc.ca/hfd/library/documents/bib107640.pdf

Seeds from Mount Rainier National Park, WA – USDA Zone: 7a-b; propagated at Corvallis, OR - USDA Zone 8b (Flessner & Trindle, 2003)
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=cyperaceae-carex-2369

Habitat description:
Moist to wet meadows, forest openings, streambanks, and rocky slopes; and in disturbed areas including trails and roadsides (Burton & Burton, 2003; Hultén, 1968; Tande & Lipkin, 2003).

Elevation range:
Lowlands to montane, but not into the alpine (Hultén, 1968; Moore & Hunt, 2003).

Soil preferences and adaptations:
Medium to coarse loamy and/or moist soils; coastal populations likely to inhabit moist, nitrogen rich soils (Burton & Burton, 2003; USDA & NRCS, 2023).

Shade tolerance:
High (USDA & NRCS, 2023).

Created 2024, Kelly Sivy
Last updated: n/a

Homer Soil & Water
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Drought tolerance:
Medium (USDA & NRCS, 2023).

Disturbance tolerance:
High fire tolerance (USDA & NRCS, 2023).

Community interactions:
Unavailable.

Wildlife associations:
No information is available for this species. However, in general, *Carex* spp. are an important source of forage and cover for waterfowl, small mammals, musk ox, and caribou in Alaska (Tande & Lipkin, 2003).

Restoration value:
Carex mertensii is widely used in native ornamental gardening, has been used for reclamation in the Pacific Northwest, and may have soil stabilization/revegetation potential for disturbed sites in Alaska, especially at mid-elevations (Tande & Lipkin, 2003). Burton and Burton (2003) report that it is an especially good candidate for high elevation revegetation of seepage sites and moist meadows.

Primary reproductive mode:
Propagated by bare root, seed, and sprigs (USDA & NRCS, 2023).

Seed type:
Orthodox (SER, INSR, RBGK, 2023).

Ease of growing:
Due to complex seed dormancy requirements, Burton and Burton (2003) advise greenhouse propagation followed by outplanting of plugs as the most effective method; for direct seeding they advise planting in fall.

SEED

- **Collection recommendations**
  Holloway (2024) provides these guidelines for sedges, in general:
  "Hand strip multiple heads or clip multiple heads when they turn from green to tan to brown. Green seeds do not loosen from the head easily and will not germinate. Place heads or stalks into a paper bag then onto screens to dry for a few days and allow seeds to be more easily removed."

  Moore and Hunt (2003) report collecting seeds by hand from Hatcher Pass from late August through September, once seeds are brown and have begun to shatter. In interior British Columbia, Burton and Burton (2003) harvested seed with well-sharpened hand clippers or sickles, as seeds are easily dislodged by movement of seed heads on thick rigid stalks. They recommend holding seed heads over bins or bags to reduce seed loss while clipping.

Propagation Profiles

- **Seeds per/lb**
  Moore and Hunt (2003) report 1,800 seeds per gram, from their Hatcher Pass collection. Harvests in Northern British Columbia report yields of 1,555 seeds per gram (Burton & Burton, 2003).

- **Processing techniques, recommended equipment**
  Air dry seeds, brush clean, and separate, followed by hand screening (Moore & Hunt, 2003). Flessner and Trindle (2003) report that chaff can irritate skin and eyes, and recommend the use of gloves, goggles, and dust masks when cleaning large quantities of seed.

  For processing with combine/thresher, Burton and Burton (2003) suggest the following:
  "Hold stalks and put seed heads into a rotary flail." For cleaning, run seeds through a fanning mill after threshing. Run the first time with a 4x19 mm slot pre-screen, 2.5 x 19 mm slot top screen, 1.8 x 12.7 mm bottom screen. On the second run, fit with a 1.8 x 12.7 mm slot prescreen 2.5 x 19 mm slot-shaped top screen, and no bottom screen. Separate seed with low speed and low suction to remove final particulates."

  Alternatively, Flessner and Trindle (2003) describe processing seed as follows:
  "Dried seed heads very chaffy; if whole heads are collected seed can be threshed using a geared-down hammermill with 1/16" screen; run through an oat dehuller one or more times; then through an office clipper with #8 top screen, 1/20" round bottom screen, medium air flow."

- **Storage**
  Burton and Burton (2003) report that seeds retain viability following 2 years of cool, dry storage. Flessner and Trindle (2003) report successful storage of seeds for a few years in dry conditions at 40°F. The SER seed information database reports 100% viability of seeds after drying to moisture content equilibrium with 15% relative humidity and freezing at -20°C for 1.2 years (SER, INSR, RBGK, 2023).

- **Scarification requirements**
  Unavailable.

- **Stratification requirements**
  Germination experiments strongly indicate that *Carex* spp. in general require light and stratification for highest germination (Holloway, 2024). Although some growers report germination without stratification, Burton and Burton (2003) report that seeds may respond to stratification when planting at low soil temperatures.

- **Germination rates and techniques**
  Moore and Hunt (2003) washed seeds prior to planting in cold running water for 12 hours. Seeds were planted in the greenhouse in spring, 1-2 seeds per cell in a root trainer. Seeds were covered lightly with sifted soil. Moore and Hunt report germination 15 to 30 days after planting, when the greenhouse was maintained at warm, moist conditions.

  Burton and Burton (2003), working with seed harvested from Northern British Columbia, report that in germination trials the highest rates of germination (87.2%) were for stratified seed exposed to 25°C/15°C thermocycle. They report 22.9 days to first germination with 50% of seeds germinating after 37.5 days. Suggested planting depth is 0.6-1.2 cm; suggested row spacing for direct seeding is 75-120 cm for dryland and 30-90 cm where well irrigated.

Flessner and Trindle (2003) direct-seeded in a fine, weed-free seedbed. Growing area was prepared as follows:
"Our best results were obtained by carbon-banding. In this method, seed was sown in spring with a Hege precision seeder, at 30 " rows, 100 seeds / ft row; overspraying the seed with an activated charcoal slurry (carbon-banding) followed by a field application of Karmex broad spectrum pre-emergent herbicide at 2.2 lbs ai/acre"

- **Establishment phase**
  Flessner and Trindle (2003) report irrigating May through July of the first year along with weed control by means of hand hoe, shallow rototilling between rows, and use of Round Up herbicide.

- **Active growth phase**
  Flessner and Trindle (2003) observed active growth from April to June; for their outplantings, weed control in early spring was important to reduce competition from other grasses and forbs. They applied ammonium nitrate at a rate of 25 lbs/acre in late winter, along with 3 applications of Tilt fungicide between March and May prior to flowering and seed set, to control rust.

  Burton and Burton (2003) also mention the importance of using selective herbicide to control weeds. They used the selective herbicide Banvel™ (dicamba) which minimized impacts to plant growth and did not affect seed yield. They also implemented annual fertilization with low nitrogen formulations to extend the life of the plot, and used Tilt fungicide to control rust.

- **Hardening phase**
  To harden, Moore and Hunt (2003) relocated plants to a lath-house after the final spring frost, with minimal fertilization after true leaves emerged.

- **Harvest, storage & shipping**
  Flessner and Trindle (2003) report that, for cultivated plants, seeds are ready to harvest by summer of the 2nd year. They harvest by clipping seed heads into bags or bins. Because seed drops easily, the use of vacuums or strippers is not necessary for small plots; however, if mechanical means are employed in cultivated fields, lay plastic between rows to capture scattered seed (Burton & Burton, 2003; Flessner & Trindle, 2003). Spread seed on tarps in a warm, dry poly greenhouse to dry.

VEGETATIVE PROPAGATION

- **Division**
  Unavailable.

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USDA & NRCS. (2023). *The PLANTS Database*. National Plant Data Team, United States Department of Agriculture, National Resources Conservation Service. https://plants.usda.gov/

Webb, C., & Ickert-Bond, S. (2022). *Alaska Flora Quick Maps, <https://alaskaflora.org/qm/>, using data from Hultén, E. (1968) Flora of Alaska and Neighboring Territories, <https://arctos.database.museum/> and <https://www.inaturalist.org/>, a product of US NSF grant 1759964* [dataset].

Propagation Profiles

Scientific name: *Carex pachystachya*
Synonyms: *C. festiva*, *C. macloviana*, *C. multimoda*, *C. pyrophila*
Common name (s): chamisso sedge
Family: Cyperaceae
USDA PLANTS code: CAPA14

Duration: Perennial
Growth habit: Graminoid
Wetland indicator status: FAC

Note: This species is listed by Hultén (1968) as ***Carex macloviana*** d'Urv. subsp. ***pachystachya*** (Cham.) Hult., and lists as a synonym ***Carex pachystachya*** Cham. Both [Panarctic flora] and the provisional Flora of Alaska (FoA) [checklist] recognize the former as a synonym and the latter as the accepted name. Hultén also lists ***Carex pyrophila*** Gandoger. as a synonym, but neither Panarctic flora, nor the FoA checklist address this nomenclature. Based on recognition by these sources, we include information documented by Canadian researchers Burton and Burton (2003) for the species they recognize as ***Carex macloviana*** d'Urv. The remaining information herein represents literature searched specific to *C. pachystachya*, unless otherwise noted in text.
Additionally, the [USDA Plants Database] acknowledges there are also varieties of *C. pachystachya*, but these are treated as synonyms to their parent species.

WEBB & ICKERT-BOND, 2022

Hultén (1968) reports ***Carex macloviana*** d'Urv. subsp. ***pachystachya*** (Cham.) Hult. from southcentral, eastern interior, and southeastern Alaska, and along the Kodiak and Aleutian archipelagos west to Unalaska.

Nearest propagation protocol:
Seed sourced from Mount Rainier and Crater Lake National Park – USDA Zones 6a-7b; protocol developed at the Corvallis, OR, Plant Materials Center – USDA Zone 8b (Flessner & Trindle, 2003)
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=cyperaceae-carex-2394

Protocol developed at the Corvallis, OR, Plant Materials Center – USDA Zone 8b (Bartow, 2015)
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=cyperaceae-carex-4019

British Columbia – USDA Zones equivalent 4a-5b; developed for *C. macloviana* (Burton & Burton, 2003)
https://www.for.gov.bc.ca/hfd/library/documents/bib107640.pdf

Created 2024, Kelly Sivy
Last updated: n/a

Homer Soil & Water
CONSERVATION DISTRICT

Propagation Profiles

Habitat description:
Meadows and gravelly shores (Hultén, 1968).

Elevation range:
All elevations.

Soil preferences and adaptations:
Fine to medium soils; *C. macloviana* also observed to do well in compact or clay rich soil (Burton and Burton 2003).

Shade tolerance:
High (USDA & NRCS, 2023).

Drought tolerance:
High (USDA & NRCS, 2023).

Disturbance tolerance:
High fire tolerance (USDA & NRCS, 2023).

Community interactions:
Unavailable.

Wildlife associations:
No information is available for this species. However, in general, *Carex* spp. are an important source of forage and cover for waterfowl, small mammals, musk ox, and caribou in Alaska (Tande & Lipkin, 2003).

Restoration value:
Unavailable.

Primary reproductive mode:
Propagated by bare root, seed, and sprigs (USDA & NRCS, 2023).

Seed type:
Carex macloviana is described as "uncertain" and *Carex pachystachya* is unlisted (SER, INSR, RBGK, 2023).

Ease of growing:
Flessner and Trindle (2003) note that seedlings readily establish in containers for plug production. Burton and Burton (2003) write that *C. macloviana* germinated readily with good emergence in field trials, though plants may take 2-3 years to establish.

SEED

- **Collection recommendations**
  Holloway (2024) provides these guidelines for sedges, in general:

"Hand strip multiple heads or clip multiple heads when they turn from green to tan to brown. Green seeds do not loosen from the head easily and will not germinate. Place heads or stalks into a paper bag then onto screens to dry for a few days and allow seeds to be more easily removed."

Bartow (2015) recommends collecting seed heads from wild stands individually, as they often grow in large patches among other native sedge species. Seed can be hand-stripped once heads mature to dark brown and begin to shatter. Alternatively, entire seed heads can be clipped beginning at the hard-dough stage and stored in cloth bags out of direct sunlight to air dry (Flessner & Trindle, 2003). If using clippers, ensure they are sharpened to cut through the hard stalk and minimize seed loss, as seeds are easily dislodged when ripe (Burton & Burton, 2003).

- **Seeds per/lb**
  Bartow (2015) reports 750-800,000 seeds per pound for uncleaned seed, and Flessner & Trindle (2003) report up to 1,375,000 seeds per pound for dehulled collections. For *C. macloviana,* Burton and Burton (2003) report 1,991 seeds per gram (~900,000 seeds per pound).

- **Processing techniques, recommended equipment**
  Flessner and Trindle (2003) provide the following notes on seed processing:
  "Hulls are easily removed by running through an oat dehuller. Threshing with a geared-down hammermill and 3/16" screen worked well; followed by a rough scalping with office clipper 1/14" screen, low air - then seed run briefly through a lab-scale oat dehuller and rescreened with office clipper using a 1/20" screen and moderately low air flow. Also, any smutted seeds can be scalped off with the proper screen size."

  If a seed stripper is used, Burton and Burton (2003) recommend placing plastic between rows to capture scattered seeds. If a combine/thresher is used, they recommend operating at 1548 rpm with a 4 mm gap. They advise that seed stalks are of insufficient length to use rotary flail. After threshing, their seed cleaning process is described as follows:
  "Run through a fanning mill twice. For the first run, use the following screen configuration: prescreen 4.89 mm round; top screen 2.83 mm square; bottom screen 0.5 mm square. For the second run, use these screens: prescreen 2.36 mm square; top screen 2.83 mm square; bottom screen 0.5 mm square. Then use a vacuum separator with speed and suction set to medium to remove dust and <5% of seeds."

- **Storage**
  Seed should remain viable for at least 5 years. Seed hulls are thought to contain germination inhibitors, which may also facilitate long term storage (Link, 1993). Flessner and Trindle (2003) describe informal germination trials of 2, 4, and 5 year old seed lots; the 4 and 5 year old seed lots germinated at approximately half the rate of 2 year seed lots, but at rates "still satisfactory for seeding containers." Seedling vigor, however, was not observed to vary by seed age. Similarly, Burton and Burton (2003) also observed declining germination for seed lots older than 2 years.

- **Scarification requirements**
  Unavailable.

- **Stratification requirements**
  Germination experiments strongly indicate that *Carex* spp. in general require light and stratification for highest germination (Holloway, 2024). Bartow (2015) reports that *C. pachystachya* seed from Oregon populations benefited from a minimum of 6 weeks cold moist stratification prior to spring germination.

  For *C. macloviana* populations in Northwestern British Columbia, Burton and Burton (2003) did not find stratification to be beneficial in germination trials.

- **Germination rates and techniques**
  Bartow (2015) describes germination techniques for *C. pachystachya* Oregon seed source as follows:
  "Sow seed in containers and place in a cooler (45°F or lower) for at least six weeks. Alternately [*sic*], containers can be placed outside in early September through December for six weeks. After a cold period, move containers to a greenhouse set between 70 and 80°F in late December. Seeds should germinate within 2–4 weeks if they receive heat, light, and water."

  Dehulling was found to increase germination from 14% to 84% (Flessner & Trindle, 2003). They achieved best results sowing in fall with carbon-banding, a process they describe as follows:
  "Seed was sown into a finely tilled, firm seed bed with a Hege precision seeder, at 30" rows, 100 seeds/ ft row; overspraying the seed with an activated charcoal slurry (carbon-banding) followed by a field application of Karmex broad spectrum pre-emergent herbicide at 2.2 lbs ai/ acre."

  Germination trials of *C. macloviana* by Burton and Burton (2003) showed 66-69% germination of untreated seeds when exposed to a 25/15°C alternating temperature. Seedling emergence was observed at 25 days with 50% potential reached after 41.5 days. Stratified seeds germinated at similar or reduced rates.

  For direct seeding of *C. macloviana* plots, Burton and Burton (2003) recommend a seeding depth of 0.6-1.2 cm.

- **Establishment phase**
  For field plots direct sown in the fall, Flessner and Trindle (2003) report an establishment time of about six months (i.e., over winter). During the establishment phase and prior to seedling emergence, they had success using broad-spectrum herbicide to control weeds. After seedling emergence, they controlled weeds using a combination of cultivation and spot-wicking with Round Up. For rust and disease control during this phase, they made three applications of fungicides Tilt and Bravo at label rates.

- **Active growth phase**
  Active growth occurred from March to June at the Corvallis Plant Materials Center. As soil begins to warm in spring, expect more rapid crown development. Monitor stand and control for rust, fungus, and weeds to ensure stand health (Flessner & Trindle, 2003).

- **Hardening phase**
  Unavailable.

- **Harvest, storage & shipping**
  Flessner and Trindle (2003) caution that in cultivated stands grown for seed increase, little seed is produced during the first year while plants are still establishing; seed production does not occur in harvestable quantities until the second year. Their "smaller" plots (size not given) were harvested by clipping seed heads, as is recommended for wild stands; however, they note that larger plots might be harvested mechanically. They began harvesting plots when seed was easily shaken loose from seed heads – May and early June, in Corvallis. Seed heads were clipped into barrels, transferred to a greenhouse, and spread on tarps for drying. Seeds ripened readily and could be easily collected from the tarps.

VEGETATIVE PROPAGATION

- **Division**
  Unavailable.

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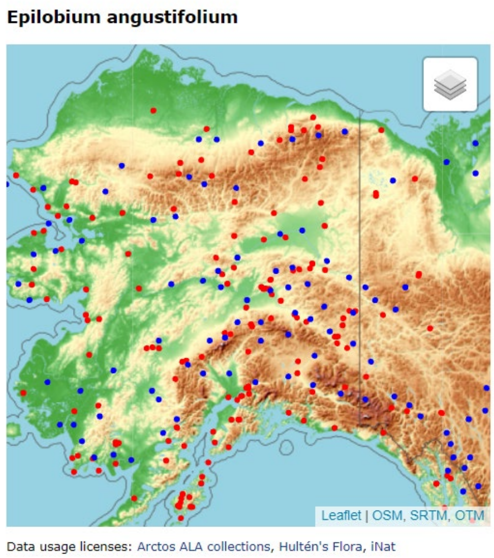
Propagation Profiles

Scientific name: *Chamerion angustifolium*
Synonyms: n/a
Common name (s): fireweed
Family: Onagraceae
USDA PLANTS code: CHAN9

Duration: Perennial
Growth habit: Forb/herb
Wetland indicator status: FACU



WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
Glacier National Park, MT - USDA Zone 5a (Luna & Dedekam, 2008)
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=onagraceae-chamerion-2912

Habitat description:
Occurs in meadows, forests, river bars, lakes and bogs, roadsides and recently burned or disturbed areas throughout Alaska (Fleenor, 2016; Hultén, 1968).

Elevation range:
Sea level to high alpine (Pavel, 1992).

Soil preferences and adaptations:
C. angustifolium grows in many soil types, including acid to neutral to alkaline soils, clays, clay-loams, and sandy loams, provided there is adequate mineral availability and soils do not become water-logged (Fleenor, 2016; Pavel, 1992). It is also found on frozen soils and thin layers of soil above permafrost (Broderick, 1990; Pavel, 1992).

Shade tolerance:
Some studies have reported shade intolerance, but others have noted that it adapts to persist in shade through reduced cover, productivity, and/or frequency (Fleenor, 2016; Pavel, 1992).

Drought tolerance:
Variable. In the southern portion of its range (lower 48) fireweed is restricted by water availability (Fleenor, 2016).

Disturbance tolerance:
C. angustifolium has high tolerance to fire and can persist and adapt to a wide spectrum of successional stages, due to its rhizomatous growth and wind dispersed seed (Fleenor, 2016). Fireweed has been recorded to naturally colonize oil spill and mine waste sites (Fleenor, 2016).

Community interactions:
An early seral species that can become weedy and displace other species where it proliferates. Abundant stands of fireweed can suppress seedling establishment of conifers (Fleenor, 2016). It commonly occurs in pioneer communities with willows (*Salix* spp.) (Pavel, 1992).

Wildlife associations:
Fireweed is a preferred forage for moose, caribou, hares, and mountain goats, and is an important flower for many pollinators including hummingbirds, butterflies, and insects (Pavel, 1992).

Restoration value:
High value in restoration and reclamation of disturbed sites, as it can germinate easily in these areas and proliferate through rhizomatous growth (Fleenor, 2016; Pavel, 1992). It has successfully colonized sites in Alaska characterized by 30 years of oil/mining disturbance (Ebersole, 1987). Can be used for soil stabilization and has been known to develop mycorrhizal associations amidst coal mine spoils (Broderick, 1990; Pavel, 1992).

Primary reproductive mode:
Propagates sexually through wind-dispersed seed, and asexually through rhizomes. The latter is the predominant reproductive method after disturbance (Pavel, 1992).

Seed type:
Most likely orthodox, as soil seed banks are known to retain viability for 1-5 years, yet maximum longevity of seed banks in soil is unknown (SER, INSR, RBGK, 2023). There is a possibility that seed surviving only shorter periods (less than 2 years) may exhibit recalcitrant or intermediate characteristics (SER, INSR, RBGK, 2023).

Ease of growing:
Densmore et al. (2000) reports successful seeding in Denali National Park when planted into "seed trap" depressions and fertilized with slow-release fertilizer and compost. Higher establishment success and vigorous growth was observed when revegetating with transplants.

SEED

- **Collection recommendations**
  Fireweed seeds are small, grey to black in color, and nestled in white hairs giving a fluffy appearance (Fleenor, 2016). The seed hairs respond to humidity to ensure dispersal into pockets of moist soil to germinate (Pavel, 1992). Each plant can have 15 or more flowers, with each flower

containing a capsule with 300-500 seeds (Pavel, 1992). Hand collect seeds in late summer, just before they begin to disperse; lower capsules will ripen and disperse earlier in the season than capsules towards the top of the plant, which ripen later in the season (Fleenore, 2016).

In Alaska, similar species *C. latifoilum* (dwarf fireweed) is hand collected in late July (Moore & Hunt, 2003).

- **Seeds per/lb**
  6,800,000 seeds per pound (Fleenor, 2016).

- **Processing techniques, recommended equipment**
  Silky hairs make it challenging to clean seed. For large seed collections, use a hammermill and air column separator; smaller batches can be manually cleaned by running achenes over a screen until pappus separates from achenes (Fleenor, 2016; Luna & Dedekam, 2008). A household kitchen blender can also be used to successfully clean fireweed seeds (Scianna, 2004). Or, for small seed lots (e.g., 0.1 pound) a laboratory brush machine may be used, fit with a #40 mantel set to medium speed to separate seeds from capsules and hairs (Barner, 2009). A series of laboratory test sieves mesh size 20, 40, and 50 is then used to remove other debris, before using an Office Clipper to air screen seed at low temperature and low air; set Office Clipper with a 40 x 40 wire top screen and 50 x 50 wire bottom screen (Barner, 2009).

- **Storage**
  Natural seed banks can lose viability within 18-24 months (Broderick, 1990; Pavel, 1992). Luna and Dedekam (2008) report storing seed in sealed containers at 1-3°C (34-37°F) for "at least a few years." Barner (2009) reports storing seed at 33-38°F.

- **Scarification requirements**
  Not required.

- **Stratification requirements**
  A 30-60 day period of cold, moist stratification at 2°C is recommended to facilitate uniform germination of Montana seed (Luna and Dedekam, 2008). For northeastern Alberta seed, no form of pre-treatment was required (Smreciu et al. 2013).

- **Germination rates and techniques**
  Seeds tolerate a wide range of temperatures during germination (Pavel, 1992). In the field, fireweed needs bare mineral soils and ample light to germinate (Lutz 1953). Seeds naturally disperse in late summer/early fall and overwinter beneath snow as rosettes or with shoot buds formed on lateral roots (Pavel, 1992).

  Trials from the United States (exact location unknown) report 100% germination within 21-56 days when germinated in 1% agar under an 8/16 light hour cycle at temperatures of 15-25°C (SER, INSR, RBGK, 2023). Trials with Central-Western Yukon seed ecotypes germinated seed in petri dishes lined with pre-moistened Whatman #2 filter paper, set in a Ziploc bag with a wet paper towel, and placed seed in a 14 and 24°C growth chamber and 200 µmol light level (Gordon, 2016). Germination rate was 60% (Gordon, 2016).

For highest germination potential, surface sow in warm, humid conditions with ample light (Broderick, 1990; Pavel, 1992); seeds should germinate within 10 days under these conditions (Fleemore, 2016). Broderick (1990) reported 100% germination of Canadian collected seed within 10 days. Smreciu et al. (2013) reports 75% germination rate of Northeastern Alberta seed.

Luna and Dedekam (2008) report germinating seeds in an automated greenhouse under a temperature cycle of 21°C day/15°C night. Seedlings were grown in 172 ml cone-tainers filled with milled sphagnum peat, perlite, and vermiculite mixed with 1 gram Osmocote controlled release fertilizer ($13N:13P_2O_5:13K_2O$; 8 to 9 month release rate at 21°C) and 0.20 gram Micromax fertilizer (12%S, 0.1%B, 0.5%Cu, 12%Fe, 2.5%Mn, 0.05%Mo, 1%Zn).

For in situ field planting, sow in early to late fall with sufficient time to germinate and grow prior to winter (Fleenor, 2016). They further advise:
"For outdoor plantings, seed should be broadcast or drilled with the drop tubes disconnected at the openers to allow seed to land on the soil surface or be only slightly buried. Seed should be mixed with other seed or a carrier, such as rice hulls, to facilitate flow through a drill."

Finally, Pinno et al.'s (2017) greenhouse germination study sought to determine which soil types characteristic of reclamation sites (peat-mineral, clay topsoil, and forest-floor mineral) were most conducive to germination. *C. angustifolium* germination was highest with a "forest floor-mineral mix," and in general required consistently high moisture levels to germinate. Biomass of seedlings was high in all reclamation soil types tested, and biomass increased positively with watering rate (Pinno et al., 2017).

- **Establishment phase**
  Luna and Dedekam (2008) report a 1-month establishment phase, during which they note that seedlings required consistently moist conditions during germination and establishment.

- **Active growth phase**
  Luna and Dedekam (2008) report a 3 month active growth phase, during which seedlings were trimmed back and watered "as needed" and allowed to dry slightly between waterings.

- **Hardening phase**
  Luna and Dedekam (2008) report moving seedlings outdoors for hardening during summer and fall months.

- **Harvest, storage & shipping**
  Luna and Dedekam (2008) report that seedlings may be outplanted during fall, or overwintered within a nursery, covered with microfoam sheets.

VEGETATIVE PROPAGATION

- **Cuttings**
  Cuttings from spring roots arising from previous years' growth can be transplanted (Fleenor, 2016). Smreciu et al. (2013) summarizes a micro-propagation method of culturing root explants

excised from sterile seedlings; browning from oxidation can be mitigated with citric or ascorbic acids.

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Propagation Profiles

Scientific name: *Dryas drummondii*
Synonyms: n/a
Common name (s): Drummond's mountain-avens
Family: Rosaceae
USDA PLANTS code: DRDR

Duration: Perennial
Growth habit: Forb/herb, shrub/subshrub
Wetland indicator status: FACU

WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
Northern Interior British Columbia (Burton & Burton, 2003) - USDA Zone equivalent 4b
https://www.for.gov.bc.ca/hfd/library/documents/bib107640.pdf

Seeds collected from Flathead River and propagated in West Glacier, Montana (Luna et al., 2008) **-** USDA Zone 5b
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=rosaceae-dryas-180

Habitat description:
Pioneer species commonly found in gravel bars, mountains, roadside and alpine areas (Burton & Burton, 2003; Hultén, 1968). In Southcentral Alaska, occurs throughout nearly all mountainous regions, including the Wrangell, Talkeetna, Alaska, Chugach, and Kenai ranges.

Elevation range:
Sea level to 1100 m (Hultén, 1968).

Soil preferences and adaptations:
Coarse textured mesic to dry soils with good drainage. Tolerant of alkaline soils. In nursery settings, this species establishes best on very sandy or gravelly, loose, moist soils, and succumbs to root rot when grown in loamy or poorly drained soils (Burton & Burton, 2003).

Created 2024, Kelly Sivy
Last updated: n/a

Shade tolerance:
Not formally investigated, but inferred to have a low shade tolerance, given habitat preferences.

Drought tolerance:
The USDA Plants Database reports low drought tolerance, but studies in Alberta suggest it to be tolerant of drought conditions (Burton & Burton, 2003; Gerling et al., 1996).

Disturbance tolerance:
Medium-high. Based on its frequent occurrence in riparian habitats, this species is likely tolerant of occasional flood disturbance, provided the site is well-drained. The USDA Plants Database reports medium fire tolerance (USDA & NRCS, 2023).

Community interactions:
Forms a symbiotic relationship with the nitrogen fixing bacteria *Frankia* spp.

Wildlife associations:
Unknown, but the USDA reports this plant as having low protein potential to grazing animals (USDA & NRCS, 2023).

Restoration value:
Dryas drummondii's role as a nitrogen-fixer and colonizer is widely documented. It's considered a good candidate for restoration of nutrient poor soils, particularly in revegetation of gravel pits and low elevation mine sites, provided there is adequate moisture (Burton & Burton, 2003). Well-developed *Dryas* mats have also been shown to retain organic matter and moisture, and to facilitate establishment of tree species (Blundon et al., 1998). It is hypothesized to serve as a nursery plant in recently deglaciated habitats and to provide early ground cover on poor sites (Chapin et al., 1994; Kohls et al., 1994).

Primary reproductive mode:
Reproduces from seed, and also through rhizomatous growth.

Seed type:
Orthodox (SER, INSR, RBGK, 2023).

Ease of growing:
Formalized germination protocols are rare, but Luna et al. (2008) report uniform germination at 50% under natural stratification conditions. Although slow to establish from seed, stands may persist for 20-30 years until shade becomes limiting (Burton & Burton, 2003). They advise propagation from seed in a greenhouse and then transplanting, as opposed to sowing outside.

SEED

- **Collection recommendations**
  For collections made in Alaska, Holloway (2024) advises "Harvest when the achenes become tan/brown and are easily pulled from the head. If immature, a lot of tugging does not release individual achenes."

Glacier National Park reports collecting seeds by hand when plumose achenes readily detach from the receptacle (mid-late August in Montana). Seeds are light tan at maturity (Luna et al., 2008). In British Columbia (Burton & Burton, 2003) seeds are collected by hand by detaching mature achenes; they also report success clipping entire stalks while still slightly green and allowing seed to mature in the sun. For stands of uniformly mature seeds, they report success harvesting with vacuums. They also note that due to abundant pure stands in their area, it may be more efficient to collect seed in the wild than from cultivated plants.

- **Seeds per/lb**
  In Glacier National Park, collections were 905,825 seeds/lb (1,997,000/kg) at 100% purity (Luna et al., 2008). They are also generally reported at 908,000 seeds/lb (USDA & NRCS, 2023).

- **Processing techniques, recommended equipment**
  Holloway (2024) recommends "Air dry on screens, then achenes can be rubbed against a screen to remove the hairs, or they can remain attached for sowing. Germination is not impacted by absence or presence of hairs."
  In Glacier National Park, seeds are cleaned by using a hammermill followed by an office clipper (Luna et al., 2008). In northern British Columbia, seeds are cleaned by running through a rethresher 12-15 times to remove the "fluff," then running the lot through a fanning mill as follows: prescreen 1.2x7.1 mm, top screen 1.8 x 12. 7mm, bottom screen blank (Burton and Burton 2003).

- **Storage**
  Glacier National Park stores seeds at 0°C and "low" humidity in sealed containers, and reports subsequent longevity of 3 to 5 years (Luna et al., 2008). Burton and Burton (2003) similarly report 3-5 year seed longevity. The Seed Information Database reports 80% viability after drying to moisture contents in equilibrium with 15% relative humidity and freezing at -20°C for 1 month (SER, INSR, RBGK, 2023).

- **Scarification requirements**
  Scarification is not required.

- **Stratification requirements**
  Unclear. In Montana, natural stratification is used (Luna et al., 2008). Stratification was not found to be beneficial for British Columbia seed populations; untreated seed was simply germinated in cooler soil (Burton & Burton, 2003).

- **Germination rates and techniques**
  Holloway (2024) recommends "Direct sow in autumn or spring. Indoors, sow onto a sandy potting mix. Press seeds, especially with attached hairs, onto the surface. Cover very lightly with vermiculite. Seedlings appear in 14-24 days (65-68°F/18-20°C). Growth is slow. Seedlings easily rot with too much water."

  Cold moist stratification for five months, outdoor, produced 50% germination at Glacier National Park; they use direct, covered seeding into "conetainers" in the fall, with natural winter stratification. Seedlings germinate uniformly in late spring when daytime temperatures reach

21°C during the day (Luna et al., 2008).

Ontario Hardy Plants recommends sowing immediately at 20°C to facilitate germination within three months. If seed has been stored, they recommend temperature cycling, but caution that germination rates may be lower and slower than with fresh seed (Ontario Rock Garden & Hardy Plant Society, 2023).

Burton and Burton (2003) report highest germination (70.3%) for untreated seed under a 25/15°C thermocycle. Time to first germination was 16.6 days, with 50% potential reached after 40.7 days. Germination in the greenhouse is advised; however, if sowing outside they recommend substrate is loose sandy or gravelly soil with good drainage and free of weeds – especially rhizomatous grasses that are difficult to target with herbicide. A light dusting of peat moss over freshly sown seed is recommended to keep seeds bedded.

- **Establishment phase**
  Establishment phase takes approximately 4 weeks and seedlings are thinned upon emergence of true leaves (Luna et al., 2008). When outplanting, a 75-120 cm row spacing is suggested for dryland conditions, reduced to 30-90 cm under irrigation.

- **Active growth phase**
  Active growth phase lasts 16 weeks; seedlings are fertilized with 20-20-20 liquid NPK at 100 ppm weekly during this period (Luna et al., 2008). Burton and Burton (2003) maintained stands with regular cultivation of rows and spot spraying of herbicide.

- **Hardening phase**
  Hardening phase lasts 4 weeks and plants are fertilized with 10-20-20 liquid NPK at 200 ppm in early fall; pots are flushed with water, irrigation is gradually reduced through September and October (Luna et al., 2008).

- **Harvest, storage & shipping**
  Plants can be harvested in September or overwintered in an outdoor nursery if insulated by foam cover and snow. For stand maintenance, an annual low nitrogen fertilizer composed of high P and K may be applied to extend life, but expect mats to die back at centers regardless (Burton & Burton, 2003). Seed production stands may require renewal every 5-7 years.

VEGETATIVE PROPAGATION

- **Cuttings**
  Softwood basal stems may be harvested in mid-summer, treated with a rooting hormone, and rooted in a propagation box or mist chamber for 6-8 weeks at 70-75°F/21-24°C (Holloway, 2024). Luna et al. (2008) also report that summer cuttings from softwood can be pre-rooted in a mist bed if treated with 1000 ppm of rooting compound.

- **Division**
  Propagation is possible through division of recumbent stems that already show summer rooting along their length, but plants should not be divided by plant crown (Holloway, 2024).

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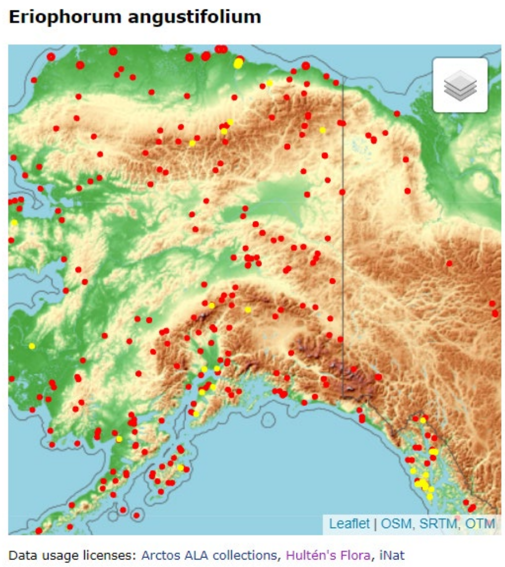
Propagation Profiles

Scientific name: *Eriophorum angustifolium*
Synonyms: n/a
Common name (s): tall cottongrass
Family: Cyperaceae
USDA PLANTS code: ERAN6

Duration: Perennial
Growth habit: Graminoid
Wetland indicator status: OBL



WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
Unavailable.

Habitat description:
Swamps, bogs, wet tundra (Hultén, 1968).

Elevation range:
In British Columbia up to 2200 meters (Klinkenberg, 2020), unspecified in Alaska populations.

Soil preferences and adaptations:
Coarse, medium, and fine soils; moist soils; also tolerant of acidic soils (USDA & NRCS, 2023).

Shade tolerance:
Shade intolerant (USDA & NRCS, 2023).

Drought tolerance:
Drought intolerant (USDA & NRCS, 2023).

Disturbance tolerance:
Flood and fire tolerant (Gebauer et al., 1995; USDA & NRCS, 2023).

Community interactions:
Unavailable.

Created 2024, Kelly Sivy
Last updated: n/a

Homer Soil & Water
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Wildlife associations:
Unavailable.

Restoration value:
Unavailable.

Primary reproductive mode:
Seeding establishment in the wild is low and the predominant reproductive method is by rhizomes (Gebauer et al., 1995).

Seed type:
Orthodox (SER, INSR, RBGK, 2023).

Ease of growing:
Unknown, but previous studies have indicated seedling establishment in the wild may be limited (McGraw & Shaver, 1982).

SEED

- **Collection recommendations**
  Holloway (2024) writes:
  "Stems have multiple flower heads each with stiff feathery bristles at the base. Flowers are hermaphroditic (male and female parts in same flower), but protogynous which means the female stigmas mature before the male anthers. Wind pollination is key, and poor wind conditions often lead to poor fruit set. Collectively, the flower heads form a fluffy white mass of 'cotton.' Achenes mature from greenish white to tan. Maturation can be uneven, and sometimes only the upper flowers develop fully mature achenes. The bristles elongate as heads mature."

  Eriophorum seed pods open early in the season, and seed maturity can be assessed by firmness, or by tugging on the bristles (Holloway et al., 2013). Harvest entire stems with multiple heads just before heads begin to fall apart and blow away (Holloway, 2024).

- **Seeds per/lb**
  160,000 seeds/lb (USDA & NRCS, 2023).

- **Processing techniques, recommended equipment**
  Removed bristles by hand or with a seed blower; seeds are tiny and are easily separated from bristles (Holloway, 2024).

- **Storage**
  Studies in England note that following 6 months of hermetic air-dry storage at 5°C, germination rates increased from 74% to 90% (Grime et al., 1981). Seeds should be frozen for long term storage. Germination percentages plummet if seeds dry out, especially after 2 years (Holloway, 2024).

- **Scarification requirements**
  None known. However, in a German study seeds failed to germinate under constant temperature after treatment with gibberellic acid or potassium nitrate (Maas, 1989). Under fluctuating temperatures, germination did occur under "low" (0.02%) solution of gibberellic acid; however, germination percent remained low (30%) compared to effect of chilling (Maas, 1989).

- **Stratification requirements**
  Although the USDA reports that *E. angustifolium* does not require cold stratification (USDA & NRCS, 2023), this may not account for northern populations. Holloway (2024) advises that for Alaska populations, cold stratify at 4°C for a minimum of 60 days, and that some have also found success with a 4 week warm stratification (18-22°C) prior to cold stratification.

- **Germination rates and techniques**
  Seeds require light to germinate and benefit from a peat-based growing medium (Bliss, 1958; Ontario Rock Garden & Hardy Plant Society, 2023).

  Holloway (2024) writes:
  "Outdoors, press achenes plus bristles into the surface of acidic, moist organic soils in late summer/autumn. Do not cover. Indoors, cold stratify at least 60 days (40°F, 4°C). Some researchers recommend a warm stratification (18-22°C (64-71°F) period of 4 weeks before the cold stratification treatment. Press seeds into the surface of the acid/peaty medium, moisten, and enclose in a plastic bag. Refrigerate (40°F, 4°C). Return container to 70°F (21°C) for germination. Percentages are often poor. Avoid lengthy drying periods during handling. If you have a wild population in a breezy area, erect a chicken wire fence at plant height so that the cottony fluff blows into the fence and gets stuck. Seeds will eventually drop to the peaty surface and germinate. Lazy, but it works!"

  European trials report germination rates of 63 and 81% under a 12/12 light cycle and 25°C/10°C thermocycle. Germination rates of 91-100% are reported under similar light conditions and warmer alternating temperatures of 33°C/19°C and 35°C/20°C (SER, INSR, RBGK, 2023). In all trials, seeds germinated in 49-98 days. In petri dish germination trials featuring wild collected seed from Germany, *E. angustifolium* had the highest germination rate (71.2%) with a 6-week 3°C chilling pretreatment and germination under fluctuating day/night temperature of a 22°C/12°C and 14 hr light/10 hr dark photoperiod (Maas, 1989).

  Seeds from Danish accessions have been successfully propagated and cultivated for ornamental use (Larsen & Ørgaard, 2013). Horticulturists describe bedding wild collected seeds in 65L containers, filled with a coarse peat growing medium with a soil pH of 4.5, sunk into a garden bed. Containers were watered 3 times per week with demineralized water; the lower third of the growing container functions as a water reservoir to keep the soil saturated (Larsen & Ørgaard, 2013). Plants reached full winter hardiness within original containers and were reported to have a long flowering season.

- **Establishment phase**
  Unavailable.

- **Active growth phase**
  Unavailable.

- **Hardening phase**
  Unavailable.

- **Harvest, storage & shipping**
  Unavailable.

VEGETATIVE PROPAGATION

- **Division**
  Holloway (2024) writes:
  > "Division of rhizomes may be done any time during the growing season. Rhizomes can be long (up to 100 cm) or clumped together and are usually unbranched. They have buds only at the tips where they turn upwards and yield a young plant. These plantlets can be severed from the mother plant and replanted. Rhizomes with no buds do not propagate."

  A research study of factors influencing growth of cottongrass was conducted using plant material collected near Toolik Field Station, Alaska. Individual tillers were cut to 25 cm length from the stem base, and cleaned of debris (e.g., leaves, soil, etc.). Tillers were planted into 3.5 L resin-impregnated paper mâché pots, filled with a 3:1 mixture of sand and peat. Pots were buried outdoors, level with tundra, to maintain root temperature consistent with natural conditions. Nitrogen additions were determined to have a stronger effect on growth and biomass, compared to phosphorous. In addition, plants were found to thrive in anaerobic soils, with biomass of all plant parts increasing, regardless of the amount of available nitrogen (Gebauer et al., 1995).

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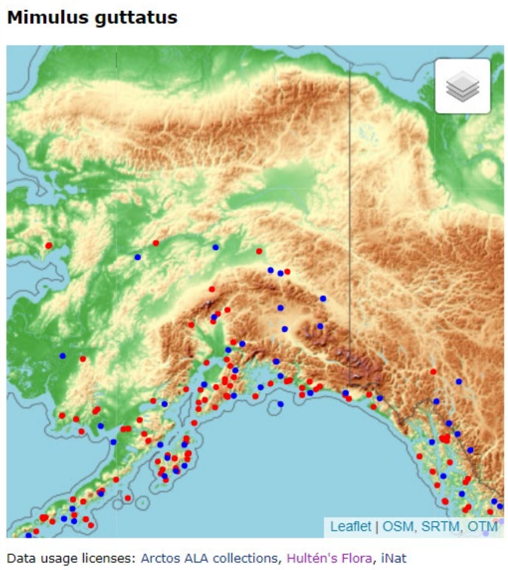
Propagation Profiles

Scientific name: *Erythranthe guttata*
Synonyms: *Mimulus guttatus; for a full list see* USDA Plants Database
Common name(s): seep monkeyflower
Family: Phrymaceae (formerly Scrophulariaceae)
USDA PLANTS code: MIGU

Duration: Annual, perennial
Growth habit: Forb/herb
Wetland indicator status: OBL

Note that *Mimulus guttatus* is still frequently referenced as the accepted name, including with the USDA Plants Database. However, recent taxonomic revision have changed both the family and genus of this plant.



WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
Seeds originating from Tonto National Forest, Arizona at 3200' processed and propagated in Bend, Oregon (Barner, 2007) - USDA Zone 6a-6b
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=scrophulariaceae-mimulus-3411

Seeds from Tennessee Valley, California, propagated in San Francisco, California (Young, 2002) - USDA Zone 10b
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=scrophulariaceae-mimulus-644

Habitat description:
Primarily coastal, ponds, streams, and wet slopes (Hultén, 1968).

Elevation range:
Up to 2200 meters in British Columbia (Klinkenberg, 2020); no information was available specific to Alaska.

Soil preferences and adaptations:
Adapted to coarse, medium, and fine soils (USDA & NRCS, 2023). Grows in moist soils with a medium tolerance for $CaCO_3$ (Lady Bird Johnson Wildflower Center, 2023).

Created 2024, Kelly Sivy
Last updated: n/a

Homer Soil & Water Conservation District

Shade tolerance:
High (USDA & NRCS, 2023).

Drought tolerance:
Low (USDA & NRCS, 2023).

Disturbance tolerance:
Unavailable.

Community interactions:
Unavailable.

Wildlife associations:
The USDA lists *E. guttata* as having low grazing/browsing value.

Restoration value:
Unavailable.

Primary reproductive mode:
Propagated by seeds and sprigs (USDA & NRCS, 2023).

Seed type:
Orthodox (SER, INSR, RBGK, 2023).

Ease of growing:
Unavailable.

SEED

- **Collection recommendations**
  Holloway (2024) writes:
  "Capsule with tiny black/brown seeds, which turn from green to brown and open at the top. Harvest entire capsules and dry on a screen that allows seeds to fall through to a tray. An air/screen cleaner will work for large quantities. Alternatively, dump seeds from mature capsules into a bag or glassine envelope. It is easy to lose large quantities of seed when capsules are fully open outdoors."

  Barner (2007) reports hand collecting 0.025 lbs of seed from Tonto National Forest, Arizona, into paper envelopes. Seeds in Tennessee Valley, California were collected between July 1st and September 30th. Mature capsules were noted to be brown in color, and seeds were described as very small and black (Young, 2002).

- **Seeds per/lb**
  The USDA Plants database describes 4,000,000 seeds/lb (USDA & NRCS, 2023). Seed collection from Arizona reported 45,360,000 seeds per pound (Barner, 2007).

- **Processing techniques, recommended equipment**
  Barner (2007) reports the following method for cleaning seed:
  "Seeds sized using Laboratory Test Sieves, mesh size 50 and 60. Lot was then air-screened using an office Clipper, with a top screen, 40 x 40 wire, and a bottom screen, blank, low speed, and low air."

  In Young's (2002) California propagation, seeds were kept dry and stored in a refrigerator (temperature not reported). Seeds were removed from the seed pods immediately before sowing.

- **Storage**
  Seeds retained 86% viability after drying to equilibrium moisture content with 15% relative humidity and freezing for 2 months at -20℃ (SER, INSR, RBGK, 2023). Some seeds remain viable for at least 5 years when frozen, although total percentages decline to 50% and lower after a few years (Holloway, 2024).

- **Scarification requirements**
  Not required.

- **Stratification requirements**
  Not required (Lady Bird Johnson Wildflower Center, 2023; USDA & NRCS, 2023).

- **Germination rates and techniques**
  Holloway (2024) writes:
  "Direct sow in moist soils. Indoors, seeds are tiny and easily lost, so use a finely milled, sterile seed starting mix. Barely cover, if at all, with fine vermiculite. Seedlings appear in 7 - 10 days (65 - 68°F, 18-20°C). Plants grow rapidly and are ready to plant outdoors in 4-6 weeks. Will bloom the first year."

  For Young's (2002) California propagation, germination trials were conducted in a controlled, indoor greenhouse. Seeds were sown on May 1st in flats by mixing in within a Sunshine Mix #4 Aggregate Plus growing medium (peat moss, perlite, major and minor nutrients, gypsum, and dolomitic lime) to achieve a light cover. Sown seeds in flats were watered with an automatic irrigation system. The seeds germinated after 15 days, germination rate was 80% (Young, 2002).

  Seeds may also be spread through broadcast seeding in spring or fall; one plant can spread widely (Lady Bird Johnson Wildflower Center, 2023).

- **Establishment phase**
  Young's (2002) trial transplanted seedlings 15 days after germination into individual 2x10" Deepot 40 tubes filled with a standard potting mix of peat moss, fir bark, perlite, and sand. Establishment took 1 month, and the transplant survival averaged 80% (Young, 2002).

- **Active growth phase**
  During active growth, Young (2002) fertilized for 3 months with Nutricote NPK (13-13-13), after which plants were pruned back to 4 nodes.

- **Hardening phase**
  Unavailable.

- **Harvest, storage & shipping**
  Cold storage, 33-38°F

VEGETATIVE PROPAGATION

- **Cuttings**
  Stem cuttings will root in water and wet potting mix (Holloway, 2024).

- **Division**
  Divide dormant rootstocks in fall or winter, or when growth begins in spring (USDA, NRCS, 2023).

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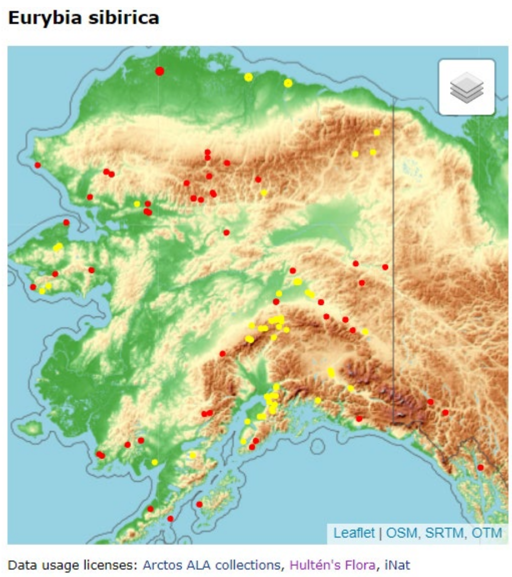
Created 2024, Kelly Sivy
Last updated: n/a

Propagation Profiles

Scientific name: *Eurybia sibirica*
Synonyms: *Aster sibiricus, A. subintergerrimus*
Common name (s): Arctic aster, Siberian aster
Family: Asteraceae
USDA PLANTS code: EUSI13

Duration: Perennial
Growth habit: Forb/herb
Wetland indicator status: FAC



WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
Collected from Logan Pass, Montana, propagated in West Glacier, Montana (Luna et al., 2008) - USDA Zone 4b and 5a
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=asteraceae-eurybia-23

Habitat description:
Rocky slopes, river flats, meadows, open areas (Hultén, 1968).

Elevation range:
Up to 1800 meters or more (Hultén, 1968).

Soil preferences and adaptations:
Adapted to well drained and dry, rocky soils (Lady Bird Johnson Wildflower Center, 2023; Luna et al., 2008).

Shade tolerance:
Low (Lady Bird Johnson Wildflower Center, 2023).

Drought tolerance:
High.

Disturbance tolerance:

Created 2024, Kelly Sivy
Last updated: n/a

Homer Soil & Water
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High (Johnson et al., 1995).

Community interactions:
Unavailable.

Wildlife associations:
For small mammals, has low forage and cover value (Quinlan & Cuccarese, 2004; USDA & NRCS, 2023).

Restoration value:
Luna et al. (2008) note that this species is a pioneer species of high-elevation disturbed habitats and is highly tolerant of sites with limited moisture and/or very well-drained soils. They describe it as "an excellent restoration species for these site conditions along roadsides and at high elevations." It is also known to respond to fire and other disturbances with "vigorous growth and profuse flowering" (Johnson et al., 1995).

Primary reproductive mode:
Mat forming; will spread asexually (via rhizomes) once established.

Seed type:
Orthodox (SER, INSR, RBGK, 2023).

Ease of growing:
Unavailable.

SEED

- **Collection recommendations**
  Seed is an achene with tufted hairs held in tight heads; achenes become mature when pappus hairs expand and heads begin to fall apart. Achenes are easily pulled from the flower head when mature (Holloway, 2024). Seeds can be collected by hand once achenes are easily separated from their receptacle; seeds will be gray when mature. Collect seeds into paper bags and store in a drying shed before cleaning and processing (Luna et al., 2008).

- **Seeds per/lb**
  2,420,000 seed per kilogram (Luna et al., 2008).

- **Processing techniques, recommended equipment**
  Seeds can be cleaned using a hammermill and office clipper (Luna et al., 2008).

- **Storage**
  Once cleaned, seeds are expected to remain viable for 3-5 years or longer (Holloway, 2024). Store at 3-5°C in sealed containers. Data from the SER-SID database describes 100% viability of seeds after drying to equilibrium moisture content and freezing at -20°C with 15% relative humidity for 3 weeks (SER, INSR, RBGK, 2023).

- **Scarification requirements**
  Unavailable.

- **Stratification requirements**
  A 5-month cold moist stratification was used to propagate seeds from Glacier National Park, but staff notes that seeds may be sown without stratification (Luna et al., 2008). Similarly, the Ontario Hardy Plant Society (2023) reports success with immediate sowing at 20°C but recommends 1-2 months of cold stratification if germination does not occur in three months.

- **Germination rates and techniques**
  Holloway (2024) writes:
  "Sow with or without hairs (can be rubbed off with a screen). Direct sow outdoors in fall or spring. Indoors, press achenes (and hairs) into the surface of a sterile potting mix. Cover lightly with vermiculite. Seedlings appear in 10-14 days, 68°F (20°C)."

  Mean germination time of seeds collected near Umiat, AK, were reported as 11 and 7 days when exposed to either continual light or continual dark conditions. Germination percent under light or dark treatment was 50 and 56%, respectively. Seeds had been air dried and cold stratified for 6-7 months at 5°F, cleaned, and bedded between moist filter paper within petri dishes held at 72°F (Bliss, 1958).

  The Ontario Hardy Plant Society recommends sowing seeds at 20°C, and if seeds do not germinate within 3 months, try stratifying at 4°C for 1-2 months, then switch back to 20°C (Ontario Rock Garden & Hardy Plant Society, 2023).

  Luna et al. (2008) reports uniform germination in 10-15 days at 22°C. For production of 800 ml plugs, propagation at their outdoor nursery facility occurred as follows: In late fall, seeds were directly sown into 172 ml cone-tainers and lightly covered with growing medium consisting of 30% sand and 70% mix of milled sphagnum peat, perlite, and vermiculite. Each cone-tainer cell was fertilized with 2 grams of Osmocote and 1 gram of Micromax. Seedlings germinated in spring under naturally fluctuating temperatures and full sun exposure. Seedlings were kept moist with an automatic irrigation system set to water in early morning until cone-tainers were leached (Luna et. al, 2008).

- **Establishment phase**
  Luna et al. (2008) report a 4-week establishment phase, and thinned seedlings once they developed true leaves (7 -15 days).

- **Active growth phase**
  Luna et al. (2008) report an 8-week active growth phase, during which plants were fertilized bi-weekly until fall season with 100 ppm of 20-20-20 NPK fertilizer. Roots and shoots were observed to develop rapidly.

- **Hardening phase**
  Luna et al. (2008) report a 4-week hardening phase, during which plants were fertilized at 200 ppm of 10-20-20 liquid NPK fertilizer. Pots were flushed with water and irrigation was tapered through September and October.

- **Harvest, storage & shipping**
  Total time to harvest including over-winter stratification was 9 months; however, accelerated production turnaround is possible with a shorter stratification period. Plants grown as bareroot or seed crops can be overwintered in an outdoor nursery under insulation foam and snow (Luna et al., 2008).

VEGETATIVE PROPAGATION

- **Cuttings**
  Plants may be propagated from rhizome cuttings made in autumn or spring, just as growth begins (Holloway, 2024).

- **Division**
  Divide in autumn or spring (Holloway, 2024).

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Propagation Profiles

Scientific name: *Geum macrophyllum*
Synonyms:
Common name (s): largeleaf avens
Family: Rosaceae
USDA PLANTS code: GEMA4

Duration: Perennial
Growth habit: Forb/herb
Wetland indicator status: FAC

WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
Bulkley Valley, northern interior British Columbia - USDA Zone equivalent 4b (Burton & Burton, 2003)
https://www.for.gov.bc.ca/hfd/library/documents/bib107640.pdf

Pullman Plant Material Center, WA - USDA Zone 6a (Skinner, 2005)
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=rosaceae-geum-2958

Glacier National Park Nursery, West Glacier, MT - USDA Zone 5a (Luna et al., 2004)
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=rosaceae-geum-185

Habitat description:
Occurs in moist forests, meadows, woods, and stream banks, from sea level to the subalpine (Burton & Burton, 2003; Hultén, 1968).

Elevation range:
Low to middle elevations (Burton & Burton, 2003).

Soil preferences and adaptations:
Adapted to coarse, medium, and fine soils with medium soil fertility required; not tolerant of salinity (USDA & NRCS, 2023). The USDA Plants database reports medium moisture use but low anaerobic tolerance, suggesting low flood tolerance. In British Columbia, it's associated with sites having fluctuating water tables and/or seepage, and prefers mineral soil; generally does best on rich sites (Burton & Burton, 2003).

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Last updated: n/a

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Shade tolerance:
The USDA reports high shade tolerance. In British Columbia it is reported to be both shade tolerant and intolerant (Burton & Burton, 2003; USDA & NRCS, 2023).

Drought tolerance:
Low (USDA & NRCS, 2023).

Disturbance tolerance:
Medium to high disturbance tolerance, with medium fire tolerance (USDA & NRCS, 2023).

Community interactions:
Unavailable.

Wildlife associations:
Possesses a unique "nectar guide," visible only under UV light, that attracts pollinators (Fertig, 2024). This plant is not known to be a palatable grazing source for mammals (Burton & Burton, 2003).

Restoration value:
Undetermined in the primary literature at this time. In Alaska has been seen to successful grow interspersed with highly invasive orange hawkweed (*Hieracium aurantiacum*), suggesting that it be strongly competitive and useful in revegetation projects (Greenstein, 2023).

Primary reproductive mode:
Propagates through rhizomes and through large seed crop (USDA & NRCS, 2023).

Seed type:
Orthodox.

Ease of growing:
Should establish quickly on moist sites with rich soil. However, because this species can be slow to establish from seed in the field, it is recommended to transplant from plugs (Burton & Burton, 2003).

SEED

- **Collection recommendations**
  Achenes are held within dry, papery flower head; hand harvest into paper bags when heads are fully dry and achenes are brown (Holloway, 2024; Luna et al., 2004; Skinner, 2005). Burton and Burton (2003) used clippers to cut leafless stalks into bins held underneath and suggest keeping seed heads aligned in the same direction. They further advise:
  > "This species holds on to its seed very well, and then its hooked appendage holds on to whatever it touches! So don't bring your dog or wear a fluffy sweater when harvesting."

- **Seeds per/lb**
  794,000 (USDA & NRCS, 2023). Burton and Burton (2003) report an average of 2,895 seeds per gram.

- **Processing techniques, recommended equipment**
  Holloway (2024) writes:
  "Dry on screens, then gently rub against screen to dislodge the seeds. May also use a hammermill to crush the heads. Aggressive rubbing/crushing will damage the seeds, so do not prolong this process. Clean in an air/screen cleaner to separate the chaff from achenes."

  Skinner (2005) reports gently rubbing achenes to dislodge seeds, and subsequent cleaning with an air column separator. Luna et al. (2004) threshed seeds using a hammermill, followed by an office clipper. Burton and Burton (2003) note that a seed stripper may be useful with a suitable harvesting head and optimal ripeness. However, they instead used a combine thresher with rotary flail, holding seed heads against the flail until seeds were removed, followed by a fanning mill with a 1.2 x 7.1 mm slot prescreen, 1.8 x 12.7 mm slot top screen, and bottom screen position blank (Burton & Burton, 2003).

- **Storage**
  The Seed Information Database reports seeds retaining 100% viability after drying to equilibrium moisture content with 15% relative humidity and freezing at -20°C for 11 weeks (SER, INSR, RBGK, 2023). Holloway (2024) reports frozen and dried seeds have a storage life of 3 years or more, retaining >50% germination. Both Luna et al. (2004) and Skinner (2005) report storing seed at room temperature in paper bags until it can be cleaned. Seed kept at 5°C in sealed containers has a longevity of 3-5 years (Luna et al. 2004).

- **Scarification requirements**
  Skinner (2005) reports that seed can be damaged by rubbing too aggressively.

- **Stratification requirements**
  Conflicting research. Burton and Burton (2003) reported that cold stratification was "detrimental" to seed germination during their trials (2 months at 5°C), and do not advise stratification. In western WA, Skinner (2005) reports significant improvement in germination with cool, moist stratification up to 60 days, whether stratified outdoors in containers or in a refrigerator. In western Montana, Luna et al. (2004) do not stratify seed, but report rapid and uniform germination that is consistent in yield and timeline with that of Skinner (2005).

- **Germination rates and techniques**
  The Society for Ecological Restoration reports 94-100% germination of seeds in 1% agar over 42 days, exposed to an 8/16 hour light cycle and 20-25°C (SER, INSR, RBGK, 2023).

  Holloway (2024) advises, for Alaska seed:

  > "Outdoors, sow in autumn. Indoors, cold stratify seeds for 60 days. Sow onto sterile seed starting mix. Cover lightly with vermiculite. Germination begins in 3 - 5 days at 21°C/70°F."

  Burton and Burton (2003) achieved strongest germination capacity (95-99%) from untreated seeds exposed to 25/15°C thermocycle. Time to first germination was 13.2 days, with 50% potential achieved after 17 days. They advise that the best germination is achieved on cool soils and a firm seedbed of loamy, well-prepared soil.

Luna et al. (2004) direct-sowed seeds into cone-tainers in the greenhouse in April; they report germination of unstratified seed within 7-10 days, reaching 90-100% germination. Greenhouse temperatures were 21-25°C day/16-18°C night and seedlings were kept inside approximately four weeks, then moved to the outdoor nursery for the rest of the growing season.

Trials at the Pullman PMC (Skinner, 2005) report that cool, moist stratification for 60 days resulted in 98% germination after 4-8 days. A 30-day stratification resulted in only 48% germination, and unstratified seed achieved the poorest results at 5%.

- **Establishment phase**

  For stand establishment outdoors Burton and Burton (2003) advise ensuring that the site is free of weeds, and in particular any rhizomatous grasses that are difficult to target with selective herbicides once young *G. macrophyllum* are establishing.

- **Active growth phase**
  Luna et al. (2004) reports an 8-week active growth phase in which plants are fertilized bi-weekly with 13-13-13 liquid NPK at 100 ppm. Similarly, Skinner (2005) reports a 2-3 month active growth phase in which plants are watered every other day and fertilized weekly with a complete, water soluble fertilizer.

- **Hardening phase**
  In Glacier National Park, plants are hardened over a 4-week period from September to October, and are then overwintered in an outdoor nursery with foam insulation. Plants were "fertilized with 10-20-20 liquid NPK at 200 ppm in early fall; pots are leached with water, irrigation is gradually reduced through September and October" (Luna et al., 2004). In Washington, plants are moved to cold frames in late March to early April (Skinner, 2005).

- **Harvest, storage & shipping**
  Skinner (2005) reports that in western Washington, *Geum macrophyllum* plants are "more susceptible than most native species to winter injury" when overwintered in containers, suggesting that some winterization will likely be necessary for any overwintered stock in Alaska.

VEGETATIVE PROPAGATION

- **Division**
  This species is rhizomatous and has been propagated by divisions of established nursery stock (Luna et al., 2004). Holloway (2024) affirms that Alaskan populations of this species can be propagated by division, in autumn or spring.

Propagation Profiles

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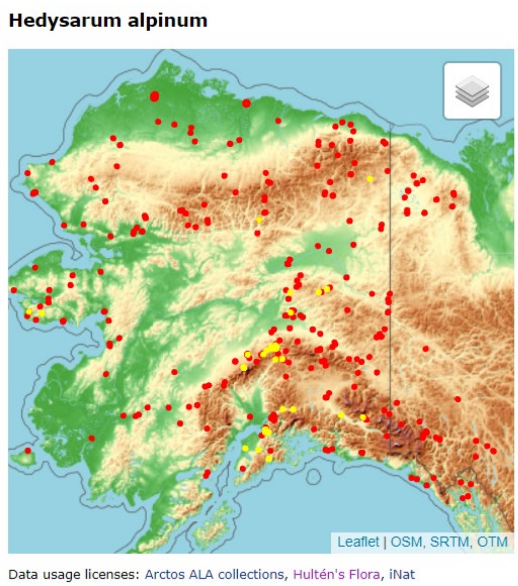
Propagation Profiles

Scientific name: *Hedysarum alpinum*
Synonyms: For the full list see [USDA Plants Database]
Common name (s): alpine sweetvetch
Family: Fabaceae
USDA PLANTS code: HEAL

Duration: Perennial
Growth habit: Forb/herb
Wetland indicator status: FACU



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Nearest propagation protocol:
Denali National Park - USDA Zone 3b (Densmore et al., 2000)
https://apps.dtic.mil/sti/pdfs/ADA396156.pdf

Alaska Plant Materials Center, Palmer, Alaska - USDA Zone 5a (Hunt & Wright, 2007)
https://dnr.alaska.gov/ag/akpmc/pdf/plant-flyers/PaxsonHedysarumalpinum.pdf

Habitat description:
Pioneer communities, rocky slopes, spruce forests, gravel bars, lakeshores, meadows, streambanks, alpine tundra (Gucker, 2007; Hultén, 1968; Klinkenberg, 2020).

Elevation range:
Sea level to 2600 meters (Klinkenberg, 2020).

Soil preferences and adaptations:
Dry to moist calcareous soil, moist to mesic gravel bars (Gucker, 2007).

Shade tolerance:
Listed as low/no shade tolerance by the USDA. However, other sources suggest shade tolerance in boreal forests (Gucker, 2007; USDA & NRCS, 2023).

Drought tolerance:
Low (USDA & NRCS, 2023).

Disturbance tolerance:
High (USDA & NRCS, 2023). Tolerates floods, sediment deposition, and ice scars inherent to riparian areas. An early pioneer species on recently disturbed sites (Gucker, 2007).

Community interactions:
Unavailable.

Wildlife associations:
Provides important forage for bears (black and grizzly), Dall sheep, caribou, and moose. Provides nesting habitat for small mammals and birds (Gucker, 2007).

Restoration value:
High. Gucker (2007) describes studies indicating multiple contexts whereby alpine sweetvetch will readily colonize as a pioneer species, including floodplains, north slope gravel pads, mining sites, and logging roads. Densmore advises transplanting greenhouse propagated seedlings for use in sites dominated by gravel fill, as opposed to direct seeding.

Primary reproductive mode:
Seeds and rhizomes.

Seed type:
Orthodox (SER, INSR, RBGK, 2023).

Ease of growing:
This species is reported to be a good candidate for direct seeding as part of a legume/grass seed mix applied to sites in need of revegetation (Densmore et al., 2000). May do poorly with transplanting (Ontario Rock Garden & Hardy Plant Society, 2023). Revegetation of sites using containerized seedlings in Denali National Park showed promising survival after 1 year; however, researchers did note that roots were sensitive to disturbance. Containerized seedling roots were difficult to remove from their containers, and root damage during transplanting was the highest cause of plant mortality (Densmore & Holmes, 1987). Emers et al. (2002) note when propagating and transplanting for future seed production, 2 growing seasons was insufficient as the percentage of flowering plants was only 2-16%. For nursery production, Holloway (2024) warns that roots are a major attractant for voles, which can decimate nursery stock.

SEED

- **Collection recommendations**
  Holloway (2024) writes:
  "Legumes turn from green to tan to brown and become papery when mature. Harvest legumes by stripping them from the stem or harvest the entire stem with legume clusters. In autumn, there is a range of maturities on any one stem, so expect variable germination."

The Alaska Plant Materials Center in Palmer recommends collection by hand or with combine when seed pods begin to crack (Hunt & Wright, 2007).

Based on experience in Denali National Park, Densmore (2000) recommends locating seeds along disturbed sites (e.g., roadsides and gravel bars), and harvesting from late July through late August. "Seeds will be brown, papery, and easily stripped off seed stalks when ripe."

- **Seeds per/lb**
  70,000 seeds/pound (USDA & NRCS, 2023).

- **Processing techniques, recommended equipment**
  Place seeds on trays and dry in a warm place for about 1 week, or dry on screens or tarps. Watch for insect damage during the drying period; if necessary, add an insecticide strips. Crush dried seeds by hand, rub against a screen or processed in a hammermill to release large seeds (Holloway, 2024). Densmore et al. (2000) writes that cleaning is not necessary; if cleaning is to be done Hunt and Moore (2007) recommend a debearder and screens.

- **Storage**
  Densmore et al. (2000) advises storing seeds long term in the freezer. Seed viability is halved after 5 years of storage under laboratory conditions (SER, INSR, RBGK, 2023).

- **Scarification requirements**
  The Ontario Rock Garden and Hardy Plant Society (2023) suggest: rub and/or nick seeds between sheets of sandpaper, follow by submerging in warm water for 24-48 hours, or until seeds have swelled. Discard any floating seeds.

  Densmore et al. (1986) reports successful germination with 30 seconds in a drum scarifier. Emers et al. (2002) report timing of seedling emergence was quickest when seeds were treated with acid scarification. However, other experiments suggest that seeds may not require any scarification (Densmore et al., 2000; Densmore & Holmes, 1987).

- **Stratification requirements**
  Germination success is reported to be facilitated by cold stratification of 60 days, but may not be required (Densmore et al., 1990; Gucker, 2007).

- **Germination rates and techniques**
  Holloway (2024) writes:
  "Outdoors, direct sow in autumn. Seeds are released in three colors. Green seeds germinate poorly. Tan seeds show germination in 10-14 days at 70-75°F (21-24°C). Very dark brown seeds are dormant and need to be scarified with sandpaper before sowing. All colors can be direct sown outdoors, but germination can vary from immediate to 2 years. Indoors, separate colors for more uniform germination. Germinate at 70-75°F (21-24°C). Seedlings are highly susceptible to damping off rot. Use sterile seed starting mix, keep the surface on the dry side, and use fungicides."

  The Alaska Plant Materials Center advises that their Paxson germplasm seed does best with light scarification, and fall seeding (Hunt & Wright, 2007).

SER reports 90 and 100% germination of scarified seeds exposed to an 8/16 hour light cycle and 15°C and 20°C temperature cycle. Germination occurred in 7-35 days (SER, INSR, RBGK, 2023). These trials used seed scarified by partially removing seed coat with a scalpel, and then chipping the seed coat.

Densmore & Holmes (1987) report successful germination exposing seeds to light/dark cycles of 16/8 hours with alternating 25/10°C thermoperiod.

Gucker (2007) report 91-95% germination following a 37-43°F cold moist stratification for 1-2 months (Gucker, 2007).

Emers et al. (2002) reports optimum seedling survival when germinated in a silt/sand/peat mixture. By contrast, seedlings germinated in a commercial potting mix died after 10 days. Seedlings emerged between 4-14 days, depending on scarification treatment.

For direct seeding in-situ, Densmore et al. (2000) advises sowing seeds in September for spring germination or in May/June for same-season germination. Seeds can be sown by hand. A slow release, 2-year fertilizer such as Osmocote 14-14-14 NPK can be applied at a rate of 560 kg/ha or 56 g/m^2. Do not use quick release or high nitrogen fertilizer. Rake soil, seed, and fertilizer to 1-2.5 cm depth to properly bed and protect seeds.

- **Establishment phase**
  Hunt and Wright (2007) suggest that general best practices include light irrigation, weed management, and use of low nitrogen/high phosphorus fertilizer to facilitate growth.

- **Active growth phase**
  Unavailable.

- **Hardening phase**
  Unavailable.

- **Harvest, storage & shipping**
  Sensitive to root damage (Densmore & Holmes, 1987).

VEGETATIVE PROPAGATION

- **Cuttings**
  The Dena'ina people of Southcentral Alaska actively manage future harvest of alpine sweetvetch by cutting off and re-planting thick ends of the roots (Kari, 2020).

- **Division**
  To propagate by division, divide plants in spring as new growth begins (Holloway, 2024).

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Propagation Profiles

Webb, C., & Ickert-Bond, S. (2022). *Alaska Flora Quick Maps, <https://alaskaflora.org/qm/>, using data from Hultén, E. (1968) Flora of Alaska and Neighboring Territories, <https://arctos.database.museum/> and <https://www.inaturalist.org/>, a product of US NSF grant 1759964* [dataset].

Propagation Profiles

Scientific name: *Hordeum brachyantherum*
Synonyms: n/a
Common name (s): meadow barley
Family: Poaceae
USDA PLANTS code: HOBR2

Duration: Perennial
Growth habit: Graminoid
Wetland indicator status: FACW

WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
Seed from Seward, AK, collected and developed/propagated at the Alaska Plant Materials Center, Palmer, AK (Hunt & Wright, 2007) - USDA Zone 5a/5b
https://dnr.alaska.gov/ag/akpmc/pdf/plant-flyers/LowelPointGermplasmmeadowbarley.pdf

Seeds from Tennessee Valley, CA, propagated in San Francisco (Young, 2001) - USDA Zone 10a-b
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=poaceae-hordeum-619

Habitat description:
Meadows, bottom lands, shores, and grassy slopes (Hultén, 1968; Rose et al., 1998). Also known to occur in wetter areas along stream banks, seeps, springs, mud flats, and sand dunes (Skinner et al., 2012). Most abundant in maritime habitats (Pojar & MacKinnon, 1994).

Elevation range:
Sea level to subalpine (Pojar & MacKinnon, 1994).

Soil preferences and adaptations:
Coarse, medium, and fine soils; tolerates mild salinity and alkaline conditions (USDA & NRCS, 2023). Present on moist to dry soils, in full sun exposure or under shade trees, and tolerates pH 6-8.5 (Hunt & Wright, 2007).

Shade tolerance:
Low (USDA & NRCS, 2023).

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Last updated: n/a

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Drought tolerance:
Medium (USDA & NRCS, 2023).

Disturbance tolerance:
High; often occurs in early-seral sites with *Leymus mollis* (Skinner et al., 2012).

Community interactions:
May compete with annual grasses (Hunt & Wright, 2007).

Wildlife associations:
The USDA reports low palatability for browsers and grazers.

Restoration value:
Has been commercialized/marketed as 'Lowell Point Meadow Barley' (Hunt & Wright, 2007; Skinner et al., 2012), and can be used for soil stabilization where a rapid cover is needed. Vigorous seedling growth adds to its utility in revegetation programs; also noted to act as a nurse plant for slower growing native species (Hunt & Wright, 2007).

Primary reproductive mode:
Seed.

Seed type:
Orthodox (SER, INSR, RBGK, 2023).

Ease of growing:
Hordeum brachyantherum is described as one of the easier native grasses to establish in the western United States. It matures early in the season and is capable of producing a seed crop in the first year of establishment if sown in late fall or early spring (Darris, 2008; Hunt & Wright, 2007).

SEED

- **Collection recommendations**
  Holloway (2024) writes:
  "Caryopsis from tight, compact flower spike with spikelets in sets of three. Spikes and spikelets easily shatter and disperse when fully dry, so careful monitoring is needed to harvest just as the color changes to brown. Caryopses are easily dislodged from the plant by hand stripping just as the color becomes a uniform brown."

  Collect seeds in late summer, store in a paper bag in a cold, dry environment (Rose et al., 1998). Young (2001) reports collecting seeds from California populations by dragging a cupped hand across seed stalks of mature inflorescences, showing light brown color, from June 1-July 31.

- **Seeds per/lb**

Rose et al. (1998) report 148,660 seeds per kilogram. Darris (2008) states that seed yield can vary widely from 30,000-100,000 seeds/lb; highly processed seed can reach 150,000 seeds/lb. The USDA reports 300,000 seeds per pound (USDA & NRCS, 2023).

- **Processing techniques, recommended equipment**
  Young (2001) suggests seed cleaning is unnecessary. However, Holloway (2024) advises:
  "The spikelets have awns that can interfere with storage and germination. Run through a debearder to remove awns (not absolutely necessary but reduces bulk and makes sowing easier). Expect a lot of unfilled seeds."

- **Storage**
  Frozen seeds last in storage for at least 5 years. Retains 96% viability when dried to equilibrium moisture content and frozen for 50 days at -20°C (SER, INSR, RBGK, 2023). Young (2001) stored seeds dry in a refrigerator.

- **Scarification requirements**
  Not required.

- **Stratification requirements**
  Successful germination has been reported both with an without stratification.

- **Germination rates and techniques**
  Rose et al. (2008) report a germination rate of 96% for seeds germinated in agar and exposed to an 8/16 light cycle at 20°C for 126 days (SER, INSR, RBGK, 2023).

  Holloway (2024) advises:
  "Sow outdoors in autumn or spring. Indoors, sow onto sterile seed starting mix. Do not cover. Keep moist. Germination begins in about 10 days at 70-75°F (21-24°C) but may be prolonged 3-4 weeks."

  Hunt and Wright (2007) indicate seed germination after 21 days.

  Young (2001) propagated seeds in a fully controlled greenhouse and reports the following:
  "[Four] 4 grams of seeds are sown per container (leach tubes) containing standard potting mix of peat moss, fir bark, perlite, and sand. [Four] 4 seeds are sown per container and are surface sown. Containers are watered in with an automatic mist and irrigation system. Seeds are sown on May 1st. 60% germination. Seeds germinated 21 days after sowing."

  Regarding germination techniques, Rose et al. (2008) writes:
  "Sow fresh seed in the fall at a depth of two to three times its height in a sand:pumice:peat 1:1:1 medium and place in [a] cold frame. Seed can also be cold stratified at 5°C for six weeks, then transferred to temperatures of 10°C (8 hours a day in the dark) and 20°C (16 hours of light) for an additional 6 weeks. It is also reported that fluctuating temperatures of 20°C (16 hours per day) and 30°C (for 8 hours) are required for germination."

- **Establishment phase**
  Young (2001) transplanted seedlings 21 days after germination to individual leach tube containers filled with a growing medium of a standard potting mix comprised of peat moss, fir bark, perlite, and sand, and reported 70% transplant survival.

- **Active growth phase**
  Unavailable.

- **Hardening phase**
  Unavailable.

- **Harvest, storage & shipping**
  Unavailable.

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Created 2024, Kelly Sivy
Last updated: n/a

Homer Soil & Water
CONSERVATION DISTRICT

Propagation Profiles

Scientific name: *Juncus mertensianus*
Synonyms: n/a
Common name (s): Mertens' rush
Family: Juncaceae
USDA PLANTS code: JUME3

Duration: Perennial
Growth habit: Graminoid
Wetland indicator status: OBL

WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
Seed collected from Mt. Hood and Mt. Baker-Snoqualmie National Forests (USDA Zones 6b-7b), and propagated in Cottage Grove, OR (Zone 8b) (Riley & Klocke, 2018)
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=juncaceae-juncus-4

Seed collected from Logan Pass, MT (Glacier National Park) - USDA Zone 4b; propagated in West Glacier, MT - USDA Zone 5a (Luna et al., 2008)
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=juncaceae-juncus-97

Habitat description:
Stream banks, pond edges, bogs, meadows, heath, snowbeds, wet subalpine meadows (Hultén, 1968; Pojar and MacKinnon, 1994).

Elevation range:
Common at middle to high elevations (Pojar and MacKinnon, 1994). In British Columbia, 100-2500 meters (Klinkenberg, 2020).

Soil preferences and adaptations:
Medium to coarse soils, mildly tolerant of alkaline soil (USDA & NRCS, 2023).

Shade tolerance:
Intermediate (USDA & NRCS, 2023).

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Last updated: n/a

Homer Soil & Water
Conservation District

Drought tolerance:
Low (USDA & NRCS, 2023).

Disturbance tolerance:
Unavailable.

Community interactions:
Unavailable.

Wildlife associations:
Unavailable.

Restoration value:
Unavailable.

Primary reproductive mode:
Sexual, but also propagated by sprigs and roots (USDA & NRCS, 2023).

Seed type:
Orthodox (SER, INSR, RBGK, 2023).

Ease of growing:
Unavailable.

SEED

- **Collection recommendations**
  Holloway (2024) writes:
  "Clump forming rush, each stem topped with a single ball composed of a many flowers. Each flower produces a single capsule, dark brown when ripe. Hand collect mature inflorescences when capsules are black-brown, just before they split and release seeds. Seeds are brown at maturity. Use clippers or scissors to cut seed balls into paper bags or tray."

  Protocols described from Montana and Oregon report collecting seed in late August, when inflorescences have matured to a dark brown and capsules are just about to split. Riley & Klocke (2018) used scissors to cut seed heads directly into paper bags. Bags could then be kept in a well-ventilated drying shed until ready to be cleaned (Luna et al., 2008; Riley & Klocke, 2018).

- **Seeds per/lb**
  45,400,000 seeds/lb (USDA & NRCS, 2023).

- **Processing techniques, recommended equipment**
  Hammermill and fanning mill (Luna et al., 2008; Riley & Klocke, 2018). Holloway (2024) writes: "Air dry on trays, and crush heads with fingers to release seeds. Can also use a hammermill to dislodge seeds. Use air/screen cleaner to separate out the chaff."

Propagation Profiles

- **Storage**
  When dried to equilibrium moisture content at 15% relative humidity, and frozen for 1 month at -20°C, seeds exhibit 94% viability (SER, INSR, RBGK, 2023).

- **Scarification requirements**
  Surface sterilization using sodium hypochlorite is known to stimulate germination in other *Juncus* species and may be worth trying for *J.* mertensianus; see germination techniques below (Holloway, 2024).

- **Stratification requirements**
  The USDA Plants database indicates cold stratification is not required; however, both Native Plants Network propagation protocols include a cold stratification period of 1-5 months.

- **Germination rates and techniques**
  94% germination is reported after germinating seeds in agar and exposing to an 8/16 hour light cycle for 84 days at 15°C (SER, INSR, RBGK, 2023).

  Holloway (2024) writes:
  "Sow outdoors in autumn in moist soils. Do not cover but press seeds into the surface of an organic soil. Indoors, cold stratify for 90 days followed by immediate sowing on acid/peaty soils. Do not cover. Keep moist. Research with other species of Juncus recommend surface sterilizing the seeds (45 min, 5.25% sodium hypochlorite solution followed by rinsing in distilled water) prior to sowing."

  At an outdoor nursery in Montana, Luna et. al (2008) obtained germination rates varying from 50 to 80%. They exposed seeds to a 5-month cold moist stratification period initiated in late fall. Seeds were surface-sown into a 6:1:1 milled sphagnum peat/perlite/vermiculite growing medium, and each 172 ml cell was fertilized with 1 g Osmocote and 0.20 g Micromax. Containers were irrigated thoroughly. Seedlings germinated in spring while exposed to naturally fluctuating outdoor temperatures and full sun (Luna et al., 2008).

  Riley and Klocke (2018), propagating in a greenhouse facility in Oregon, mixed the tiny seeds with sand for direct sowing into 107 ml containers. Containers were filled with a 40:20:20:20 peat/composted fir/perlite/pumice growing medium and fertilized with 0.5 g of Nutricote controlled release fertilizer. Entire racks were sealed inside plastic bags and refrigerated for 30 days at 1-3°C, keeping cells moist throughout the duration. Following the 30-day stratification, racks were moved to the greenhouse; no additional fertilization was added, but racks were watered lightly several times per day to maintain moisture during germination. Germination was reported as uniform and completed in 1-2 weeks (Riley & Klocke, 2018).

- **Establishment phase**
  Following natural stratification and spring germination, Luna et al. (2008) report rapid shoot and root development over a 4-week establishment phase. During this period, containers were leached thoroughly in the early morning via an automatic irrigation system.

After artificial (refrigerator) stratification, Riley & Klocke (2018) report a 2-week establishment phase; after emergence, they fertilized seedlings with soluble 12-2-14-6Ca-3Mg at 100 ppm for 1 week.

- **Active growth phase**
  Luna et al. (2008) report an 8 week active growth phase, during which seedlings were fertilized with 20-20-20 liquid NPK at 100 ppm. By week 8, seedlings exhibited substantial root production.

  Riley and Klocke (2018) also report an 8-week growth phase, during which they applied a soluble 20-9-20 NPK fertilizer at 150 ppm each week.

- **Hardening phase**
  During a 4-week hardening phase spanning August and September, Luna et al. (2008) fertilized plants with 10-20-20 liquid NPK at 200 ppm. Watering was gradually reduced in September and October, with a final irrigation prior to winterization.

  Riley and Klocke (2018) moved seedlings to an outdoor growing area in mid-September and did not attempt to induce dormancy by tapering irrigation.

- **Harvest, storage & shipping**
  Luna et al. (2008) overwintered plants in outdoor nursery under insulated foam covers and snow.

  Riley and Klocke (2018) harvested plants in mid-October for fall outplanting; plants were well irrigated prior to shipping.

VEGETATIVE PROPAGATION

- **Division**
  Luna et al. (2008) report propagating *Juncus mertensianus* vegetatively by dividing nursery stock. If propagating by division, divide rhizomes in spring or summer (Holloway, 2024).

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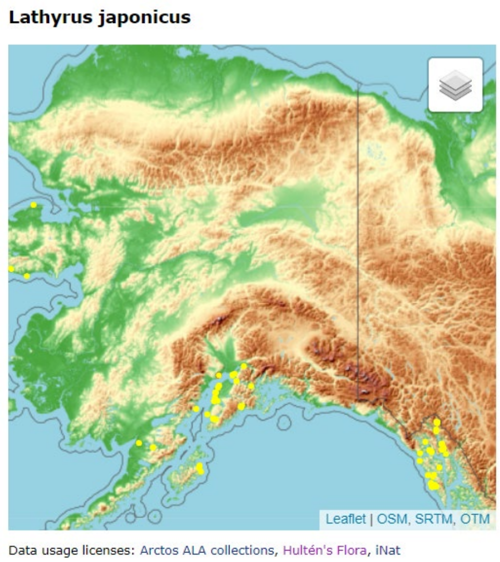
Propagation Profiles

Scientific name: *Lathyrus japonicus*
Synonyms: n/a
Common name(s): beach pea
Family: Fabaceae
USDA PLANTS code: LAJA

Duration: Perennial
Growth habit: Forb/herb
Wetland indicator status: FAC



Webb & Ickert-Bond, 2022

Nearest propagation protocol:
Seed collected from central Oregon coast, propagated in Corvallis, OR - Zone 8b-9b (Silvernail, 2021)
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=fabaceae-lathyrus

Habitat description:
Sandy or gravelly beaches and dunes (Klinkenberg, 2020; Lady Bird Johnson Wildflower Center, 2023).

Elevation range:
Low elevation, coastal (Klinkenberg, 2020).

Soil preferences and adaptations:
Medium to coarse soils, tolerates alkaline soil and mild salinity soil (Lady Bird Johnson Wildflower Center, 2023; USDA & NRCS, 2023).

Shade tolerance:
Medium (USDA & NRCS, 2023).

Drought tolerance:
Medium (USDA & NRCS, 2023).

Disturbance tolerance:
Unavailable.

Created 2024, Kelly Sivy
Last updated: n/a

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Community interactions:
Fixes atmospheric nitrogen in the soil. The biomass of *L. japonicus* was found to relate to physiochemistry of soil/substrates, and removal experiments did not reveal any significant interspecies interactions (Houle, 1997).

Wildlife associations:
Butterfly attractant, possible forage value to grazing animals (Debnath et al., 2001; Lady Bird Johnson Wildflower Center, 2023). There is some ambiguity regarding potential toxicity to humans depending on quantity and maturity of plant ingested; it is unknown whether this toxicity extends to wildlife.

Restoration value:
Restoration potential has not been formally investigated. However, its preferred habitat and nitrogen fixing ability would suggest adaptation to sediment accumulation, low nutrient availability, and/or somewhat saline conditions.

Primary reproductive mode:
Reproduces via abundant seeding. Also propagated by sprigs. In some ecosystems it's reported to reproduce primarily through extensive rhizomes, which can grow >1 meter in length (Dollard & Carrington, 2013).

Seed type:
Orthodox (SER, INSR, RBGK, 2023).

Ease of growing:
Does not transplant well (Ontario Rock Garden & Hardy Plant Society, 2023).

SEED

- **Collection recommendations**
  P. Holloway (2024) of University of Alaska Fairbanks, writes of the subspecies *L. japonicus* var. *maritimus:*
  "Flowers are protandrous. Insect pollination mostly by bumble bees is essential for good seed set. Fruit is an oblong, flattened peapod-like legume, may or may not open at maturity. Legume does not shatter. Legumes are hand stripped from the plants when the pods change from green to tan to brown and just begin to open (if at all). The texture on the outer surface also becomes papery and dry."

  Silvernail (2021) collected from the central Oregon coast in July and August, but advises that because not all seed is dispersed from the pod once it splits open, larger populations likely provide an extended collection window.

- **Seeds per/lb**
  12,000 seeds per pound (USDA & NRCS, 2023).

- **Processing techniques, recommended equipment**
  Dry seeds at room temperature. Silvernail (2021) describes seed processing as follows:
  "Legumes were first threshed in a Westrup LA-H brush machine with a solid mantle at low speed so as to avoid significant scarification... Seed was then separated from inert plant matter on a Clipper Office Tester using a 13 round top screen and no bottom screen with air at medium-high setting."

  Holloway (2024) writes:
  "Dry pods on screens, then hand crush the pods to release seeds, rub on a screen to break up the pods, or run through a hammermill or brush machine. It is easy to damage seeds with a brush mill."

- **Storage**
  May store for 14 years or more (SER, INSR, RBGK, 2023).

- **Scarification requirements**
  Mechanical scarification is required. To scarify, the seed coat can be partially removed or chipped with a scalpel (SER, INSR, RBGK, 2023). Alternatively, seed can be rubbed between sheets of sandpaper and then soaked in warm water for 24-48 hours until seed swells (Ontario Rock Garden & Hardy Plant Society, 2023).

- **Stratification requirements**
  Stratification treatments were tested by Silvernail (2021) and were not found to enhance germination.

- **Germination rates and techniques**
  Holloway (2024) writes, of the subspecies *L. japonicus* var. *maritimus*:
  "Seeds have physical dormancy called hard seeds. The degree of hardseededness varies with seed maturity. Pale green/yellow seeds are immature and will not germinate. Tan/brown seeds are partly mature and may germinate immediately. The seed coat has not become fully hardened. Dark brown seeds are fully dormant (hard) and require scarification. Soak seeds in water for 4 hours. Those that imbibe water and expand in size will germinate right away. They should be planted immediately. Scarification by nicking, abrasion with sandpaper work well, but are time consuming. A 20-40 minute soak in concentrated sulphuric acid is necessary for complete germination of fully mature seeds. Follow safety regulations when working with acid. Seedlings are very susceptible to damping off diseases."

  In germination trials conducted by Silvernail (2021) testing various combinations of scarification and stratification treatments, all seeds scarified with sandpaper showed 98-100% germination, whereas unscarified seed germinated at only 2-12%. At room temperature, scarified seeds germinated within 1 week. Germination trials were conducted using either PromixHP+ (high porosity peat and perlite) or a 1:2 ratio of washed river sand to ProMix-HP+ as growing media; establishment from seed was 100% for both media mixes.

  Dollard and Carrington (2013) report collecting and germinating wild seed for a reintroduction program in Indiana Dunes National Lakeshore (USDA Zone 6a), with the use of inoculum solution. Following seedling emergence and development of the first true leaves, plants were submerged in a solution containing *Rhizobium leguminosarum* to colonize root nodules (Dollard & Carrington, 2013). Seedlings were then transferred to larger containers and remained in a greenhouse.

- **Establishment phase**
  Greenhouse experiments conducted with seed from Hudson Bay (Northern Quebec; USDA Zone equivalent 1a-2a) showed both mineral and organic fertilizer negatively affect seedling emergence, above ground, and below ground biomass. In field plantings, mineral fertilizer appeared to promote above and below ground biomass when applied after 2 growing seasons (Deschaies et al., 2009). Similarly, fertilizer was not found to promote establishment or plant size of germinants from UK seed populations and is suggested as a possible cost reduction for commercial operations (Walmsley & Davy, 1997).

- **Active growth phase**
  Silvernail (2021) reports that after 6 months, seedlings had rhizomes protruding from drainage holes in Deepot D40 container bottoms.

- **Hardening phase**
  Unavailable.

- **Harvest, storage & shipping**
  Unavailable.

VEGETATIVE PROPAGATION

- **Division**
  Plants may be propagated by division of rhizomes, in particular from individuals which have rooted naturally (Holloway, 2024). Early studies indicated that *L. japonicus* may be a good candidate for vegetative regeneration via stem, rachis, and leaf explants (Debnath et al., 2001).

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Propagation Profiles

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Propagation Profiles

Scientific name: *Leymus mollis*
Synonyms: *L. arenarius*, *Elymus arenarius*, *E. mollis*
Common name(s): American dunegrass
Family: Poaceae
USDA PLANTS code: LEMO

Duration: Perennial
Growth habit: Graminoid
Wetland indicator status: FAC

Taxonomic ambiguity persists as to whether the synonyms are separate or the same species. Hybridization is common. This propagation profile includes information for *L. mollis* and *L. arenarius*.

WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
Planting protocols for *Leymus* sp. produced by the Alaska Plant Materials Center (S. Wright, 1994)
https://dnr.alaska.gov/ag/akpmc/pdf/BeachWildryePlantingGuide.pdf

Habitat description:
L. mollis occurs on coastlines, spits, tidal flats, sea cliffs, lakeshores, and dunes (Hultén, 1968; S. Wright, 1994; S. J. Wright & Czapla, 2013).

Elevation range:
Coastal, low elevation shorelines, 15 meters or less (Klinkenberg, 2020). Higher elevations on road shoulders.

Soil preferences and adaptations:
Dry, sandy, or gravelly soils (S. J. Wright & Hunt, 2008)

Shade tolerance:
Intolerant.

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Last updated: n/a

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Drought tolerance:
Tolerant (S. J. Wright & Czapla, 2013).

Disturbance tolerance:
High tolerance for saline conditions (S. J. Wright & Czapla, 2013).

Community interactions:
Poor competitor with other grasses and rhizomatous species; *L. arenarius* is sensitive to foot traffic and soil compaction (S. J. Wright & Czapla, 2013). Can be planted among *Deschampsia* sp. and *Artemisia* sp. (S. Wright, 1994).

Wildlife associations:
Seeds found in vole caches, and may be an important source of food (Fienup-Riordan et al., 2019).

Restoration value:
Exhibit aggressive growth and have potential for restoration of highly erodible habitats, thriving in areas unsuitable for other species (S. J. Wright & Czapla, 2013). Can also be used in streambank restoration, and/or where brackish water persists (Walter et al., 2005). "Sprigging" (small divisions taken from plants) is the recommended revegetation method, with typical survival of >90% (S. J. Wright & Czapla, 2013). Planting patterns can be arranged to facilitate uniform sand distribution or to promote dune formation (S. J. Wright & Czapla, 2013). Several revegetation case studies throughout Alaska can be reviewed in Wright and Czapla (2013).

Primary reproductive mode:
Does not reliably produce seed; vegetative reproduction by rhizomes is predominant spreading mechanism (S. Wright, 1994).

Seed type:
L. arenarius is listed as orthodox (SER, INSR, RBGK, 2023).

Ease of growing:
Propagation from seed is slow and seedlings are characterized by low vigor (S. Wright, 1994). Two cultivars were developed and released by the Alaska Plant Materials Center in 1991: 'Reeve,' for seed (harvested from Norway, *Leymus arenarius*) and 'Benson' (*Leymus mollis*) for sprigging. Wright (1994) reports the two cultivars are interchangeable in usage.

SEED

- **Collection recommendations**
  In Iceland populations, Griepsson and Davy (1994, 1996, 1997) found that seed mass of *L. arenarius* was positively correlated with germination percent and duration, with larger seeds exhibiting higher and faster germination rates. They recommend using seed mass as a proxy for seed quality and targeting larger seeds with a minimum average mass among stands of 5 mg. Collect with hulls intact for best establishment. Collect soon after seed maturation and before they start shedding from stems.

Propagation Profiles

- **Seeds per/lb**
  33,000 seeds per pound (S. Wright, 1994).

- **Processing techniques, recommended equipment**
  Unavailable.

- **Storage**
  Seed maintains 59% viability after 1 year at -20°C when dried to moisture contents in equilibrium with 15% relative humidity (SER, INSR, RBGK, 2023).

- **Scarification requirements**
  In Icelandic experiments, scarification was not found to improve germination capacity; however, authors do report that for coastal populations germination was inhibited by salinity exposure and overcome by a solution of 100 mmol 1^{-1} and 300 mmol 1^{-1} NaCl, suggesting an "osmotically enforced dormancy effect" (Greipsson & Davy, 1994).

- **Stratification requirements**
  Greipsson and Davy (1994) report improved germination of Icelandic seed populations following 2-week cold stratification at 5°C. Additional experiments indicate germination further improves with stratification periods of 4 and 6 weeks (Greipsson, 2001).

- **Germination rates and techniques**
  Trials from the UK report a 59% germination rate of seed germinated in 1% agar under an 8 hour light/16 hour dark photoperiod and 25/10°C thermoperiod (SER, INSR, RBGK, 2023). Wright (1995) also reports germination rates of about 50%.

  Greipsson and Davy (1994), in experimental trials on *L. arenarius* collected in Iceland, achieved near 100% germination rates by soaking seeds in water for 24 hours prior to a 2-week 5°C stratification, followed by germination in constant darkness and alternating 12 hour cycles of 10 and 20°C. They report poor germination of soaked/stratified seed under consistent temperatures or light exposure (Greipsson & Davy, 1994). Results from later experiments found that treatment of the seed hull with a 24 hour soak in 500 mgl^{-1} GA_3 (gibberellic acid) further promoted germination (Greipsson, 2001). The author advised that for restoration planting, seed hulls should be retained on seed and soaked in gibberellic acid to maximize establishment (Greipsson, 2001).

- **Establishment phase**
  The Ontario Rock Garden and Hardy Plant Society (2023) recommends sowing seed at 20°C, with germination expected within 3 months. In Southcentral Alaska the recommended seeding period is May 1-early September (S. Wright, 1994).

- **Active growth phase**
  Fertilize seed at a rate of 500-600 lbs/acre of 20-20-10 (S. Wright, 1994). Experiments in Iceland show that application of a slow-release fertilizer may improve establishment of *L. arenarius* on volcanic, sandy barrens over the first two years, while annual application of rapid release fertilizer was more economical over a 4 year period and resulted in similar biomass and tiller density (Greipsson & Davy, 1997). Deficits in phosphorous led to plants with increased root and rhizome

mass, whereas deficits in potassium resulted in plants with more above-ground growth (Greipsson & Davy, 1997).

- **Hardening phase**
  Unavailable.

- **Harvest, storage & shipping**
  Unavailable.

VEGETATIVE PROPAGATION

- **Collection recommendations**
  Wright (1994) advises collecting in the form of "sprigs," which are small divisions taken from living plant; well developed roots or green leaves do not need to be attached. Green leaves will likely die back when transplanting, but new growth will continue from the roots. Divide a clump until only a portion of below ground crown and above ground leaf mass exists. Further trimming is optional. Sprigs may be harvested in small quantities with a shovel, or for larger quantities in areas not sensitive to disturbance, a backhoe can be used to remove and transfer sod blocks where clumps and sprigs can be further divided by hand. For commercial production, a potato digger may also be used (Wright, 1994).

- **Planting recommendations**
  In Alaska, sprigs have successfully established from plantings made from May through September; in general Wright (1994) advises transplanting prior to September 1 south of Arctic Circle, and prior to August 1 in areas north of the Arctic Circle.

  Sprigs can be planted by hand, or for large-scale planting, heavy equipment can be used to dig trenches and use the "drop-and-stomp" technique with clumps of grasses. Sprigs do not need to be vertical in the planting hole. Use a 3-4' spacing. (S. Wright, 1994). A 1-acre natural stand can generally yield 7-acres of transplant in the field (S. J. Wright & Czapla, 2013).

  Similar to the recommendation for seed establishment, fertilize vegetative transplants at a rate of 500-600 lbsacre of 20-20-10 (S. Wright, 1994).

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Propagation Profiles

Scientific name: *Lupinus arcticus*
Synonyms: n/a
Common name (s): arctic lupine
Family: Fabaceae
USDA PLANTS code: LUAR2

Duration: Perennial
Growth habit: Forb/herb
Wetland indicator status: FACU

Webb & Ickert-Bond, 2022

Nearest propagation protocol:
Bulkley Valley, northern interior British Columbia – USDA Zones 4a-5b (Burton & Burton, 2003)
https://www.for.gov.bc.ca/hfd/library/documents/bib107640.pdf

Habitat description:
Roadsides, meadows, dry and damp slopes, gravel bars (P. Holloway et al., 2021; Hultén, 1968).

Elevation range:
Up to at least 1,500 meters (Hultén, 1968).

Soil preferences and adaptations:
Grows in dry sand or sandy loam, well-drained soils, neutral to slightly alkaline (Burton & Burton, 2003; USDA & NRCS, 2023).

Shade tolerance:
Low (Burton & Burton, 2003).

Drought tolerance:
Low (USDA & NRCS, 2023).

Disturbance tolerance:
Unavailable.

Community interactions:
Lupinus arcticus has a symbiotic relationship with nitrogen fixing bacteria, *Rhizobium* spp. Burton and Burton (2003) report that, under cultivation, stands of *Lupinus arcticus* subjected to competition from grasses or annuals tend to be relatively short-lived (3-5 years).

Wildlife associations:
Provides butterfly habitat (Alaska Native Plant Society, 2023). Although not considered toxic to wildlife, *Lupinus arcticus* is known to cause adverse reactions in sheep and cattle and is therefore not recommended for revegetation in areas where domestic animals graze. This species is also a host for lupine aphid (*Macrosiphum alibifrons*) (Burton & Burton, 2003).

Restoration value:
As a nitrogen fixer, *Lupinus arcticus* may help restore soil in degraded sites, and stabilize soil where erosion is a concern (Burton & Burton, 2003).

Primary reproductive mode:
Seed

Seed type:
Orthodox (SER, INSR, RBGK, 2023).

Ease of growing:
Susceptible to powdery mildew. Relative to Nootka lupine, this species is more difficult to establish, and more short-lived.

SEED

- **Collection recommendations**
  The legume shatters when mature; legumes often are destroyed by insect larvae leaving them empty or full of webbing/frass (Holloway, 2024). Holloway further writes:
  "Seeds are borne in legumes (pods) on stems that range from a few inches in length to nearly 12 inches (30 cm). The individual pods ripen from the bottom up on the stem. The pods also twist open when fully dry and explosively release seeds, again from the bottom up. Some seeds get caught in the twisted halves of the legume, but most scatter everywhere. This difference in maturity requires repeated harvests, or choose a period when the middle pods begin to mature. The lower pods will have released their seeds already, but the ones at the top might not be mature. If you wait until all pods are blackish and twisted, it is too late. Try enclosing entire stalks after flowering in a cheesecloth bag, or knee-high stocking secured around a stem with a twist tie. Legumes will release seeds explosively within the bag. This bag method doesn't work well in rainy areas because the bags become soggy and the entire stem will rot. Upon harvest, dry entire stems in an enclosed paper bag or beneath layers of newspaper or cloth and allow pods to explode open. Seeds range in color from light brown, greenish brown to nearly black, with lighter seeds being less mature. Dormancy range is reflected in seed color, from none (pale colored seeds) to significant physical seed coat dormancy (black)."

Burton and Burton (2003) found that for northwestern British Columbia populations, optimal seed harvest occurred from mid-July through the end of August. They recommend clipping seed heads directly into bins or into paper bags. Alternatively, they report success harvesting the entire flowering stalk after the top pods have blackened and allowing the remaining pods to ripen in the sun.

- **Seeds per/lb**
  108 seeds per gram (Burton & Burton, 2003).

- **Processing techniques, recommended equipment**
  Burton and Burton (2003) suggest processing seed with a combine thresher, set at 1241 rpm with 4mm gap. Ensure loose seed is removed between threshing batches, to avoid cracking any cleaned seeds left behind. After threshing, clean seed via a fanning mill set according to the following protocol: "Prescreen 4.9 mm round; top screen 4.8 mm round; bottom screen 1.2 mm square. If pods and trash are still abundant, put through a second time with a just 4 mm square top screen (or hand screen), then through a vacuum separator with speed set high and suction set to low to remove dust and <5% of seeds."

- **Storage**
  In trials with British Columbia seed, seeds stored for 1 year under cool dry conditions had higher germination rates in the second year after harvest. However, they also report that seeds of *L. arcticus* are generally long-lived and robust to a range of storage conditions (Burton & Burton, 2003).

  The Society for Ecological Restoration reports seeds retain 100% viability following drying to equilibrium moisture content with 15 % relative humidity and freezing for 13 days at -20°C (SER, INSR, RBGK, 2023).

- **Scarification requirements**
  This species benefits from scarification. To scarify, soak seeds in water for 4 hours and plant seeds that double in size. After soaking, seeds that don't double in size are dormant; scarify these by nicking with a knife or needle, or rubbing with sandpaper. Alternatively, acid-scarify for 10 minutes (Holloway and Gauss, 2021).

- **Stratification requirements**
  Mixed findings. May benefit from stratification, but it may not be required.

- **Germination rates and techniques**
  Scarified seeds set in 1% agar and exposed to an 8/16 hour light cycle, at 10-20°C yielded 100% germination in 7-14 days (SER, INSR, RBGK, 2023). The Native Plant Network protocol indicates that germination occurs at 20-21°C (Baskin & Baskin, 2002).

  Holloway (2024) writes:
  "Outdoors, direct sow in autumn. You will get some germination the first year, then more in subsequent years. Seeds outdoors can persist for years in a seed bank as long as they are fully mature. Indoors, soak seeds in water for 4+ hours and plant those that have doubled in size (not dormant). The ones that have not doubled are dormant with a hard seed covering. Air dry the

seeds, then scarify by nicking with a knife or needle, rubbing with sandpaper or acid scarification for 10 minutes concentrated sulfuric acid; 20 minutes battery acid. Use extreme caution when using acid."

Burton and Burton (2003) report that although stratification was not required, highest germination rates were achieved with a combination of stratification and scarification. From their lab trials they report 95.2% germination of scarified/stratified seeds exposed to a 30/20°C cycle. Seedlings began to germinate at 6.5 days, with 50% of seeds germinated in 14 days.

Densmore, working with seeds harvested in Denali National Park, reports good germination after nicking seed coat with file prior to planting (Densmore et al., 2000).

Burton and Burton (2003) report a 13% decrease in germination of seeds from green seed pods relative to seed from ripened pods. They also report satisfactory germination rates for seeds sown directly into the field in both spring and fall. For direct-seeding of untreated seeds, cooler soils tended to improve germination rates.

- **Establishment phase**
  Unavailable.

- **Active growth phase**
  Unavailable.

- **Hardening phase**
  Unavailable.

- **Harvest, storage & shipping**
  Unavailable.

VEGETATIVE PROPAGATION

- **Division**
  May be divided in spring (Holloway, 2024)

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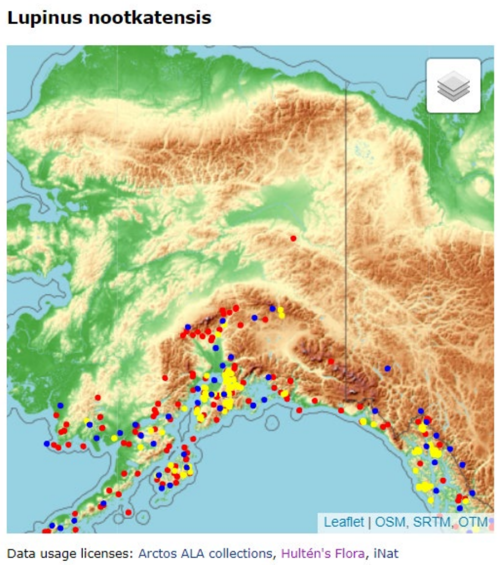
Propagation Profiles

Scientific name: *Lupinus nootkatensis*
Synonyms: n/a
Common name (s): Nootka lupine
Family: Fabaceae
USDA PLANTS code: LUNO

Duration: Perennial
Growth habit: Forb/herb
Wetland indicator status: FACU



WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
Georgeson Botanical Garden, Fairbanks, Alaska (Holloway, 2014) - USDA Zone 3b
https://georgesonbotanicalgarden.org/wp-content/uploads/2021/05/2014.-Holloway-Note.56.lupine.pdf

Habitat description:
Dry and open slopes, meadows, gravel bars (Favorite, 2002; Hultén, 1968).

Elevation range:
Low to middle elevations in Alaska. In British Columbia, up to 1920 meters (Klinkenberg, 2020).

Soil preferences and adaptations:
Medium to coarse soils, silt loam or sandy well-drained soils (Favorite, 2002).

Shade tolerance:
Low. Full sun promotes vigorous growth, partial shade will result in leggy plants with less branching (P. Holloway, 2014).

Drought tolerance:
None (USDA & NRCS, 2023).

Disturbance tolerance:
Unavailable.

Created 2024, Kelly Sivy
Last updated: n/a

Homer Soil & Water
CONSERVATION DISTRICT

Propagation Profiles

Community interactions:
Influences plant competition through the formation of dense patches (Vetter et al., 2018). Fixes nitrogen. Slightly toxic, seeds are poisonous and cause internal inflammation (Hultén, 1968; USDA & NRCS, 2023).

Wildlife associations:
Roots are readily consumed by grizzly bears (Favorite, 2002).

Restoration value:
Acts as an ecosystem engineer in sub-polar ecosystems through its slope stabilization and nitrogen fixing capability (Vetter et al., 2018).

Primary reproductive mode:
Seed.

Seed type:
Orthodox (SER, INSR, RBGK, 2023).

Ease of growing:
Despite the abundance of seeds produced, this species can be difficult to propagate from seed (Holloway, 2014). Once established, it spreads rapidly by rhizomes in mild climates and coastal areas. Susceptible to powdery mildew (Holloway and Gauss, 2021). Even though lupine is difficult to grow from seed, this method is still recommended over bareroot production or plant salvage, as mature plants do not transplant well from the wild (Holloway, 2014; Ontario Rock Garden & Hardy Plant Society, 2023).

SEED

- **Collection recommendations**
  Timing of seed collection is crucial, as legumes do not ripen evenly, and once ripen will shatter (Holloway, 2014). Pods mature from the bottom up on the stalk and dehisce explosively to spread seed when brown/black. Begin harvest when middle pods begin to mature. Lower pods will have released seeds, and pods at the tip will be immature. Or collect over a period of days or weeks as seeds mature. Holloway and Gauss (2021) recommend enclosing the entire stalk after flowering in a cheesecloth bag or knee-high stocking secured around the stem with a twist tie. Harvest the entire stalk of pods. Enclose in a paper bag and allow pods to pop open. Note that larvae feed on seeds, which can make collection of viable seeds difficult.

- **Seeds per/lb**
  10,333 seeds per pound (USDA & NRCS, 2023).

- **Processing techniques, recommended equipment**
  Unavailable.

- **Storage**
  Seeds retain 100% viability following drying to equilibrium moisture content with 15 % relative humidity and freezing for 48 days at -20°C (SER, INSR, RBGK, 2023).

- **Scarification requirements**
  See germination techniques below.

- **Stratification requirements**
  None.

- **Germination rates and techniques**
  Holloway (2024) writes:
  "Seeds range in color from light brown, greenish brown to nearly black. The lighter the color, the less mature the seeds are. They will have a range of dormancies ranging from none (pale colored seeds) to significant physical seed coat dormancy (black). Outdoors, direct sow in autumn. You will get some germination the first year, then more in subsequent years. Seeds outdoors can persist for years in a seed bank as long as they are fully mature."

  Indoors, soak seeds in water for 4 hours and plant seeds that double in size. After soaking, seeds that don't double in size are dormant; scarify these by nicking with a knife or needle, or rubbing with sandpaper. Seeds can also be acid scarified for 32-40 minutes and rinsed. Legume seeds are susceptible to damping off; to mitigate, apply fungicide drench immediately after sowing in potting soil (Holloway, 2014).

- **Establishment phase**
  Thin seedlings after the first true leaves emerge (Favorite, 2002). Plants are also susceptible to powdery mildew once established (Holloway and Gauss, 2021), suggesting that continued fungicide drench treatment may be warranted across all stages of cultivation.

- **Active growth phase**
  Unavailable.

- **Hardening phase**
  Unavailable.

- **Harvest, storage & shipping**
  Unavailable.

VEGETATIVE PROPAGATION

- **Division**
  May be divided in spring (Holloway, 2024).

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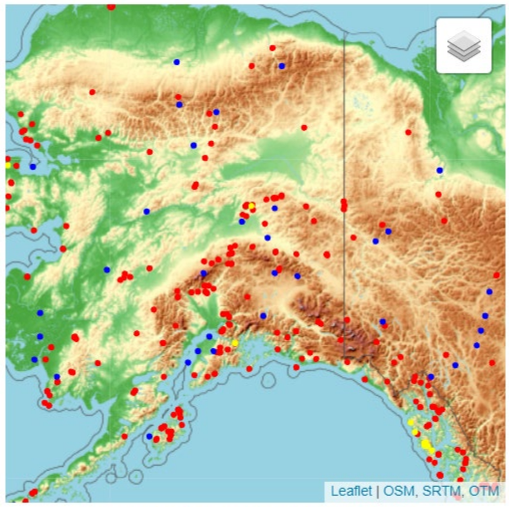
Propagation Profiles

Scientific name: *Luzula parviflora*
Synonyms: several, see [USDA Plants database]
Common name (s): smallflowered woodrush
Family: Juncaceae
USDA PLANTS code: LUPA4

Duration: Perennial
Growth habit: Graminoid
Wetland indicator status: FAC



WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
Northern Interior British Columbia (Burton & Burton, 2003) - USDA Zone equivalent 4a-5b
https://www.for.gov.bc.ca/hfd/library/documents/bib107640.pdf

Propagation protocol developed for Corvallis Plant Material Center, seed source unknown (Bartow, 2005a) - USDA Zone 8b
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=juncaceae-luzula-2927

Habitat description:
Moist forest and tundra (Hultén, 1968).

Elevation range:
Low to high elevations. In British Columbia, up to 2575 meters (Klinkenberg, 2020; Pojar & MacKinnon, 1994).

Soil preferences and adaptations:
Medium to coarse, nutrient medium to nutrient rich soils; wet to mesic/hydric (Burton & Burton, 2003; Klinkenberg, 2020).

Shade tolerance:
The USDA reports high shade tolerance; coastal populations in British Columbia report both shade tolerance and intolerance (Burton & Burton, 2003; USDA & NRCS, 2023).

Drought tolerance:
Low (USDA & NRCS, 2023).

Disturbance tolerance:
High. Habitat preferences strongly suggest that natural disturbances are important component to this species' natural and life history (Penskar & Crispin, 2008).

Community interactions:
Unavailable.

Wildlife associations:
Excellent forage value (Gerling et al., 1996).

Restoration value:
The ability of *L. parviflora* to grow on poor soils and colonize recently disturbed sites – such as borrow pits after road construction and recently burned/logged sites – suggest it is a good candidate for revegetation and restoration practices (Burton & Burton, 2003; Kershaw & Kershaw, 1987; Penskar & Crispin, 2008).

Primary reproductive mode:
Seeds and sprigs (USDA & NRCS, 2023).

Seed type:
Orthodox (SER, INSR, RBGK, 2023).

Ease of growing:
Burton and Burton (2003) recommend using a greenhouse to propagate seed for plug production.

SEED

- **Collection recommendations**
  Burton and Burton (2003) collected seeds of *L. parviflora* in Bulkley Valley, British Columbia, starting in mid-July. Because seeds shatter somewhat easily, they recommend using sharpened hand clippers and clipping seed directly into a bin or bag to minimize seed loss during harvest.

  Holloway (2024) writes:
  "Self-compatible. Individual flower heads can contain up to 100 flowers. Fruit is a capsule with usually 3 seeds per capsule. Harvest seeds when capsules become brown and before they crack open. Seeds are tiny and easily lost. Use hand clippers or knives and hold entire seed heads over a bag or tray to capture seeds during harvest."

- **Seeds per/lb**
  6,241 seeds per gram (Burton and Burton, 2003).

- **Processing techniques, recommended equipment**
  Holloway (2024) writes:

"Dry entire flower heads on screens that allow seeds to fall through to a tray below. An air/screen cleaner or seed blower can be used to separate trash, but a lot of seeds will be lost if air is too strong."

Burton and Burton (2003) used a combine thresher and fanning mill to process seed:
"Run through combine thresher at 1548 rpm with 4 mm gap. Clean seed with fanning mill set with a 1.2 mm x 7.1 mm slot prescreen, 1.2 mm x 1.5 mm slot top screen, and blank bottom. Final clean with a 0.6 mm hand sieve."

- **Storage**
  Store under cool, dry conditions (Burton & Burton, 2003).

  Seeds have been documented to persist in the soil for over 10 years, and up to 150-200 years in Alaska seedbeds (Bennington et al., 1991; SER, INSR, RBGK, 2023).

- **Scarification requirements**
  Experimental trials with seeds collected in the Colorado Rockies found that seed stored for 8 months at room temperature, then scarified a the micropyle, resulted in 100% germination. When stored for 1 month at room temperature, then scarified at the micropyle, germination was 66%. For seed either unscarified, or scarified at the hilum, germination was less than 30% (Bell & Amen, 1970).

  Holloway (2024) notes that seed benefit from a gibberellic acid soak after drying and before sowing.

- **Stratification requirements**
  Variable results. For seeds originating from the Olympic Peninsula in Washington, a 5 week cold moist stratification was used (Bartow, 2005b). However, for Northern British Columbia seed populations, a 60 day, 5°C stratification was found to reduce germinate rates (Burton & Burton, 2003).

- **Germination rates and techniques**
  The only trial on record with the SER Seed Information Database reports 82% germination after 154 days when germinated in 1% agar under a 12/12 hr light cycle and 15/5°C thermocycle.

  A study by Bell et al. (1970) of summer harvested seeds from the Colorado Rockies suggest that an after-ripening period is an important dormancy-breaking mechanism for successful germination.

  Holloway (2024) writes:
  "Seeds are dormant immediately after harvest, but dormancy disappears following dry storage at room temperature (21°C, 70°F) for 6-8 months. Seeds benefit from a 24 hr soak in 1000 ppm gibberellic acid (GA_3) after dry storage and prior to sowing. Sow onto surface of sterile seed starting mix. Best germination at alternating temperatures (25/10°C; 77/50°F for 16/8 hrs). Even under optimum conditions, germination may be prolonged: 20-60 days."

Burton and Burton (2003) report that *L. parviflora* germinated best on cool soils. Of their germination trials, results were consistently highest when germinated under a 25/15°C thermocycle. Seeds began germinating after 25 days, with 50% potential after 42 days.

Bartow (2005a) reports sowing seeds into containers filled with soilless peat-based growing medium (Sunshine #1), amended with Micromax micronutrients and Osmocote 14-14-14 slow release fertilizer. They also describe the following germination method with thermocycling:
"Seeds were placed in plastic germination boxes on moistened germination paper and stored in a growth chamber set at 8°C days and 4°C nights with 8 hours of light for 45 and 90 days each. One control box of seeds was left in a greenhouse set at fall temperatures (16°C days/10°C nights.)"

- **Establishment phase**
  Burton and Burton (2003) report successfully establishing seed production plots by producing plugs (from wild seed) in the greenhouse, and then outplanting plugs to prepared fields. Preferred soils are loamy and cool with a firm seedbed. They also used the selective broadleaf herbicide Banvel™ (dicamba) with no apparent damage to *L. parviflora* plants.

- **Active growth phase**
  Unavailable.

- **Hardening phase**
  Unavailable.

- **Harvest, storage & shipping**
  Unavailable.

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Propagation Profiles

Scientific name: *Papaver radicatum*
Synonyms: n/a
Common name (s): rooted poppy
Family: Papaveraceae
USDA PLANTS code: PARA11

Duration: Select
Growth habit: Forb/herb
Wetland indicator status: Unavailable

WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
Kentucky, seed source unknown (Baskin & Baskin, 2002) - USDA Zone 7a
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=papaveraceae-papaver-1553

Habitat description:
Alpine region within arctic climates; arctic poppies are known as one of the world's most northern-occurring plants (Dyer, 2018). Found in mesic and dry tundra, dry cliffs, and talus slopes in alpine zones (Klinkenberg, 2020; Panchen et al., 2022).

Elevation range:
High elevations throughout their range. Up to 2600 meters in St. Elias Mountain Range in Alaska (Baskin & Baskin, 2002; Hultén, 1968).

Soil preferences and adaptations:
Sandy and gravelly soils (Hultén, 1968).

Shade tolerance:
Low (Dryer, 2018).

Drought tolerance:
Unavailable.

Created 2024, Kelly Sivy
Last updated: n/a

Homer Soil & Water Conservation District

Disturbance tolerance:
Papaver radicatum is an early succession species that rapidly colonizes areas exposed by receding glaciers (Jones & Henry, 2003).

Community interactions:
Does not compete well, and reproduction is limited by dense vegetation (Aiken, 2007; Panchen et al., 2022).

Wildlife associations:
Eaten by voles (Holloway, 2024).

Restoration value:
Unavailable.

Primary reproductive mode:
For southern Norwegian populations, *P. radicatum* is known to only reproduce sexually, with no potential for asexual reproduction in the wild (Nordal et al., 1997). An earlier study of populations in the Northwest Territories of Canada observe that reproduction by seed is rare, even with a near total lack of asexual reproduction (Bell & Bliss, 1980).

Seed type:
Unavailable.

Ease of growing:
Does not do well in warm temperatures. Plants may not flower until second season and are short-lived (Dyer, 2018). Panchen et al. (2022) describe the germination strategy of wild populations of *P. radicatum* as "slow and steady," whereby germination occurs later, at a lower rate, and over a longer period of time.

SEED

- **Collection recommendations**
  Holloway (2024) writes of the subspecies *P. radicatum* spp. *alaskanum*:
  "Oblong capsule with holes just beneath the cap. Harvest entire capsules just as holes begin to open and capsule turns brown. Dry on screens so seeds fall through onto a tray. The black/brown seeds are tiny but easy to extract in quantity."

- **Seeds per/lb**
  Unavailable.

- **Processing techniques, recommended equipment**
  With careful harvest and handling cleaning may not be necessary; otherwise use an air/screen cleaner to remove trash (Holloway, 2024).

- **Storage**
  Unavailable.

- **Scarification requirements**
  Unavailable.

- **Stratification requirements**
  Optimal germination of seeds of *P. radicatum* var. *pseudoradicatum*, collected in China, occurred following 120 days of chilling at 5°C (Ahn et al., 2011). In a recent study on seed viability of arctic species in the Canadian Arctic, researchers describe cold stratifying fall-collected *P. radicatum* seeds at -20°C for 30 days, before germinating the following season (Panchen et al., 2022).

- **Germination rates and techniques**
  Germination of *Papaver* spp. have responded to pre-germination treatments of gibberellic acid, which can accelerate and/or promote uniform germination; exact concentrations (recommended starting concentration of 100 milligrams GA per 100 milliliters water) would need to be determined for a given species and seed accession (Holloway, 2011). To germinate, Holloway (2024) further advises:
  "Direct sow outdoors in autumn or spring. Germination is better in light and alternating temperatures. Germination begins in 7-10 days at 25/10°C for 16/8 hrs or constant 21°C (70°F)."

  The Ontario Hardy Plant Society suggests exposing seeds to fluctuating outdoor winter temperatures, including freezing for 3 months, followed by a gradual increase in light and temperature in spring (Ontario Rock Garden & Hardy Plant Society, 2023).

  Baskin and Baskin (2002) report that seeds show morphiophysiological dormancy, and that germination took place between 19°C and 23°C. Seeds from Greenland exhibited a pronounced germination threshold of 19°C, and germination occurred most rapidly between 19-23°C; above these temperatures, germination was found to rapidly decrease (Olson & Richards, 1979). Authors further note differences among the seed populations in percent germination and overall seed viability, hypothesized to be related to available solar radiation inherent across a populations' range (Olson & Richards, 1979).

- **Establishment phase**
  Unavailable.

- **Active growth phase**
  Unavailable.

- **Hardening phase**
  Unavailable.

- **Harvest, storage & shipping**
  Unavailable.

Propagation Profiles

VEGETATIVE PROPAGATION

- **Division**
  Plants may be propagated via division during non-flowering times (spring or autumn), preferably in spring as crown growth begins (Holloway, 2024).

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Propagation Profiles

Scientific name: *Picea glauca*
Synonyms: n/a
Common name (s): white spruce
Family: Pinaceae
USDA PLANTS code: PIGL

Duration: Perennial
Growth habit: Tree
Wetland indicator status: FACU

WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
Seeds collected near Tyonek, Alaska - USDA Zone 5a, germinated in Durham, NC - USDA Zone 8a (Densmore, 1979)
https://www.frames.gov/catalog/6401

Summary of Alaska Plant Materials Center experiments and grower experiences throughout Alaska, specific seed sources unknown (Holloway, 1985)
https://georgesonbotanicalgarden.org/wp-content/uploads/2021/05/1985.Holloway.prop_.ak_.native.plants.pdf

Habitat description:
Muskegs, bogs, river banks, and mountain slopes (Nesom & Guala, 2003); generally upland, warm, well-drained permafrost-free sites (Abrahamson, 2015).

Elevation range:
Sea level to over 1500 meters, with stunted growth characteristics in higher elevation populations (Hultén, 1968).

Soil preferences and adaptations:
Well drained mineral soils where there is no permafrost or it is very deep (Nesom & Guala, 2003; USDA & NRCS, 2023). Tolerant of acidic and alkaline soils, with optimum pH range between 4.7-7 (Abrahamson, 2015).

Shade tolerance:
Intermediate (USDA & NRCS, 2023).

Drought tolerance:
High (USDA & NRCS, 2023).

Disturbance tolerance:
Medium. However, mature stands have low fire tolerance, and stands can be severely impacted fire intervals less than 40-50 years (Burns & Service, 1990).

Community interactions:
Unavailable.

Wildlife associations:
Used by many species for both cover and forage, including numerous small mammal and bird species, moose, and caribou (Abrahamson, 2015).

Restoration value:
Successfully used for revegetation of coal mine overburden sites, and has also naturally recolonized agricultural fields (Abrahamson, 2015).

Primary reproductive mode:
Seed.

Seed type:
Orthodox (SER, INSR, RBGK, 2023).

Ease of growing:
Easy and fast (Holloway, 2024).

SEED

- **Collection recommendations**
  Alaskan stands are reported to produce "good" seed cone crops at 45-170 years old and older (Abrahamson, 2015; J. Zasada, 1971). Most seed cones are held in the uppermost 6-8 branch whorls (Alden, 1985).

  Consider seed production conditions and seed viability when selecting stands for seed harvest. For in-depth recommendations and review of collection and processing of *P. glauca* seed cones in Alaska, see Alden (1985) Chapter 3: Seed Supply and Handling. Seed production may be restricted within 2-12 year intervals (Alden, 1985; Youngblood & Safford, 2008). The relationship between climatic conditions, seed crop production, and seed viability is complex and dependent on conditions for up to 3 years prior. Abundant seed crops in Interior Alaska are determined by warm and dry conditions during the early growing season of the previous year, with weather during the seedfall year an important factor in determining seed viability and maturation (Alden, 1985; Roland et al., 2014).

Seeds cones are highly susceptible to pathogens, such as spruce cone rust *Chrysomyxa pirolata*, and predation by rodents and insects. Alden (1985) reviews several species of insects that can infest cones with no external evidence of inhabitation, which should be considered when collecting cones for harvest. Seed viability is highest during peak seed dispersal which generally ranges from late summer through early fall; in interior Alaska, peak seed dispersal occurs in September (Abrahamson, 2015). Seeds may continue to be released after that, but seed viability drops considerably (e.g., seed viability in stands at Bonanza Creek outside of Fairbanks was 72% in September, and reduced to 29% by March (Zasada, 1985).

Because of the high degree of variability in seed cone crop abundance, seed vigor, and seed maturation while in the cone, timing collection efforts is difficult. Alden (1985) summarizes some key criteria: "In general, white spruce cones should be collected only after the length of the embryo is 75% of the length of the embryo cavity, seed coat and wings begin to darken, cone-moisture content declines to 150% or less of dry weight, specific gravity is less than 0.95, cones begin to yellow or brown, and scales begin to loosen on the earliest-maturing cones." Collecting seed cones 2-4 weeks prior to ripening, with plans for after-ripening of seeds while still in cones, may ensure seeds reach full vigor (Alden, 1985; Youngblood & Safford, 2008). Facilitate post-harvest ripening of premature cones by air-drying collected cones in half-filled burlap sacks or open screens for a few weeks at 5-15°C and 60-75% relative humidity. Cones may also be ripened post-harvest under field conditions provided there is adequate ventilation (Alden, 1985). Remove seeds from cones promptly once ripened, as failing to remove them on time can adversely impact seedling growth rate after germination (Alden, 1985).

Topping trees may stimulate cone production while also managing tree height for future collection efforts (Alden, 1985).

Holloway (2024) summarizes her guidance on seed collection:
"Cones need to be harvested before the scales open and release seeds. They change from green to tan to brown when fully mature. Cone opening is determined by maturity as well as humidity. Cones/scales do not shatter when mature. It is common for cones to open, then reverse and close in rainy weather. They can be hand harvested using knives, clippers, pruning saws… They can also be removed from cut timber during commercial harvest… Some people place screened seed capture trays beneath the trees and capture winged seeds as they fall to the ground. (You lose a lot if the wind is blowing or the humidity is high, and cones do not open fully). Winged white spruce seeds can float far away from their source with even a slight breeze."

- **Seeds per/lb**

  135-400,000 seeds/lb (Youngblood & Safford, 2008).

  500,000 seeds per kilogram; an individual tree may produce 8-12,000 cones during good years, equivalent to 35 liters, or 250,000 seeds (Burns & Service, 1990).

- **Processing techniques, recommended equipment**

  Extraction and processing of ripened seeds from cones requires careful handling and procedures, and in some cases represents an iterative process. Once cones have matured, expose to additional drying under heat to flex the cones scales and maximize seed extraction: Place cones in convection kiln for 6-24 hours at 38-49°C; some experimentation may be necessary to determine the lower maximum temperatures within that range to avoid seed damage (Youngblood & Safford, 2008). Once cones are dried, tumble or shake seeds from opened cones. Any seed cones that fail to re-open can be remoistened, redried, and retumbled. Seed collections with considerable amounts of debris can be cleaned with an oscillating screen scalper. Take care when removing wings from the seed coat to avoid damaging seed; removal of wings can be facilitated by pre-soaking with a fine water mist (Alden, 1985). For further recommendations, see Alden (1985) Chapter 3: Seed Supply and Handling.

Holloway (2024) summarizes additional guidance regarding seed processing:
"Foresters have specific methods for determining the maturity of cones. It is worthwhile connecting with US or State Forestry personnel in the area to learn methods (e.g. moisture content, specific gravity) and possibly use their equipment. Just because there's a cone doesn't mean there are seeds inside, and often, normal-looking black seeds can be unfilled (no embryo). Harvest cones when they turn from green to tan to light brown and before scales open. Place them in a bag or on a covered tray so the scales separate. In wet areas, an oven dryer works well to dislodge seeds. A lot of seeds will fall out, but many are stuck in the cone scales. Foresters shake the cones to dislodge the seeds. This can be done by hand, by bouncing the cone around in a closed paper bag, or with special cone tumblers or vibrators. If the seeds are not released, cones can be remoistened (scales close) and redried (scales open up) to release the seeds. Dry cones on screens that allow seeds to fall through the screen. Avoid breezy areas because seeds are winged and can blow around. Once separated from the cone, rub off the wings using a screen or hand rubbing in a cloth bag. Use an air screen cleaner to separate seeds from their papery wings."

- **Storage**
  Seeds remain viable for 1 year in the wild; clean and dry seed may retain viability up to 10 years in storage (Alden, 1985). Seed viability was reportedly maintained for 5-17 years when hermetically stored at 2-4°C with 4-8% moisture content (SER, INSR, RBGK, 2023). Other trials on file with the SER Seed Information Database report seeds to retain viability after 10-20 years at 4-8% moisture content stored between -10°C and 3°C. Alden (1985) recommends drying seeds at 25-30°C to stabilize seed moisture content and then storing at 4-8% moisture content between 2 and -18°C. Germination rates of seeds stored 7 years at -18°C to 3°C and 7% moisture was similar to germination rate of freshly collected seed (Youngblood & Safford, 2008). Store in 4-10 mil polyethylene bags to maintain moisture content within specifications and ensure seed longevity (Youngblood & Safford, 2008).

- **Scarification requirements**
  Unavailable.

- **Stratification requirements**
  Seeds will germinate without stratification, but germination may be accelerated by stratification (Youngblood & Safford, 2008). Timing and handling of collected seeds is thought to affect prechilling requirements. For nursery propagation, pre-chilling seed at 2-4°C is recommended (Burns & Service, 1990). In some Alaska-based studies, stratification of mature seeds collected from high latitudes was detrimental to germination (Youngblood & Safford, 2008). Holloway (1985) similarly reports that for fully mature seed, pretreatments did not generally increase germination percentage. However, Densmore (1979) found that for seeds collected on the Kenai

Peninsula, cold stratification at 2-5°C for 84-99 days significantly increased germination. Densmore also found that, across all light and stratification treatments, unstratified seeds exposed to a long light cycle had the highest germination rate (90+%), suggesting that the efficacy of stratification requirements may ultimately be dependent on photoperiod implemented during germination.

- **Germination rates and techniques**

For Alaskan seed, Holloway (1985) advises sowing in spring or fall, or germinate on filter paper or in 3:1 peat/vermiculite at 20-25°C (68-77°F). She provides additional guidance:

"Sow seeds in tree tubes such as Spencer Lemaire or Rootrainer® Hillson books. Do not use shallow plant trays and cell packs. It is critical that tree roots have plenty of room to grow downward, and containers need openings in the bottom to promote fibrous root development. Sow 2-3 seeds per tube (based on germination test) filled with a friable potting mix (often 3:1 (v:v) peat/perlite or peat/vermiculite). Sow on the surface, then cover with fine gravel, perlite or vermiculite. Keep moist during germination and fertilize weekly with liquid complete fertilizer (e.g. 18-18-18) after seedlings are 2 – 4 cm (1 – 1.5 in) tall. Seed germination should be timed so seedlings are planted outdoors before they are 6 mos old. Older seedlings left in the tubes or ones overwintered in the tubes, can have significant root growth problems (girdling) that can impact growth for many years after planting."

In general, it is advised to germinate seeds at a mean temperature of 10-24°C (Burns & Service, 1990). Diurnal temperature changes can be implemented to facilitate germination. See Burns and Service (1990) for an extensive summary on the interaction between light intensities and temperatures for affecting germination; overall they advise 400 lumens/m^2 with a thermoperiod cycle of 25°C/20°C for day and night. In general, light durations of less than 14 hours may cease growth, while light cycles of 16 hours or more can accelerate growth.

Densmore's (1979) study suggests that for unstratified seed, long light cycles appear to facilitate germination and that photoperiodic control could break conditional dormancy, especially at lower temperatures. In this study, exposing seeds to a long (e.g., 22 hours/2 hours dark) day light cycle resulted in the highest germination (90%+); across all light conditions, higher germination rates occurred at lower (<20°C) temperatures.

Youngblood and Safford (2008) summarize germination methods for stratified seed, advising to pre-chill 14-21 days at 3-5°C under light, on top of blotter. Pre-chill 2-4°C for 6 weeks to achieve high germination rate; or run under cold water for 24 hours, blot dry, refrigerate for 4°C for 3 weeks; stratification may be bypassed when storing cones at 5°C for 4 weeks.

For growing medium, Youngblood and Safford (2008) instruct providing a mineral mixture with high water retention potential, such as rotten wood, shallow duff, or organic soil and mineral mixtures. A commercial mix of equal parts sphagnum peat moss and vermiculite, or sphagnum peat moss, peat moss, and vermiculite will facilitate a high stem caliper and stem height, and heavy stem and root system for containerized seedlings.

Finally, note that germination is negatively impacted for seeds treated with insecticides, fungicides, and rodent repellent (Youngblood & Safford, 2008).

- **Establishment phase**
  Once germinated, extend light/simulated daylength to prevent dormancy and facilitate growth; 414 -4150 umol/m²/sec (Youngblood & Safford, 2008).

- **Active growth phase**
  Macro and micro nutrients and rhizobacteria will promote seedling emergence (Youngblood & Safford, 2008). Reductions in photoperiod, nitrogen stress, and moisture stress will elicit dormancy in seedlings. To break dormancy, expose seedlings to 4-6 weeks at 0°C or lower (Youngblood & Safford, 2008).

- **Hardening phase**
  Reduce photoperiod to trigger hardening off (Youngblood & Safford, 2008).

- **Harvest, storage & shipping**
  Picea glauca is sensitive to shock during transplanting and susceptible to "check," this can be minimized by treatments that promote early root growth (Burns & Service, 1990).

  For in-depth descriptions of various techniques implemented to increase seed cone production for harvest among cultivated stands of *Picea* spp., see Youngblood and Safford (2008).

VEGETATIVE PROPAGATION

- **Cuttings**
  For best rooting ability, target young/juvenile trees for cuttings; trees 10-15 years old or older may not be as successful (Burns & Service, 1990). Summer stem cuttings may also be taken from lower lateral branches, for grafting and tissue culture, which is sometimes used to build clonal tree nurseries, but this method is not often used for day-to-day propagation since propagation by seed is preferable (Holloway, 2024).

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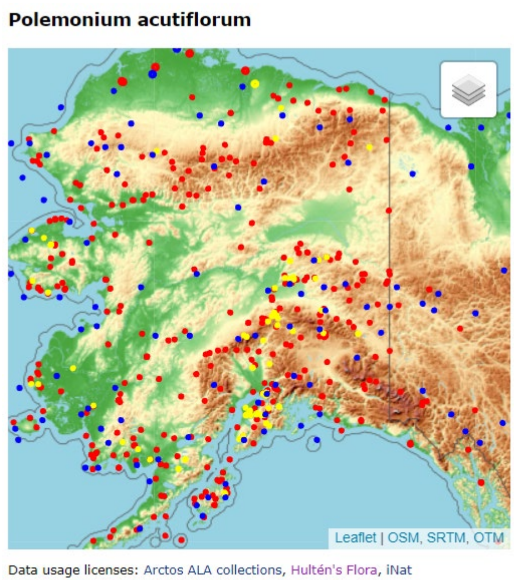
Propagation Profiles

Scientific name: *Polemonium acutiflorum*
Synonyms: *Polemonium caeruleum* ssp. *villosum*
Common name (s): tall Jacob's-ladder
Family: Polemoniaceae
USDA PLANTS code: POAC

Duration: Perennial
Growth habit: Forb/herb
Wetland indicator status: FAC



WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
Unavailable.

Habitat description:
Wet meadows, streamsides, thickets, tundra (Hultén, 1968; Klinkenberg, 2020).

Elevation range:
Middle to subalpine (Pojar and MacKinnon, 1994). In British Columbia, this species is found from sea level to 2440 meters (Klinkenberg, 2020).

Soil preferences and adaptations:
Adapted to medium and coarse soils (USDA & NRCS, 2023).

Shade tolerance:
High (USDA & NRCS, 2023).

Drought tolerance:
Low/none (USDA & NRCS, 2023).

Disturbance tolerance:
Unavailable.

Community interactions:
Unavailable.

Wildlife associations:
Low forage (generally 5-10% of diet) and low over value for small mammals (Quinlan & Cuccarese, 2004).

Restoration value:
Unavailable.

Primary reproductive mode:
Primarily by seed but may also be propagated from cuttings and division (USDA & NRCS, 2023).

Seed type:
Unavailable.

Ease of growing:
Unavailable.

SEED

- **Collection recommendations**
  Holloway (2024) writes:
  "Fruit consists of tiny brown capsules opening at the top. Capsules have variable ripening on individual plants, so repeated harvests are necessary. Once capsules open, seeds can be scattered with the slightest movement or breeze. Harvest entire capsules by hand; cut multiple stems, then dump upside down into a paper bag; or use electric shears to cut stems and dump them into a tray. With electric shears, you get a variety of maturities, so harvest is timed for greatest capsule maturity."

- **Seeds per/lb**
  464,940 seed per pound (USDA & NRCS, 2023).

- **Processing techniques, recommended equipment**
  Holloway (2024) writes:
  "Many seeds dislodge easily from capsules after drying on screens or trays. Others remain stuck in the bottom of the capsule and require gentle rubbing on a screen. Air/screen cleaners are best for separating seeds from chaff."

- **Storage**
  Seeds stored frozen may maintain 50% or greater viability for at least 5 years (Holloway, 2024).

- **Scarification requirements**
  Unavailable.

- **Stratification requirements**
  Unavailable.

- **Germination rates and techniques**
  The PMC (2004) recommends soaking fresh seed for 24 hours before fall sowing, or direct sowing in spring after cold storage. In one study seeds were germinated in petri dishes lined with moist filter paper and exposed to continuous fluorescent light and 21°C; authors reported only 4% germination after 30 days, concluding that more complex germination requirements were at play. In outdoor plots, seeds successfully established on both irrigated and unirrigated plots, and bloomed mid to late August (Rutledge & Holloway, 1994).

  Holloway (2024) writes:
  "Tiny black seeds may be sown outdoors in spring or autumn. Indoors, sow onto sterile germination medium and cover lightly with fine vermiculite. No special pretreatments necessary. Seedlings appear in 10-14 days at 68°F (20°C)."

- **Establishment phase**
  Unavailable.

- **Active growth phase**
  Unavailable.

- **Hardening phase**
  Unavailable.

- **Harvest, storage & shipping**
  Unavailable.

VEGETATIVE PROPAGATION

- **Division**
  Plants may be propagated through division in spring, just as growth begins (Holloway, 2024).

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Propagation Profiles

Scientific name: *Polemonium pulcherrimum*
Synonyms: n/a
Common name(s): Jacob's-ladder
Family: Polemoniaceae
USDA PLANTS code: POPU3

Duration: Perennial
Growth habit: Forb/herb
Wetland indicator status: Unavailable

WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
Seeds propagated by Alaska Plant Material Center (seed source unknown), Palmer, Alaska (Moore & Hunt, 2006) - USDA Zone 5a
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=polemoniaceae-polemonium-2747

Bulkley Valley, Northwestern British Columbia (Burton & Burton, 2003) - USDA Zone equivalent 4b
https://www.for.gov.bc.ca/hfd/library/documents/bib107640.pdf

Glacier National Park (Luna et al., 2002) – USDA Zone 5a
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=polemoniaceae-polemonium-126

Habitat description:
P. pulcherrimum grows in dry, rocky places occurring in low to mid-elevation sites up to alpine habitats (Hultén, 1968; Hunt & Wright, 2007). Will colonize road shoulders, talus and scree slopes, and cliffs (Luna et al., 2002).

Elevation range:
Up to 2,000 meters (Hultén, 1968).

Soil preferences and adaptations:
Adapted to gravel soils, with tolerance of saline conditions; dose not tolerate wet soils (Wright & Czapla, 2013).

Created 2024, Kelly Sivy
Last updated: n/a

Homer Soil & Water
CONSERVATION DISTRICT

Shade tolerance:
Moderate (Burton & Burton, 2003).

Drought tolerance:
High (Wright & Czapla, 2013).

Disturbance tolerance:
Seedbank density and seedling emergence may be sensitive to disturbances that compact surface soils (Zabinski et al., 2000). Studies in Alaska suggest that *P. pulcherrimum* may also show sensitivity to soil toxicity associated with munitions exercises conducted on military training grounds (Doherty et al., 2019).

Community interactions:
Weak competitor (Wright and Czapla, 2013).

Wildlife associations:
Unavailable.

Restoration value:
Vigorous seedlings and tolerance of dry areas makes *P. pulcherrimum* a good candidate for revegetation projects (Hunt & Wright, 2007; Wright & Czapla, 2013). The 'Butte' germplasm, developed by the Alaska Plant Materials Center in Palmer, AK, is recommended for revegetation use and is reported to grow quickly and easily in appropriate ecosystems (Hunt & Wright, 2007).

Primary reproductive mode:
Can be propagated by seed or plant division (Lady Bird Johnson Wildflower Center, 2023).

Seed type:
Orthodox (SER, INSR, RBGK, 2023).

Ease of growing:
P. pulcherrimum has deep, fibrous tap roots and strong ability to reseed itself in the wild (Hunt & Wright, 2007).

SEED

- **Collection recommendations**
  Time collection just as or prior to seed ripening, as over-ripe seeds will dehisce and seed loss will occur (Burton & Burton, 2003). When ripe, seeds are red brown to black (Luna et al., 2002; Moore & Hunt, 2006). Moore and Hunt (2006) report hand-collecting seeds in July/August in Alaska, once "grayish" capsules began opening. In Northwest British Columbia, seeds were harvested by Burton and Burton (2003) from July to October, with ripe seeds often observed in June. Avoid collecting when wet, as seeds become slimy, which could be related to fungus (Burton & Burton, 2003; Hunt & Wright, 2007).

  To collect, hold seed heads over bin or paper bag, and use hand clippers or scissors to clip seed heads into receptacle; store in well-ventilated shed before cleaning (Burton & Burton, 2003; Luna et al., 2002). For seed harvest from cultivated stands, place plastic between rows to minimize seed loss and recover dropped or dehisced seed, and collect seeds from plastic immediately as they become slimy with ambient surface moisture (Burton & Burton, 2003).

- **Seeds per/lb**
  The Alaska Plant Materials Center reports 413,115 seeds per pound for the 'Butte' germplasm (Hunt & Wright, 2007). Luna et al. (2002) report 704,000 seed per kg, for seed collected in Montana.

- **Processing techniques, recommended equipment**
  Moore and Hunt (2006) report air drying seeds and cleaning seeds with a brush cleaner, hand screening, and air. Luna et al. (2002) reports cleaning seeds with a hammermill and 1/16" screen. Burton and Burton (2003) report cleaning seeds with a fanning mill, set with a 1.2 x 7.1 mm prescreen slot; 1.5 mm square top screen; and blank bottom screen. Chaff is then removed with a vacuum separator at medium suction.

- **Storage**
  Moore and Hunt (2006) reports storing seed in a freezer, temperature unspecified. Seed may retain 88% viability after drying to moisture contents in equilibrium with 15% relative humidity, and freezing at -20°C for 47 days (SER, INSR, RBGK, 2023).

- **Scarification requirements**
  Not required.

- **Stratification requirements**
  Luna et al. (2002) report cold-moist stratifying Montana collected seed by placing in fine-meshed bags and burying in peat moss within ventilated containers for 60 days at 3°C. Protocols for germination of Alaska seed indicate no pre-treatment is required (Hunt & Wright, 2007; Moore & Hunt, 2006). Trials conducted by Burton and Burton (2003) using seed from Northern British Columbia determined that a 60-day, 5°C stratification reduced germination capacity, and also do not recommend pre-treating seed.

- **Germination rates and techniques**
  Seed requires light to germinate (Ontario Rock Garden & Hardy Plant Society, 2023). Germination trials from Canada report 100% germination over 35 days in 1% agar under an 8/16 hour light cycle at 15-20°C (SER, INSR, RBGK, 2023). Additional treatments of 250mg/L gibberellic acid and thermocycles of 25/10°C also yielded 100% germination in 35 days. Three US trials (exact location unknown) germinating under the same temperature and light conditions report 60-78% germination rate over 63-70 days (SER, INSR, RBGK, 2023).

  Moore and Hunt (2006), propagating Alaska seed under greenhouse conditions, planted 1 seed per cell, in a growing medium of well-drained upland soil. Seeds germinated after 10 days. Burton and Burton (2003) report highest germination capacity (75-93%) with untreated seed germinated under a day/night thermocycle of 25/15°C; seeds began emerging after 6 days with 50% capacity after 11 days.

In their Montana greenhouse propagation, Luna et al. (2002) report a 75% germination rate. Seeds were direct sown into 172 mL cone-tainers filled with a growing medium of 6:1:1 milled sphagnum peat, perlite, and vermiculite, with 1 gram of Osmocote controlled release fertilizer (13N:13P2O5:13K2O; 8 to 9 month release rate at 21C) and 0.20 grams of Micromax fertilizer (12%S, 0.1%B, 0.5%Cu, 12%Fe, 2.5%Mn, 0.05%Mo, 1%Zn). Seeds were germinated inside a greenhouse where night temperatures were maintained at 16-18°C and day temperatures were maintained between 21-25°C. Seedlings emerged after 8 days. Seedlings were hand watered and moved to the outdoor nursery in mid-May (Montana), where they were irrigated early mornings.

To sow 'Butte' germplasm, seed at ¼" depth into well drained soil; broadcast seeding may also be used (Hunt & Wright, 2007).

- **Establishment phase**
  Luna et al. (2002) report a 4 week establishment phase. For stand establishment, Burton and Burton (2003) recommend preparation of a weed-free, loamy, firm seedbed; selective herbicides are not recommended for use with this species.

- **Active growth phase**
  Moore and Bunt (2006) reports minimal fertilization once true leaves appeared; overly rich soils can cause leaves to droop (Hunt & Wright, 2007). Burton and Burton (2003) advise keeping plots weed-free and recommend annual application of a low nitrogen fertilizer for stand maintenance and longevity. Luna et al. (2002) report plants becoming "root tight" after a 12-week active growth phase, with no flowering in the first year.

- **Hardening phase**
  To harden, Moore and Hunt (2006) report moving plants to a lath-house. During their 4 week hardening phase in Montana, Luna et al. (2002) report fertilizing plants with 10-20-20 liquid NPK at a rate of 200 ppm during August and September, with irrigation tapering off from September to October and a final irrigation before winterizing plants.

- **Harvest, storage & shipping**
  Luna et al. (2002) report total time to harvest as 6 months, with plants overwintering outdoors under insulated foam covers and snow.

VEGETATIVE PROPAGATION

- **Division**
  P. pulcherrimum may be propagated by division (Lady Bird Johnson Wildflower Center, 2023).

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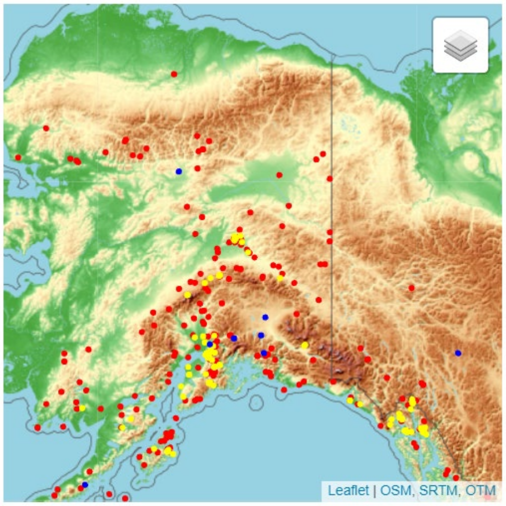
Propagation Profiles

Scientific name: *Pyrola asarifolia*
Synonyms: n/a
Common name (s): liverleaf wintergreen
Family: Pyrolaceae
USDA PLANTS code: PYAS

Duration: Perennial
Growth habit: Subshrub
Wetland indicator status: FACU

Pyrola asarifolia



Data usage licenses: Arctos ALA collections, Hultén's Flora, iNat

WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
Unavailable.

Habitat description:
Dry to moist sites, wooded areas (Gucker, 2007; Hultén, 1968).

Elevation range:
Low to near timberline (Pojar and Mackinnon, 1994).

Soil preferences and adaptations:
Moist, acidic soils with thick/deep litter layers (Gucker, 2007).

Shade tolerance:
High (USDA & NRCS, 2023).

Drought tolerance:
Unavailable.

Disturbance tolerance:
Low (USDA & NRCS, 2023).

Community interactions:
Pyrola is a host and reservoir for inland spruce cone rust *Chrysomyxa pirolata*, a fungus disease affecting spruce trees and cones (Alden, 1985).
Some research indicates *Pyrola* might be mycoheterotrophic, meaning is gets all or some of its food from parasitizing fungi rather than through photosynthesis.; therefore it may be (at least partially) a parasitic plant (Bader, 2016; Hashimoto et al., 2012).

Wildlife associations:
Unavailable.

Restoration value:
Early seral species, also capable of persisting through late seral and climax stages. In Glacier Bay, Alaska, colonizes early successional glaciated rock surfaces (Cooper, 1930; Gucker, 2007).

Primary reproductive mode:
Most likely asexual; little is known but rhizomatous growth seems to be the dominant reproductive mode (Gucker, 2007).

Seed type:
Unavailable.

Ease of growing:
Difficult to grow and very difficult to germinate from seed (Downing, 1996).

SEED

- **Collection recommendations**
  Seeds are in a capsule which opens from the base (Holloway, 2024). Seeds are small and dust-like (Lady Bird Johnson Wildflower Center, 2024).

- **Seeds per/lb**
  0.0001 grams per 1000 seeds (SER, INSR, RBGK, 2023).

- **Processing techniques, recommended equipment**
  Unavailable.

- **Storage**
  Unavailable.

- **Scarification requirements**
  Unavailable.

- **Stratification requirements**
  Unavailable.

- **Germination rates and techniques**
  Data is lacking. Some studies on *Pyrola* spp. and *Pyrola asarifolia* in other regions have found seeds to be mycoheterotrophic and therefore dependent on a symbiotic fungus for germination (Bader, 2016; Hashimoto et al., 2012). Consequently, plants may need soil native to the collection source for germination.

  Holloway (2024) writes:
  "Seeds of wintergreen are extremely tiny and are often called dust seeds. After many attempts, researchers at UAF have had no success developing a reliable method of germination. Research in Japan hints that germination, like that of orchids, requires association with mycorrhizal fungi that provide nutrients for the developing seed instead of an embryo or endosperm (Hashimoto et al., 2012). Japanese populations of *Pyrola asarifolia* showed roots full of the same mycorrhizae associated with nearby tree species such as *Betula* sp. If that is the case, a method of seed germination may be similar to orchid germination using micropropagation. Test tubes full of nutrients replace the mycorrhizal fungi in feeding the tiny seeds. Grown in flasks or test tubes, this method might provide an economical method of propagation for *Pyrola*."

  In the Greater Yellowstone Ecosystem, germination of seeds in field-collected soils suggests that germination is best in unburned, heat-treated soils (Gucker, 2007). Germination was provoked by heating soils to 50°C for 1 hour; seedlings were more likely to emerge when germinated in soils collected in tufted hairgrass/sedge communities compared to forest and woodland soils (Clark, 1991; Gucker, 2007).

- **Establishment phase**
  Unavailable.

- **Active growth phase**
  Unavailable.

- **Hardening phase**
  Unavailable.

- **Harvest, storage & shipping**
  Unavailable.

VEGETATIVE PROPAGATION

- **Division**
  Holloway (2024) writes:
  "Wintergreen produces shallow, elongate rhizomes that could be used for propagation. The only success at UAF was with clumps (12 x 12 in by 6 in deep; 30 x 30 x 15 cm) of forest soils collected and re planted. Re-growth occurred 2 years later around the edges of the original clump. One attempt to propagate by harvested and cleaned rhizome cuttings planted into flats of peat, was not successful."

Propagation Profiles

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Propagation Profiles

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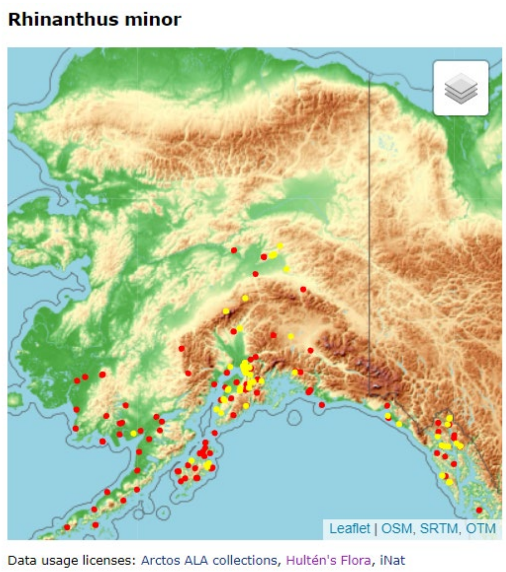
Propagation Profiles

Scientific name: *Rhinanthus minor*
Synonyms: n/a
Common name (s): little yellow rattle
Family: Scrophulariaceae
USDA PLANTS code: RHMI13

Duration: Annual
Growth habit: Forb/herb
Wetland indicator status: FACU



WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
Unavailable.

Habitat description:
Mesic to moist meadows; fields, pastures and lowland clearings from steppe to montane zones (Hultén, 1968; Klinkenberg, 2020).

Elevation range:
In British Columbia, occurs from 60-2073 meters (Klinkenberg, 2020).

Soil preferences and adaptations:
Occurs on clay, sand, chalky soils, and sometimes on peat; prefers soils above 5.0 pH (Westbury, 2004).

Shade tolerance:
Low (Westbury, 2004).

Drought tolerance:
Low; likely drought intolerant (Westbury, 2004).

Disturbance tolerance:
Unavailable.

Community interactions:
This plant is a therophyte (completes life cycle quickly and seeds can survive harsh conditions), and a facultative hemiparasite (partially parasitic but also produces its own food through photosynthesis). It grows on roots of grasses, legumes, and yarrow. Of three host species studied, Westbury (2004) report *Rhinanthus minor* plants connected to *Achillea millefolium* (common yarrow) were taller, more branched, and produced more seed capsules. Yellow rattle can stunt the growth of its host, reducing reproduction (Holloway, 2024).

Wildlife associations:
Unavailable.

Restoration value:
Because of its germination requirements and complex species and soil interactions, it is rare in some systems and can dominate in others. It is capable of readily invading unproductive grasslands amidst dense vegetation, when there is ample opportunity for root hemiparasitism, provided that light competition with other plants remains low (Hulst et al., 1987). It is widely used by gardeners and restoration practitioners to manage grass populations and promote native species and wildflowers; it partially bonds to root systems of grass species, thereby keeping grass populations in check and providing a foothold for wildflower species that might otherwise be outcompeted. European studies suggest its utility as a monitoring tool for grassland and meadow restoration, observing that abundance of *R. minor* indicates soil productivity capable of supporting both host and hemiparasite (Fry et al., 2017; Westbury et al., 2006).

Primary reproductive mode:
Only known to reproduce by seed (Westbury, 2004). Plants are self-compatible and mostly insect pollinated (Holloway, 2024).

Seed type:
Orthodox (SER, INSR, RBGK, 2023).

Ease of growing:
In the wild, it can be rare to sprout from seed, due to a lack of persistent seed bank and few seeds produced per plant (Westbury, 2004). In the absence of host plants, individuals stay stunted and may only produce seed under highly favorable "artificial" conditions (Hulst et al., 1987). In North America, use caution when sowing outdoors as it has potential to become weedy (Ontario Rock Garden & Hardy Plant Society, 2023).

SEED

- **Collection recommendations**
  Seeds are large and winged, and readily eject from ripe capsules disturbed by wind or animals. The fruit is a tan/light brown, dry capsule; seed production is poor if a host plant is not present (Holloway, 2024). Holloway further writes:
  "Capsules change from green to tan/brown when mature. They crack open at the top and can release seeds by wind or other disturbance. Tan/light brown winged seeds fall to the bottom of the capsule and "rattle" when shaken. Harvest entire capsules or stems into a paper bag or tray

before the capsules open. Spread onto drying screens to allow for capsules to dry thoroughly. Seeds may fall out of capsules, but many need to be crushed lightly to release all seeds."

Seed production in the absence of hosts and/or in the absence of nutrients is reportedly minimal with as few as 1-2 seed capsules per plant; commercially grown plants may yield seed at 40-100 kg/ha, depending on weather and sward (host/plot community) conditions (Westbury, 2004).

- **Seeds per/lb**
  Unavailable.

- **Processing techniques, recommended equipment**
  Use a seed blower or air/screen cleaner to separate seeds from chaff; viability rapidly declines the longer seeds are dried, so processing should be quick (Holloway, 2024).

- **Storage**
  The SER Seed Information Database reports the oldest known collection to be 15 years old, with average germination from 93-94% (SER, INSR, RBGK, 2023). Westbury (2004) maintained seed viability for 21 months by exposing to an extended 36-week chilling period at 3°C, followed by a return to naturally cold temperatures outdoors, and reported 99% germination.

- **Scarification requirements**
  Experimental treatments involving scarification have not demonstrated an increase in germination rate.

- **Stratification requirements**
  Seed has intermediate physiological dormancy; a long period of cold stratification is required (Ter Borg, 2005). Review by Westbury (2004) advises breaking dormancy by exposing seed to 2-6°C for 3 months. In a test of European seed lots, stratification at 5°C for 13-37 weeks was sufficient to break dormancy, resulting in up to 97% germination (Marin et al., 2017).

- **Germination rates and techniques**
  Holloway (2024) writes:
  "Seeds are short lived when dry and should be planted outdoors in autumn very soon after harvest. Indoors, seeds germinate best after a 3-month cold stratification period. Sow onto sterile seed starting mix at 21°C (70°F). Germination begins in 10 days, but it can be prolonged depending on how long the seeds remain dry. For container culture, plan to include a host plant in the pots."

  Additional information on germination protocols relevant to North American is sparse. However, this species is a model research plant in Europe for studying host-plant interactions with respect to grassland restoration, and studies occasionally include a propagation component.

  One study featuring wild collected seed in Belgium determined that wet (compared to dry or moist) soil conditions adversely affect germination and flowering rate, yet promoted flower and seed production (Ducarme & Wesselingh, 2010). In general, cold stratification at 2-6°C for 3 months is recommended (Westbury, 2004). Germination may be accelerated by exposing seed to an increasing range of warmer temperatures during final weeks of stratification (Ter Borg, 2005). The Ontario Rock Garden and Hardy Plant Society (2023) similarly recommends sowing seed at 4°C for 3 months, followed by an increase to 20°C for 3 months.

Westbury's (2004) United Kingdom germination trials sought to determine the effects of various storage conditions and protocols. The highest germination rates (69%) were achieved with freshly collected seed placed in darkened, refrigerated storage at 3°C for 14 weeks. Seeds held first for 5 weeks in dry storage at 22°C, followed by exposure to 3°C for 14 weeks had 55% germination rate; seeds placed in moist storage preceding exposure to 3°C had the poorest germination result (21%). Authors also evaluated the effect of breaking the 3°C refrigeration period with subsequent warming to 16°C; these treatments all returned poor results regardless of seed storage conditions (fresh, dry, moist). Authors note that alpine and arctic collected seeds may require lower temperatures (e.g., 2°C) for germination.

Of note, trials comparing laboratory germination rates among commercially available European seed lots demonstrated that mean germination time and percent emergence were key indicators of seed vigor, corresponding with subsequent plant establishment, growth, and host-parasite relations, with possible repercussions for subsequent year seed lots (Marin et al., 2019). Authors recommend these characteristics as important metrics to monitor commercial seed quality.

Finally, European researchers report the successful application of a tetrazolium test (TTC) to identify dormant versus dead *R. minor* seeds for commercial applications, and predict germination within 2 days (Marin et al., 2017). However, P. Holloway warns that although tetrazolium tests are a promising tool, use caution and use in appropriate context. She explains: "Tetrazolium is most accurate with crop seeds where germ percentages are very high (>80%). There is also a tendency to receive false positives/negatives because the tetrazolium solution does not stain the embryo, but rather the outer seed layers. Just because it turns pink does not necessarily mean seeds are viable. Also, if the TTC soak is too long, all tissues will eventually turn pink so timing is important. Or if you do the TTC test in light rather than darkness it can mean false positive. A lot of literature on seeds uses TTC, but I am highly skeptical of its use on wild collected seeds. It is a lot tricker that you might think."

- **Establishment phase**
  For seeds directly sown in meadows into freshly raked or harrowed soil, few plants are expected to establish during the first year. Allow numbers to naturally increase in subsequent years from seeds shed from newly established plants (PlantLife, 2024).

- **Active growth phase**
  As with germination techniques, scant information was located for plant establishment and growth pertaining to North America populations. The following guidelines are provided for UK-based gardeners: For plants established by direct sowing in the field, keep meadow cut/mowed after seed has been shed in late summer, and maintain at ankle height during fall for overwintering (PlantLife, 2024).

  Westbury (2004) advises that low concentrations of chlorophyll can stunt plants, as they have limited ability to assimilate inorganic nitrogen. Stimulate growth with phosphate (Na_2HPO_4) to enhance plant height and biomass, and promote efficient water use by plants (Seel et al., 1993).

The addition of soil amendments and fertilizers can mitigate susceptibility of host plants to parasitic affects by *R. minor*.

- **Hardening phase**
  Unavailable.

- **Harvest, storage & shipping**
  Unavailable.

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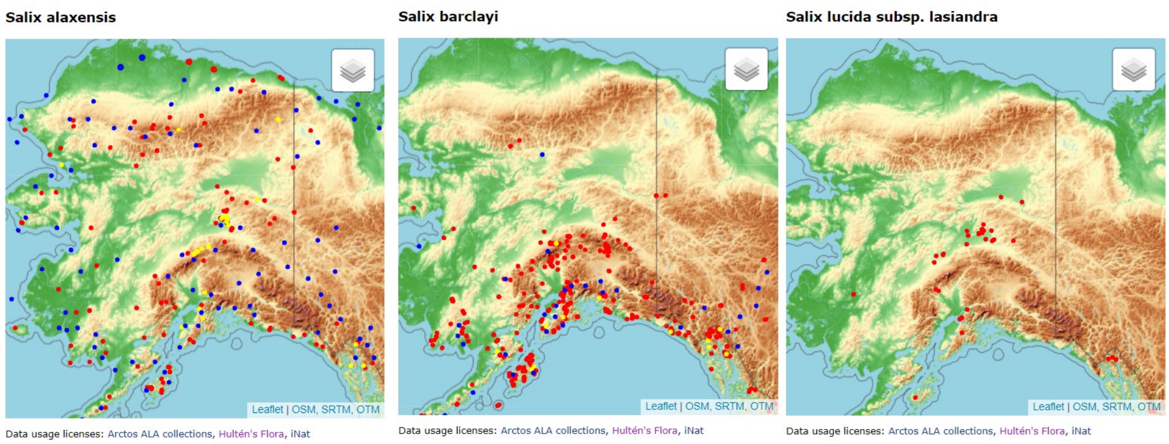
Propagation Profiles

Scientific name: *Salix alaxensis, S. barclayi, S. lucida* ssp. *lasiandra*
Synonyms: see USDA Plants Database
Common name(s): feltleaf, Barclay's, Pacific
Family: Salicaceae
USDA PLANTS code: SAAL, SABA3, SALUL

Duration: Perennial
Growth habit: Shrub, tree
Wetland indicator status: *S. alaxensis*: FAC
S. barclayi and *S. lucida* ssp. *lasiandra*: FACW



WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
S. alaxensis - Propagation from summer stem cuttings in Fairbanks, Alaska (Holloway & Peterburs, 2009) - USDA Zone 3b

Propagation of *Salix* sp. from cuttings (species and collection source location unknown) Moscow, Idaho - USDA Zone 6b (Morrison et al., 2009)
https://npn.rngr.net/renderNPNProtocolDetails?selectedProtocolIds=salicaceae-salix-3519

Habitat description:
S. alaxensis occurs along creeks and rivers with fast flowing water, along wet meadows and thickets, lakeshores, talus slopes, and gravel floodplains; it occurs in wetlands, alpine meadows, and young forests (Collet, 2002; Innes, 2014).

S. barclayi forms thickets along central and western southcentral Alaska coast, occurring along shores, bogs, mixed forests and forest clearings (Collet, 2002; Hultén, 1968). It is the dominant species found in subalpine thickets and moist disturbed sites south of the Alaska Range (Collet, 2004).

S. lasiandra is found in wet habitats: riverbanks and lakeshores, floodplains, pond edges, fast flowing streambanks, and sandbars along streams (Collet, 2004; Hultén, 1968; Pojar & MacKinnon, 1994).

Elevation range:
S. alaxensis occurs up to 1,800 meters; found in coastal to sub-alpine and alpine zones (Hultén, 1968; Innes, 2014; Klinkenberg, 2020). *S. barclayi* is recorded up to 2,300 meters in British Columbia; steppe to alpine and alpine zones (Klinkenberg, 2020). *S. lucida* does best at low elevation sites (Moore, 2002).

Created 2024, Kelly Sivy
Last updated: n/a

Homer Soil & Water
CONSERVATION DISTRICT

Propagation Profiles

Soil preferences and adaptations:
Both *S. alaxensis* and *S. barclayi* are adapted to fine, coarse, and medium soils, with high anaerobic tolerance; *S. lasiandra* occurs on similar soil characteristics yet is intolerant of medium soils, as this species tends to prefer heavy damp soils (Moore, 2002; USDA & NRCS, 2023). *S. alaxensis* is generally found among mineral soils with thin organic litter, slightly acidic to slightly alkaline nutrient-rich content with good drainage and aeration; permafrost is commonly found beneath (Innes, 2014).

Shade tolerance:
All three willow species are shade intolerant (Innes, 2014; USDA & NRCS, 2023).

Drought tolerance:
All three willow species exhibit low drought tolerance (USDA & NRCS, 2023).

Disturbance tolerance:
Willows can act as early seral species with high capability for vegetative regeneration, and in general tolerate natural disturbances. *S. alaxensis* in particular is flood tolerant and can sprout after and survive low to medium intensity fires; however, browsing pressure from moose and snowshoe hares can severely suppress early seral stands (Innes, 2014).

Community interactions:
Willow species in general are typical of early seral plant communities, with no adverse community interactions known (Innes, 2014).

Wildlife associations:
Willows are a critical source of browse and cover for moose, snowshoe hares, ptarmigan, and other small mammals (Innes, 2014).

Restoration value:
Willows present excellent candidates for habitat restoration, erosion control and streambank stabilization, and reclamation; propagation from stems is an easy, reliable and recommended method for these sites (Collet, 2002; Innes, 2014; Moore, 2002).

Primary reproductive mode:
Willows propagate by seed and stem cuttings, and sprout vegetatively from root crowns and stem bases, and in some situations by layering (Innes, 2014). Propagation via stem cuttings and live staking is the predominant propagation technique.

Seed type:
S. alaxensis and *S. lasiandra* both exhibit orthodox seed characteristics; seed type is not listed for *S. barclayi* (SER, INSR, RBGK, 2023).

Ease of growing:
Because of the ease of propagating from cuttings, the majority of literature pertains to vegetative propagation. The main limitation to propagation from seed is collection in the wild (Dreesen, 2003). Seeds of these summer-dispersing willow species are short-lived (~8 weeks) with rapid decline in viability once seeds disperse, which should be taken into consideration when planning seed collection, handling, and storage (Zasada et al., 2008). Once germinated, seedlings undergo rapid growth, and transplantable

seedlings can be produced within 1 growing season (Dreesen, 2003; Zasada et al., 2008). Cultivating seed stocks from reproductive cuttings of male and female plants can expedite the development of seedstock and bypass the challenges of viable wild seed harvest (Dreesen, 2003). Willows established from seed begin producing seed once 6-10 years old, whereas plants established from willow sprouts can flower as early as 3 years old (Innes, 2014).

SEED

- **Collection recommendations**
  In Alaska, flowering and seed dispersal of *S. alaxensis* occurs in the wild from May to July; this is one of the earliest willow species to disperse seed, which generally co-occurs with receding spring floodwater (Innes, 2014). Catkins and leaves of *S. barclayi* and *S. lasiandra* start appearing mid-May to mid-June and disperse in mid-June; in alpine zones catkin development of *S. barclayi* may occur as late as mid-August, with possible repercussions on seed maturity (Collet, 2004).

  Seed viability for summer-dispersing willow species is notoriously short-lived (Zasada et al., 2008). Schedule field collection as close to seed dispersal as possible, monitoring catkin color as it approaches yellow to yellow-brown at maturity and the capsule begins to open (Zasada et al., 2008). Seed dispersal may occur over several days during warm, dry, and windy conditions or be prolonged up to a month during wet and cool weather. Collect catkins into paper bags to dry and avoid overpacking bags to ensure adequate air-flow within bags; keep bags out of direct sun. (Zasada et al., 2008).

- **Seeds per/lb**
  Seed yield is highly variable. Collections of *S. alaxensis* seed on the Arctic slope yielded 7-10 seeds per capsule, roughly equivalent to 333-1,174 seeds per catkin (Zasada et al., 2008). Estimates of seeds per pound were not available for *S. alaxensis,* but harvest from Idaho of *S. lasiandra* reported 11,500 seeds/ pound (Zasada et al., 2008).

- **Processing techniques, recommended equipment**
  Seeds should be processed and stored immediately as exposure to room temperature will rapidly reduce viability. For summer-dispersing species like *S. alaxensis,* storing seed with cotton still affixed may also adversely affect viability, in addition to interfering with seedling density and distribution when sown (Zasada et al., 2008). To separate cotton from seed, place catkins in screen covered box in a single layer, housed in a warm (20-25°C) and dry (25-35% humidity) area with circulating air flow; once capsules open, transfer to a container where an airstream may be applied to coax cotton free from seed, and then use screens to filter any other debris (Zasada et al., 2008). Seed may also be separated from cotton with a 1-hp mini-shop vacuum (Dawes, 2003), described as:
  "We cover a wooden table with newspapers to catch any seeds that might fall through, and on top of that place a piece of recycled plastic decking for greenhouse benches. This decking has 2.5-cm (1-in) square holes and provides some aeration. On top of the decking we lay a piece of fiberglass window/door screen. We spread the capsules thinly over the screen, and then lay another section of fiberglass screen over the capsules, anchoring the newspaper, screens, and capsules with a few push thumbtacks around the perimeter. After the capsules open (generally just a few days), we use a 1-horsepower mini-shop vacuum with a clean cloth filter to extract the

seeds. We slowly and uniformly pass the nozzle over the top layer of screen. The seeds and just a little of the cotton are pulled through the screening; most of the cotton and the larger debris remains sandwiched in between. Inside the vacuum, the cotton adheres to the cloth filter and the seeds and minor debris collect in the bottom of the cannister. When the seedlot is finished, we simply pour the seeds into a zip-locktype bag and keep them refrigerated for a few days until they are sown."

- **Storage**
  Seed viability will rapidly decline at room temperature: viability of *S. alaxensis* was lost following 1 month of room temperature storage (Zasada & Densmore, 1977). Pre-drying seed to 6-10% of dry weight is recommended along with immediately storing seed in sealed containers with constant humidity at temperatures of -5°– 40°C, to maintain viability longer than 6 months (Zasada et al., 2008). For storage longer than 3 years, results are mixed. While viability of *S. lasiandra* was maintained following 36 months storage at -19°C, germination of *S. alaxensis* declined by as much as 40% (dropping from 94.5% to 55%) after 36 months at -10°C (Densmore & Zasada, 1983; Zasada & Densmore, 1980).

- **Scarification requirements**
  Scarification is not required.

- **Stratification requirements**
- For summer-dispersing willow species such as *S. alaxensis* and *S. lasiandra,* stratification is not required; overwintered seeds have not been found to germinate after dispersal (Baskin & Baskin, 2002; Innes, 2014; Zasada et al., 2008).

  The USDA lists cold stratification as a requirement for germination of *S. barclayi* (USDA & NRCS, 2023)*;* however, given that seed dispersal of this willow occurs in summer, as with other summer-dispersed willow species cold stratification is more likely not a germination requirement (Collet, 2004; Densmore, 1979; Zasada et al., 2008).

- **Germination rates and techniques**
  Germination of *S. alaxensis* is most successful on wet to moist mineral soils, with germination rate regularly exceeding 90% (Innes, 2014). Unlike fall-dispersing willow species, which require stratification to break dormancy, germination of *S. alaxensis* in the wild occurs 12-24 hours following dispersal, with no evidence of dormancy in response to temperature and germination primarily occurring at 5-30°C and declining at temperatures above 30°C (Zasada et al., 2008; Zasada & Viereck, 1975). Lab germination trials show 94-97% germination between 5-25°C; germination of seed previously frozen may range 59-74% (Baskin & Baskin, 2002, 2003; Zasada et al., 2008). Zasada and Densmore (1980), working with Alaska seed, reported 94.5% germination of fresh *S. alaxensis* seed at 25°C; seeds stored 36 months reached their maximum germination rates of 67-74% when germinated at 15-20°C.

  To sow fresh seed, sow immediately after seed collection, between 15-25°C into sand, peat, or 3:1 sand-to-peat seedbed (Holloway, 1985). Or use a mix of *Sphagnum* peat moss and perlite, which provides good aeration, light and moisture and allows small seeds to nest between moss particles (Dreesen, 2003). Mini-plug containers, either 14 x 14 x 29mm (for 2-3 week growth) or 19 x19 x 63mm (for 4-6 week growth) provide adequate size for germination while conserving nursery space (Dreesen, 2003). Press - but do not bury - seed into a moist seedbed; maintain moisture by fine misting spray and/or with use of close shading to preserve humidity (Zasada et al., 2008). High moisture is important for germination, especially for seed that has been frozen (Innes, 2014). Germination rate may be higher with light exposure, however light is not a requirement for germination (Densmore & Zasada, 1983; Zasada et al., 2008). Once germinated, remove any shading as seedlings thrive in full light (Zasada et al., 2008).

- **Establishment phase**
  For greenhouse plugs, growing medium must be kept moist. Dreesen (2003) recommends covering benches/tables where plug trays sit with a copper-coated fabric to "reduce root egress from cells," and places filter fabric underneath copper fabric to encourage water movement. A soluble nitrogen fertilizer of 200 mg/l is applied 1-2 times per week. Plugs are transplanted into 164 mL Ray Leach Super Cells™ SC-10 containers filled with 2:1 mix of Sunshine Mix (#1 or #2) to 1 part perlite (with CRF incorporated at 2.7 kg/0.765m^3).

  For in-situ/field planting in disturbed areas, presence, or amendment of planting area with native, organic rich soil was found to enhance establishment of *S. alaxensis* on disturbed floodplain sites, yet may impact seedling survival (Cooper & Van Haveren, 1994). Sufficient water was a critical component of establishment, and selection of restoration sites within 1-2 meters from water table is recommended for establishment of *S. alaxensis* from seed in the field (Cooper & Van Haveren, 1994).

- **Active growth phase**
  Dreesen (2003) transplants seedlings from 164mL containers into 2.8l (1 gal.) Treepots™ filled with growing medium of aged bark, pumice, and peat (55:35:10 ratio by volume) and top-dressed with 15 grams of controlled release fertilizer per pot. Plants are grown under full sun and watered often.

- **Hardening phase**
  Unavailable.

- **Harvest, storage & shipping**
  Unavailable.

VEGETATIVE PROPAGATION

Stem cuttings

- **Collection**
  Near Fairbanks, Alaska, harvest of *S. alaxensis* stem cuttings is recommended from early to mid July to ensure peak rooting success (Holloway & Peterburs, 2009). When identifying stands for stem cuttings, target both male and female plants to ensure genetic diversity and maximum sustainability of stand over the long run (Landis et al., 2003). Sex of plants can be identified when flowering in spring, and then labeling the individuals for later collection during dormant period; alternatively, identify dormant season willows through examination of floral buds (Landis et al., 2003). Male buds are larger and occur in upper branches just beneath terminal bud; sex can be further verified by slicing buds open with razor blade and inspecting (Landis et al., 2003).

Steinfeld (2003) reports collecting *Salix* sp. cuttings (Oregon) in late fall, once leaves begin to drop, or early winter, prior to bud swell. Cuttings of equal ratios of male and female plants were harvested from healthy stems of current year's growth, with a minimum stem diameter of ⅜ - ⅝" and presence of healthy, intact buds (Steinfeld, 2003)

- **Processing and Storage**
  Store processed hardwood cuttings under refrigerated cold storage; otherwise cuttings can be stored in outdoor winter burial pits or packed with snow and cached in unheated buildings (Mathers, 2003).

  Morrison et al. (2009), used 1 year-old rooted cuttings to establish a stooling bed. Following harvest in the field, stems were inspected for disease, and cut with a bandsaw into 7.5 cm (3") lengths. They targeted segments with stem diameters 13mm (0.5") or less. They advise selecting/planning cuttings such that one healthy bud is within top 1", with the second bud somewhere else on cutting. Cuttings were placed in sealed plastic bags and stored at 1°C.

  Steinfeld (2003) sealed harvested stem cuttings in plastic bags and stored at 28-30°F until processing. Just before planting, stems were cut into segments 4-6" in length with at least 2 buds present, with the terminal bud ½" or less from top of cutting.

- **Planting techniques**
  Root softwood or hardwood cuttings in aerated in water, sand or perlite (Holloway, 1985). Hardwood and softwood cuttings collected near Fairbanks rooted with similar performance, and majority of root formation occurred within 2 weeks of planting, irrespective of hormone and wounding treatment, base or tip cuttings, or planting in sand or perlite (Holloway & Zasada, 1979).

  Holloway and Peterburs (2009) observed 80% or more rooting success from *S. alaxensis* stems harvested mid-July, using the following protocol:

  > "Cuttings were treated with 0.3% indole-3-butyric acid powder and propagated in perlite/vermiculite (1:1 by vol) under intermittent mist with bottom heat [26C (78F)] in a greenhouse with a minimum night greenhouse temperature of 15C (59F). Light consisted of natural daylight."

  Provided that cuttings are made from healthy plants, Mathers (2003) suggests that rooting success should be high (90% or more) and rooting hormones are unnecessary. If using rooting hormone, consider the season of harvest. Indole-3-butyric acid had the strongest effect on increasing the quantity and length of primary roots of spring-harvested cuttings of willow species *S. glauca* and *S. planifolia*, collected In Northwest Territories, Canada (Ficko & Naeth, 2022).

  Mathers (2003) advises to soak cuttings in tepid water for 48-72 hours prior to planting to stimulate primordial roots. Fikco & Naeth (2022) found that root length was longest with soaking of 10 days, with no repercussion to plant of an extended soak (Ficko & Naeth, 2022). However, Mathers advises to soak roots only until initial roots begin to swell, and cautions that any further growth is likely to become damaged upon sticking of cuttings (Mathers, 2003)

Morrison et al.'s (2009) protocol reports that three days prior to planting, cuttings were soaked in running tap water, in the shade. Cuttings were then planted into 336 mL containers with a 1:1 growing medium of *Sphagnum* peat moss and vermiculite, and then watered to saturation and left to drain.

Steinfeld's (2003) propagation took place outside on gravel pads, graded for drainage, with no shade, and an overhead fixed irrigation system. Cuttings were planted into 1,2,3, or 4 gallon sized TreePots™ filled with SunGro Horticulture Grower's Gold Mix #1 (40% composted pine/fir bark (fine 3/8" minus), 35% Canadian sphagnum peat moss (growers grade) and 25% screened volcanic pumice (3/8"minus). Growing medium was pre-moistened, fertilized with a 6-10-6/fritted trace element starting fertilizer, and lightly tamped once cuttings were struck. Cuttings were struck such that the terminal bud was just above growing medium. Containers were placed on a rack system outfitted with hardware cloth on bottom and wire mesh above, featuring either 4 x 4" or 8 x 8" openings for support. Once established, they describe:

> "Several weeks after seedlings have been transplanted, a isobutylidene diurea top dressing is applied to each container. Wil-Gro (Wilbur-Ellis), a 18-6-12 with Mg, S and Fe elements, is applied as follows: 1/16 cup for 1-gallon containers, 1/8 cup for 2, 3 and 4-gallon containers. Seedlings are only fertilized one time per year. If a seedling is held over for a second year, controlled-release fertilizer is again applied as a topdress in the spring."

Finally, Dreesen (2003), describing planting procedure for development of *Salix* sp. nursery seedstock, planted cuttings in either 164mL SC-10 RayLeachSuperCells™ top-dressed with 5-6 month controlled release fertilizer (Osmocote Plus $15N{:}9P_2O_5{:}11K_2O$) at 3.5 kg/m^3, or in 2.8l (1 gal) Treepots™ top-dressed with 15 grams of fertilizer. Containers were marked by gender, and once seed is produced it is collected, cleaned, and sown into a second generation of containers.

- **Establishment**
  Establishment for Morrison et al. (2009) took place over 2 weeks, after which Peters Excel Cal-Mag ($15N{:}5P_2O_5{:}15K_2O$) was applied at 114 ppm N twice per week. They describe their pruning process as:

  > "During the growing season, cuttings are pruned 3 or 4 times, depending on growth and available workers to do the pruning. As soon as shoots reach 20 to 25 cm (8 to 10 in) in height, we prune them back to 15 to 20 cm (6 to 8 in). We let them grow another 15 cm (6 in) or so, and then remove half of the new growth achieved since the last pruning, repeating this process as needed. In early September, cuttings are pruned the last time to about 41 cm (16 in)."

  Establishment for Steinfeld (2003) was reported as 1 month, during which seedlings were watered 1-2 times week.

- **Active Growth**
  Active growth for Morrison et al. (2009) lasted 4 weeks, during which Peters Professional Conifer Finisher ($4N{:}25P_2O_5{:}35K_2O$) was applied at 24 ppm N every other week, until August. After this period, fertilization was alternated with Finisher with CAN-17 (liquid calcium ammonium nitrate [17N]) at 77 ppm N for the twice per week fertilization. Fertilization was ceased once leaves began turning color and dropping in fall (mid to late October in Idaho).

Active growth for Steinfeld (2003) lasted 3 months, during which seedlings were hand weeded every 6 weeks and watered early morning with frequency determined by moisture of plug as compared to field capacity, no drier. Temperatures into the high 80s in their area dictated irrigation up to 4.5 hours every 2-3 days.

- **Hardening**
  Both Morrison et al. (2009) and Steinfeld (2003) report a hardening phase of 3 months. Steinfeld (2003) report tapering off watering frequency starting in late summer, and transferring seedlings into unheated greenhouse overnight for early overnight freeze-ups. They further describe pruning protocol to minimize root circling at container bottoms:

  > "Roots will circle and amass at the bottom of the containers due to the container design. Per client request, the bottom inch of the root plug will be pruned during the hardening phase. This is accomplished by pulling the plug from the container and cutting off the end of the plug with an industrial-strength paper cutter. Clients with containers that will remain for two years will often chop the bottom inch of the container off using a chop saw with an abrasive blade. This leaves the bottom of the container completely open, which prevents spiraling the second year but makes the container unusable after extraction."

- **Harvest, Storage and Shipping**
  Morrison et al. (2009) report by late November rooted cuttings were removed by hand from pots and placed in labeled plastic bags, 5 per bag (stems may protrude from top opening of bags). They advise to check for healthy appearance in stems, and firm root systems with shoot diameter of 6mm or more. Bags were stored in "stack-and-nest" tote boxes and placed in cooler at 1°C for 4-5 months. They advise that small cuttings were easier to maintain and store yet still provide capability for production of larger cuttings. Overall, from 150 original cuttings they produced 4500 microcuttings that rooted with 99% success.

  Steinfeld (2003) shipped seedlings in their original 1,2,3, or 4 gallon container, standing upright within cardboard boxes and shipped in enclosed trucks (refrigerated or unrefrigerated).

Live Staking

- **Collection and Processing**
  All three species (*S. alaxensis, S. barclayi,* and *S. lasiandra*) are recommended by Collett (2002) as good candidates for propagation via dormant cuttings. Studies have shown variable establishment and survival, which could be related to season of harvest and soil characteristics at planting site (Holloway & Zasada, 1979; Zasada et al., 1987). Despite this, live staking can be effective and presents an easy technique with minimal labor. As with stem cuttings, ensure that equal mix of male and female individuals are harvested (Landis et al., 2003). From Casey Greenstein, Natural Resources Specialist with Homer Soil and Water Conservation District:

  > "Locate harvest sites during growing season, when leaves are still present on stems, to aid species identification. For identification of dormant willows, Dominique Collet's "Willows of Southcentral Alaska" (Collet, 2002) provides good guidance. To maximize establishment success, harvest stakes while willows are dormant and before leaves appear, winter through early spring/end of March. Establishment rate can be reduced by as much as 50% for stakes harvested during the growing season. Use a ⅓ rule when harvesting: don't collect more than

⅓ of individual shrub or ⅓ of stems at a given site. Select cuttings for a target length of 3-4' long and 0.5 - 2" diameter. Cut off top few inches of stem at right angle, and cut the bottom of stem at 45° angle to facilitate planting end and identify top from bottom. Store stakes with small amount of snow to reduce drying during transport. To prepare stakes for planting, several stakes (10-18" in length) can be made from one cutting. Discard any buds ("pussy willows") less than ¼" diameter, and leave 1-2 leaf buds (smaller than pussy willow buds) minimum per segment."

- **Planting**
  Holloway (1985) advises that if direct planting, plant in spring, outdoors in a moist substrate. From Casey Greenstein, Natural Resources Specialist with Homer Soil and Water Conservation District:

  "Plant stakes as soon as soil thaws, or before July 1. Immediately prior to planting, soak in cold water 24-48 hours; for our area (south central Alaska) longer soaking is better. Pre-punch planting holes with rebar, shovel or drill, and plant bottom end (marked by 45° cut) into hole with approx ¾ of stake length underground and 1-2 leaf buds above ground. The stake should be planted deep enough to reach the water table on site. If more than 1-2 buds, ¼ of the stake, or 4" of stake is still above the soil surface, trim it back to this height. Plant stakes 1-3' apart. Pack soil tightly around stakes, creating a moat around stems for water to collect. Stems can be planted with native grasses or hay mulch. For dry sites, use larger cuttings and more water; for shady sites plant with more above ground length to facilitate light exposure. At least 6" of buried portion of stake should be exposed in permanently wet soil to encourage rooting and minimize air pockets. Water stakes as necessary, establishment may take a couple years."

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Propagation Profiles

Scientific name: *Sanguisorba canadensis*
Synonyms: *S.c.* var. *latifolia*, *S.c.* ssp. *latifolia*, *S. sitchensis*, *S. stipulata.*
Common name (s): Canadian burnet
Family: Rosaceae
USDA PLANTS code: SACA14

Duration: Perennial
Growth habit: Forb/herb
Wetland indicator status: FACW

WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
Wild-harvested seeds from commercial supplier in Kenai – USDA Zone 4b-5a, and germinated in Fairbanks – USDA Zone 3b (Holloway & Matheke, 2003)
https://rngr.net/npn/journal/articles/seed-germination-of-burnet-sanguisorba-spp

Habitat description:
Moist to wet meadows and roadside ditches, swamps, forest openings and seepages (Holloway & Matheke, 2003; Klinkenberg, 2020).

Elevation range:
Middle elevations to subalpine.

Soil preferences and adaptations:
Moist to wet soils with high organic matter content.

Shade tolerance:
Low/none (Klinkenberg, 2020).

Drought tolerance:
Low.

Disturbance tolerance:
Unavailable.

Community interactions:
Unavailable.

Wildlife associations:
Unavailable.

Restoration value:
Good potential for roadside revegetation (Holloway, 2024).

Primary reproductive mode:
Primarily by seed but can also be divided (USDA & NRCS, 2023).

Seed type:
Orthodox (SER, INSR, RBGK, 2023).

Ease of growing:
Rapid germination under controlled conditions (Holloway & Matheke, 2003).

SEED

- **Collection recommendations**
  Holloway (2024) writes:
  "Flower spikes hold up to 500 individual flowers in tight clusters that bloom from the bottom up. Fruit is an achene with 4-winged calyx held in a thimble-shaped cluster. Lower achenes mature first. Harvest when clusters begin to fall apart when rubbed together with your fingers. Harvest entire heads and dry on screens."

- **Seeds per/lb**
  The Seed Information Database reports a mean seed weight of 11.51 grams/1000 seeds (SER, INSR, RBGK, 2023).

- **Processing techniques, recommended equipment**
  Gently hand-strip the seed from the inflorescence, then clean with an air column separator or air/screen cleaner. The calyx husk doesn't necessarily need to be removed.

- **Storage**
  Seeds last at least 3 years when frozen (Holloway, 2024). Holloway and Matheke (2003) stored cleaned *Sanguisorba* seeds at 39°F for 6 months to 1 year and reported no significant declines in germination rate relative to freshly harvested seed. The Seed Information Database reports seeds maintaining 100% viability after drying to moisture content in equilibrium with 15% relative humidity and freezing at -20°C for 1.92 years (SER, INSR, RBGK, 2023).

- **Scarification requirements**
  Holloway and Matheke (2003) found no significant difference in germination rates between seeds with or without the papery calyx hull when removed by mechanical abrasion.

- **Stratification requirements**
  Unavailable.

- **Germination rates and techniques**
  Holloway (2024) writes:
  "Outdoors, direct sow in autumn or spring. Indoors, sow onto sterile potting mix. Cover lightly with mix or vermiculite. Germination begins in about 3 - 5 days, 77°F (25°C), but germination is gradual over a 30-day period."

  Holloway and Matheke (2003) report germination rates of nearly 80% when grown at 25°C, but rates drop to 40-50% when growing temperature is decreased to 20°C or increased to 30°C. Their results do not indicate that cool, dry storage (39°F, 1 year), nor removal of the calyx hull significantly impact germination rates.

- **Establishment phase**
  Unavailable.

- **Active growth phase**
  Unavailable.

- **Hardening phase**
  Unavailable.

- **Harvest, storage & shipping**
  Unavailable.

VEGETATIVE PROPAGATION

- **Division**
  Plants may be propagated by division of the crown in spring, just as growth begins (Holloway, 2024).

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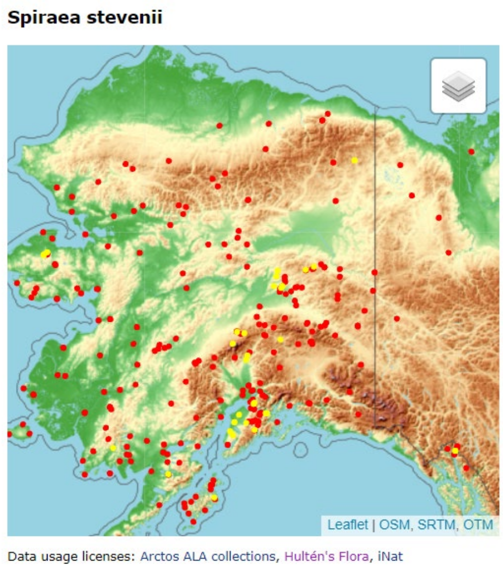
Propagation Profiles

Scientific name: *Spiraea stevenii*
Synonyms: *S. beauverdiana*
Common name (s): beauverd spirea
Family: Rosaceae
USDA PLANTS code: SPST3

Duration: Perennial
Growth habit: Shrub
Wetland indicator status: FACU



WEBB & ICKERT-BOND, 2022

Nearest propagation protocol:
Fairbanks, Alaska (P. Holloway & Peterburs, 2009).

Habitat description:
Common plant, found in woods, alder thickets, meadows, and tundra bogs (Hultén, 1968).

Elevation range:
Low to alpine (Pojar and MacKinnon, 1994; Hultén, 1968).

Soil preferences and adaptations:
Organic soils, moist to dry soils (Lady Bird Johnson Wildflower Center, 2023; Pojar and MacKinnon, 1994).

Shade tolerance:
Medium (Lady Bird Johnson Wildflower Center, 2023).

Drought tolerance:
Unavailable.

Disturbance tolerance:
Spiraea species in general are speculated to have high disturbance tolerance as they appear to thrive in recently fire- or flood-disturbed sites, with newly abundant light and other resources (Zasada & Stickney, 2008).

Created 2024, Kelly Sivy
Last updated: n/a

Homer Soil & Water Conservation District

Community interactions:
Unavailable.

Wildlife associations:
Unavailable.

Restoration value:
Zasada and Stickney (2008) suggest that *Spiraea* spp. are appropriate for native revegetation projects along riparian and wetland areas.

Primary reproductive mode:
Primarily seed, and can also regenerate from basal sprouting (Zasada & Stickney, 2008).

Seed type:
Unavailable for *S. stevenii*, but other species in this genus are orthodox (SER, INSR, RBGK, 2023).

Ease of growing:
Zasada and Stickney (2008) report that seeds germinate readily with no pretreatment required, especially if sown before seeds dry out.

SEED

- **Collection recommendations**
  Flowers from June-August with fruit maturing from July-September, depending on elevation and overstory (Zasada & Stickney, 2008). Fruit consists of tiny brown follicles that open at the top; harvest entire head just as follicles turn from green to brown. Seeds are tiny and can be shaken out of follicles into an envelope (Holloway, 2024).

- **Seeds per/lb**
  Unavailable.

- **Processing techniques, recommended equipment**
  Dry heads at room temperature on screens until fruits have fully opened, allow seeds to drop through the screens with a bit of gentle shaking (Holloway, 2024; Zasada & Stickney, 2008).

- **Storage**
  Seeds can be stored for several months and up to 1 year (Zasada & Stickney, 2008). Frozen seeds may last 2 years or more in storage (Holloway, 2024).

- **Scarification requirements**
  Unavailable.

- **Stratification requirements**
  Freshly collected seeds may be sown directly in the fall without stratification. If seeds are stored, then stratification is generally advised (Zasada & Stickney, 2008). Holloway (1985) suggests 90-day cold stratification at 4°C.

- **Germination rates and techniques**
  Germinate under constant light and a 25/10°C thermocycle, or germinate under constant temperature within 20-25°C (Holloway, 1985). Holloway (2024) further writes:
  "Some seeds germinate immediately, but a 60-90 day cold stratification treatment increases germination percentages and speeds up germination. Sow onto sterile seed starting mix, and do not cover. Keep moist. Seedlings appear beginning in about 2 weeks (70°F, 21°C), but germination can be slow over 6-8 weeks."

  Calmes and Zasada (1982) cold stratified seeds collected from the boreal forest in Alaska for 30 days at 2°C and reported 95% germination when exposed to 10-25°C, and only 40% germination at 5°C. As with Densmore's (1979) findings, their trial determined that light was a requirement for germination; no seeds germinated in the dark regardless of stratification.

  Ontario Rock Garden provides this general guideline for all *Spiraea* species: "Expose to fluctuating outdoor winter temperatures including freezing for 3 months. Gradually increase light and temperature in the spring" (Ontario Rock Garden & Hardy Plant Society, 2023).

- **Establishment phase**
  Unavailable.

- **Active growth phase**
  Unavailable.

- **Hardening phase**
  Unavailable.

- **Harvest, storage & shipping**
  Unavailable.

VEGETATIVE PROPAGATION

- **Cuttings**
  Collect semi-hardwood or hardwood cuttings from late June through mid-July, to allow time for root development (Holloway, 1985; Holloway, 2024; Holloway & Peterburs, 2009).

  Treat cuttings with rooting hormone and insert into peat or sand in a mist bench (Holloway, 1985). Holloway and Peterburs (2009) describes the treatment applied to cuttings prior to rooting:

  > "Cuttings were treated with 0.3% indole-3-butyric acid powder and propagated in perlite/vermiculite (1:1 by vol) under intermittent mist with bottom heat [26°C (78°F)] in a greenhouse with a minimum night greenhouse temperature of 15°C (59°F)." Cuttings were exposed to naturally occurring daylight.

- **Division -** Plants may be propagated by division in spring, or late summer.

- **Simple layering -** For simple layering, Holloway (2024) writes:
  "Choose young, succulent, bendable stems near the ground. Wound the center of the stem, treat with rooting hormone, and bury in compost. Remove leaves from all parts of the stem that will be buried. Allow tip of leafy branch to emerge from the compost. Keep in place with a peg or rock. Cut from the mother plant early the next season. Sometimes it is better when the entire shrub is cut to the ground resulting in lots of young succulent stems that can be bent easily."

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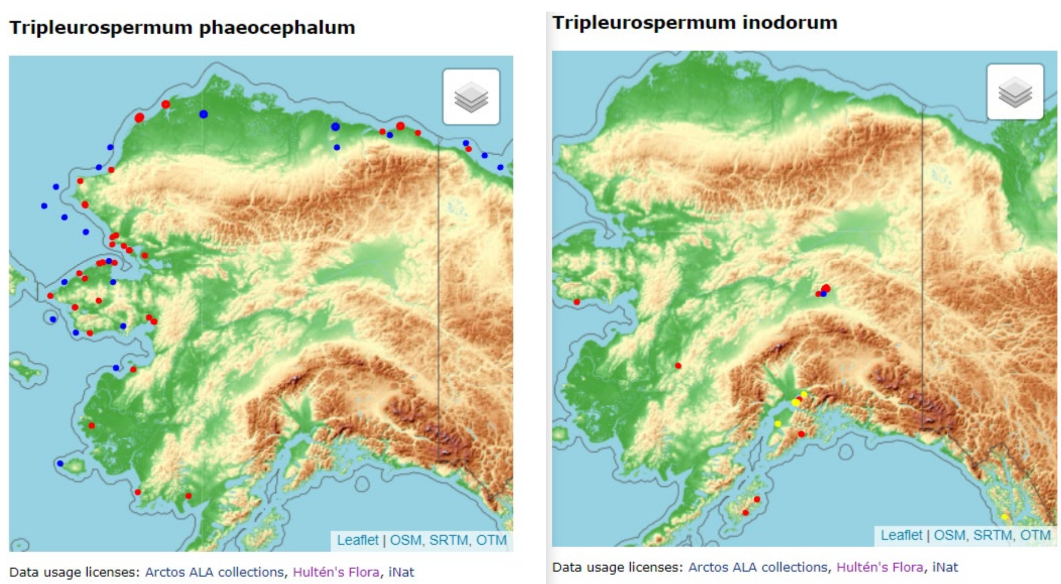
Propagation Profiles

Scientific name: *Tripleurospermum maritimum*
Synonyms: see below
Common name (s): false mayweed
Family: Asteraceae
USDA PLANTS code: TRMA17

Duration: Annual, biennial, perennial
Growth habit: Forb/herb
Wetland indicator status: FAC

Taxonomic ambiguity persists with the recognized subspecies: ***T. maritimum* ssp. *phaeocephala*** (also called false mayweed, or Arctic wild chamomile/seaside chamomile, formerly recognized as ***T. phaeocephalum***), which occurs on the arctic coast; ***T. maritimum* ssp. *maritimum*** (false mayweed), an introduced sub-species primarily occurring in WA and OR; and to a lesser extent ***T. perforatum*** (scentless chamomile, formerly known as ***T. inodorum***), a widely-distributed species with non-native status throughout Pacific Northwest with reported occurrences in Alaska (Hultén, 1968).

In the literature species have been both combined or parsed despite unique ecology, distribution, and occurrence. Information presented below refers to the primary species *T. maritimum*, unless otherwise noted. Due to sparsity of information specific to that species, information for the aforementioned species may also be presented, as propagation characteristics may share similarities, with the caveat that unique propagation requirements for Alaska populations are likely.



WEBB & ICKERT-BOND, 2022
Range maps were not available for other species/synonyms

Nearest propagation protocol:
No propagation protocol for *T. maritimum* was available. There was information for the Kotzebue Germplasm *T. maritimum* ssp. *phaeocephala*, developed by the Alaska Plant Materials Center, Palmer Alaska (Hunt & Wright, 2007) - USDA Zone 2b, 5a
https://dnr.alaska.gov/ag/akpmc/pdf/plant-flyers/KotzebueGermplasmarcticwildchamomile.pdf

Habitat description:
T. maritimum spp. *phaeocephala* is found on seashores (Hultén, 1968), sand, gravel, and among grasses along the arctic coast (Hunt & Wright, 2007).

Created 2024, Kelly Sivy
Last updated: n/a

Homer Soil & Water
CONSERVATION DISTRICT

Elevation range:
Unavailable.

Soil preferences and adaptations:
Coastal populations in Estonia have high salinity tolerance (Ievinsh et al., 2021). In Alaska, *T. phaeocephalum* grows in medium well drained soil; Kotzebue germplasm will grow in a wide range of soils and drainage conditions (Hunt & Wright, 2007).

Shade tolerance:
Unavailable.

Drought tolerance:
Unavailable.

Disturbance tolerance:
Unavailable.

Community interactions:
Unavailable.

Wildlife associations:
Revegetation with *T. maritimum* spp. *phaeocephala* can contribute to bird habitat (Hunt & Wright, 2007).

Restoration value:
May do well in in mineral soils, as very high tolerance of heavy metals in soil/substrate was found in Estonian coastal plant populations (Ievinsh et al., 2021). The arctic species *T. phaeocephalum* is considered a colonizer recommended in reclamation and revegetation seed mixes (Hunt & Wright, 2007).

Primary reproductive mode:
Seed.

Seed type:
Orthodox (SER, INSR, RBGK, 2023).

Ease of growing:
May persist as an annual, biennial, or perennial depending on site conditions (Holloway, 2024).

The Kotzebue Germplasm of *T. maritimum* spp. *phaeocephala* is reportedly vigorous and very easy to grow (Hunt & Wright, 2007).

The non-native *T. perforatum* spreads abundantly due to a lack of seed dormancy, persistent seed bank, and ability for 2nd year seeds to germinate throughout the growing season (Bowes et al., 1995).

Propagation Profiles

SEED

- **Collection recommendations**
  Holloway (2024) writes of *T. maritimum* spp. *phaeocephala*:
  "Contains daisy-like flowers with up to 50 individual disk flowers in a head. Each disk flower produces a single achene or fruit. Achene with tufted hairs. Harvest achenes when the entire head dries, becomes brown, and begins to fall apart. Long-season flowering means variable maturity rates. Hand harvest individual heads or clip with electric shears into a paper bag or onto a tray."

- **Seeds per/lb**
  Unavailable.

- **Processing techniques, recommended equipment**
  Dry on screens, rub against the screen to dislodge achenes and break up heads, or use a hammermill. An air/screen cleaner will separate achenes from chaff (Holloway, 2024).

- **Storage**
  Seeds can persist in the soil for 5+ years (Holloway, 2024).

  Seeds stored for 11 years are reported to achieve 73% germination (SER, INSR, RBGK, 2023).

  A European study of *T. inodorum* found that seeds were more likely to retain viability when buried 2 cm below the soil surface, compared to seeds remaining on the surface or only lightly covered (Jensen, 2009).

- **Scarification requirements**
  Unavailable.

- **Stratification requirements**
  Unavailable.

- **Germination rates and techniques**
  Germination of *T. maritimum* is reported at 94% when placed in 1% agar under a 12/12 hour thermoperiod of 23°C/9°C (SER, INSR, RBGK, 2023). Laboratory germination tests based on seeds of this species in the Czech Republic identified the following conditions:
  "In laboratory experiments seeds germinated best at 15-28 deg C, with a moisture content of < 20% and 15-30% in soil and sand respectively and when surface sown. Germination was stimulated by NH4-N and particularly by No3-N, but was not affected by various systemic herbicides" (Zemanek, 1970).

  Recent trials investigating the mineral tolerances by Estonian populations of *T. maritimum* describe the following protocol for greenhouse propagation:
  "Seeds were surface sterilized with 5% NaOCl, imbibed in water and germinated in autoclaved substrate (Garden Soil, Biolan, Finland) in plastic plant tissue culture containers in a growth cabinet. Established seedlings with the two true leaves were individually transplanted first to 250 mL plastic containers and after two weeks to 1.3 L plastic containers filled with a mixture of heat-

treated substrate containing Garden Soil and quartz sand (1:1, v/v). Plants were cultivated in an experimental automated greenhouse with supplemented light (380 µmol m–2 s–1 at the plant level) with 16 h photoperiod, day/night temperature 24/16 °C, and relative air humidity 60 to 70%. Substrate water content was kept at 50 to 60% using deionized water." (Ievinsh et al., 2021).

Holloway (2024) writes, of *T. maritimum* ssp. *phaeocephala*:
"Outdoors, direct sow in autumn or spring. Cover lightly. Indoors, sow onto sterile seed starting mix. Germination is easy beginning in 8-14 days at 7°F (21°C)."

Germination tests on *T. perforatum* found that in oxygen deficient soils (o_2 concentrations at 20.9%, 15%, 10%, 5%, and 2.5%), scentless chamomile achieved highest germination in soils treated with 20.9% o_2 (Yasin & Yasin, 2019).

- **Establishment phase**
  Ievnisch et al. (2021) investigated the effect of nutrient additions on growth of Estonia *T. maritimum*, finding that mineral nutrients in soil increased the dry weight up to 60%. Shoot biomass increased 20-30% with the addition of either calcium nitrate or ammonium sulphate as fertilizer. Mineral nutrients or ammonium sulphate additions had no effect on root growth.

- **Active growth phase**
  Unavailable.

- **Hardening phase**
  Unavailable.

- **Harvest, storage & shipping**
  Unavailable.

VEGETATIVE PROPAGATION

- **Division**
  T. maritimum ssp. *phaeocephala* plants may be propagated by crown division in spring, just as growth begins, or in autumn (Holloway, 2024).

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Appendix B – Recommended Reading

Compiled by Kelly Sivy, Casey Greenstein, and Bonnie Bernard
Homer Soil and Water Conservation District

CONTENTS

Items with (*) include catalog of taxon-specific propagation information, in addition to general reference.

National Native Seed Needs

National Academy of Sciences, Engineering, and Medicine. (2023). *An Assessment of Native Seed Needs and the Capacity for Their Supply: Final Report.* Washington, DC: The National Academies Press. https://doi.org/10.17226/26618

Alaska Native Plant Organizations

Alaska Native Plant Society
A non-profit organization for the study and conservation of Alaska's native plants.
https://aknps.org/

Alaska Plant Materials Center
Alaska Department of Natural Resources, Division of Agriculture
Serving Alaska's needs in the production of native plants and traditional crops.
https://dnr.alaska.gov/ag/akpmc/index.htm

Georgeson Botanical Garden
A nationally recognized botanical garden dedicated to plant culture and conservation, part of the School of Natural Resources and Extension at the University of Alaska Fairbanks.
https://georgesonbotanicalgarden.org/

Online Databases

Alaska Flora Quick Maps
http://alaskaflora.org/qm/

Alaska Plant Materials Center – Plant Flyers
Alaska Department of Natural Resources, Division of Agriculture
https://dnr.alaska.gov/ag/akpmc/Pubsplantflyers.htm

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Klinkenberg, B. (2020). E-Flora BC: Electronic Atlas of the Plants of British Columbia [eflora.bc.ca]. Lab for Advanced Spatial Analysis, Department of Geography, University of British Columbia, Vancouver. https://ibis.geog.ubc.ca/biodiversity/eflora/

Native Plants Journal
Online Journal Content Archive
https://npj.uwpress.org/content/by/volume

Native Plant Network
Reforestation, Nurseries and Genetics Resources – Propagation Protocols
https://npn.rngr.net/propagation/protocols

Native Plant Network
Reforestation, Nurseries and Genetics Resources – Publications
https://rngr.net/publications

Ontario Rock Garden & Hardy Plant Society
Germination Guide Plant List
https://onrockgarden.com/index.php/germination-guide/germination-guide

Society for Ecological Restoration
Restoration Resource Center Project Database
https://ser-rrc.org/project-database/?type=resource#app

Society for Ecological Restoration
Seed Information Database
https://ser-sid.org/

United States Department of Agriculture. (2023). 2023 USDA Plant Hardiness Zone Map.
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Appendix C – Collection Permits

Written by Bonnie Bernard
Homer Soil and Water Conservation District

CONTENTS

Land Ownership

The original geographic scope of this research project was Southcentral Alaska, but as the project progressed, so did the spatial reach of our research. However, this section specifically addresses landownership in Southcentral, but many of the issues surrounding collection permits are applicable statewide. When in doubt, use a land ownership mapping tool and contact the land manager before any collections.

In general, persons wishing to collect plant material for scientific study or commercial use should first determine who owns the land from which they plan to collect, and then contact the corresponding management office. It is the individual's responsibility to know and abide by the laws that apply to a given collection location. The Kenai Peninsula Borough maintains a robust collection of geospatial resources, including an online map tool that can be used to look up landowner information for parcels within the borough. Similar tools are available for the Matanuska-Susitna Borough. At the statewide level, the BLM maintains a geodatabase that more coarsely maps Federal, State, Native, and private ownership.

- Kenai Peninsula Borough: https://geohub.kpb.us/
- Matanuska-Susitna Borough: https://data.matsugov.us
- Statewide (BLM Lands, Minerals, and Realty): http://sdms.ak.blm.gov/isdms/imf.jsp

Personal, Commercial and Scientific Use

In September of 2023, the Alaska Native Plant Society published a thorough guide (https://aknps.org/wp-content/uploads/NativePlantSourceList.pdf) to collecting plant materials for personal use. Though collecting native plant materials for the purposes of production falls outside most agencies' definitions of personal use, it isn't always clearly addressed by commercial use policies either. Furthermore, collecting plant materials for horticultural research may be better addressed by a scientific permit, rather than a personal or commercial permit. If in doubt, contact the land management agency's local office, and ask them about their permitting requirements. They are the best source of information about their agency's regulations.

Major Landowners in Alaska

Basic permitting information for major landowners in Southcentral Alaska is summarized below. Additional maps and resources are linked where available. Please note that this guide is intended to serve as a starting point; it does not authorize collection of plant materials. Parties interested in plant materials collection are strongly advised to consult the landowner before harvesting.

<u>Federally Owned & Managed Lands</u>

US Forest Service (USFS)

Permits to collect plant material from National Forest lands can typically be obtained at a USDA Forest Service District Office. Depending on the size and intended use of the collection, a Forest Product Removal Permit (FS-2400-1) or a Forest Products Free Use Permit (FS-2400-8) will likely be appropriate. Permit types, costs, and stipulations may also vary between regions, and Forest Service personnel can help collectors determine which permit is best suited for their collection goals. It is important to work with the local district office to ensure that collectors are aware of all terms and specifications of their permits, including any seasonal restrictions, any species with protected status, and/or any special management areas where harvest is prohibited.

There is additional statutory guidance specifically for Southcentral Alaska: https://www.federalregister.gov/documents/2000/03/10/00-5581/special-forest-products-resource-management-in-the-alaska-region, plus a 2002 Categorical Exclusion Decision Memo on Special Forest Products for the Seward and Glacier Ranger Districts. These indicate that for non-commercial personal use, most activities don't require a permit, but individuals are "expected to exercise reasonable care in protecting the resource from damage." In most personal use cases we do not require a 2400-8 permit, but individuals can always apply for one if they care to.

Personal Use Permits

Individuals collecting a small amount of plant material for personal use may be allowed to harvest under a Forest Products Free-Use Permit (FS-2400-8) if "supply is not limited and value is low." Individuals collecting plant materials under a Forest Products Free-Use Permit are specifically prohibited from selling or exchanging material harvested under that permit. If collecting large volumes of plant material, a Forest Product Removal Permit (FS-2400-1) is needed.

Commercial Use Permits

For persons interested in collecting plant materials for a native plant business, a Forest Product Removal Permit (FS-2400-1) is likely more appropriate. This permit authorizes small commercial and larger-scale personal collections that are "expected to have limited resource impacts," and they allow collectors to remove forest products, such as plant materials, when such removal would otherwise be illegal. The standard fee for this permit is $20, though larger or more complicated collection requests may incur additional charges.

Obtaining Permits

To obtain permits, collectors should visit and/or contact the district office that corresponds to the region in which they intend to collect. Forest Service staff can help determine which permit is right for your intended use. Chugach National Forest is divided into three large Ranger Districts, with district offices in Girdwood, Seward, and Cordova. Additional information may be found via the following links:
https://www.fs.usda.gov/wildflowers/ethics/permit.shtml
https://www.fs.usda.gov/main/chugach/passes-permits

Bureau of Land Management (BLM)
On most BLM lands, small volumes of plant material can be collected for personal use without a permit. However, commercial use harvest of plant materials requires a permit, or even a contract. General information about collecting on BLM land is available at https://www.blm.gov/Learn/Can-I-Keep-This.

Personal Use Permits
On BLM lands, plant materials such as seeds or transplants are referred to as "special forest products."
In Alaska, Free Use Permits may be issued for materials that are for personal use; materials collected under a Free Use Permit cannot be bartered or sold. BLM does not permit the taking of cuttings or transplants without a permit, but BLM does allow for limited seed collection (100 seeds per species per year) without a permit for personal use.

Commercial Use Permits
Any research or commercial use of seeds, cuttings, or transplants from BLM lands requires a Forest and Wood Products Permit. Some additional information is available at the following link, but collectors will ultimately need to contact their local Alaska BLM office for more information and necessary forms: https://www.blm.gov/programs/natural-resources/forests-and-woodlands/forest-product-permits

Obtaining Permits
Collectors are encouraged to contact their local Alaska BLM office before harvesting, even if only making personal collections, as some areas may be closed to certain uses. An interactive map of BLM lands in Alaska is available at http://sdms.ak.blm.gov/isdms/imf.jsp.

US Fish and Wildlife Service (USFWS), Includes National Wildlife Refuges

Personal Use Permits
Personal use collection of whole plants or plant cuttings is allowed in non-wilderness areas but prohibited within wilderness areas. Collectors are encouraged to visit refuge headquarters or visitor centers to ensure that no special restrictions exist for their region or species of interest, and to obtain up-to-date maps of designated public use areas.

Commercial Use Permits
Some commercial or research activities may only be authorized on National Wildlife Refuge lands only with a Special Use Permit. These required permits help ensure that the permitted activity is consistent with the refuge's wildlife conservation goals, and permit fees are collected to help cover the cost of this evaluation. Special Use Permits are subject to specific conditions and may place limitations on use locations, timing, etc.

Obtaining Permits
Persons interested in commercial use harvest of plant material should contact a refuge office or the refuge manager to determine if such harvest is appropriate on the refuge in question. Information about permits can be found at:
https://fwsepermits.servicenowservices.com/fws

Additional information about Special Use Permits can be found at: https://www.fws.gov/service/special-use-permits-national-wildlife-refuges

National Park Service (NPS)
Removing plant materials from lands owned or managed by the National Park Service (NPS) is generally prohibited, and collection permits are issued only under very limited circumstances. Title 36, Chapter I, Part 2.1 of the Code of Federal Regulations (CFR) dictates that "possessing, destroying, injuring, defacing, removing, digging, or disturbing from its natural state plants or the parts or products thereof" is an expressly prohibited use of National Park Service resources. It also specifically prohibits the unauthorized removal of natural products from the park area, and the sale or commercial use of natural products (36 CFR 2.1).

Personal Use Permits
There is currently no known avenue for the issuance of personal use permits for plant material collection on National Park Service lands.

Commercial or Scientific Use Permits
There is currently no known avenue for the issuance of commercial use permits for plant material collection on National Park Service lands. Only under extremely limited circumstances are park superintendents authorized to issue specimen collection permits for scientific use. A collection permit will not be issued if the specimen "is readily available outside of the park area" (36 CFR 2.5). As such, none of these circumstances are likely to cover collection for horticultural research or cultivation.

Obtaining Permits
The removal of plant materials from NPS lands can only be authorized by the park superintendent under extremely rare circumstances. This is not expected to be a fruitful path of inquiry for collectors looking to start a native plant business.

Department of Defense (DOD), includes USAF Joint Base Elmendorf-Richardson
No plant material collection is allowed on Joint Base Elmendorf-Richardson, which is managed by the US Department of Defense (DOD).

State Owned and Managed Lands

AK Department of Natural Resources (AK DNR), Division of Parks & Outdoor Recreation (Includes State Parks)
The Alaska Administrative Code (AAC) Article 1 "State Park Land and Water Restrictions" explicitly prohibits the removal of trees and plants from state park lands, except for personal consumption of berries or other edible plants; or unless authorized by special permit.
Information on the types of permits available, as well as application guidance, is available at: https://dnr.alaska.gov/parks/permit/index.htm

AK Department of Natural Resources (AK DNR), Division of Mining, Land & Water (DMLW)
On AK DNR lands managed by the Division of Mining, Land, and Water (DMLW), personal use collection of plant materials is covered under "generally allowed uses." Commercial use harvest of plant materials from any general state land requires an official permit obtained from the DMLW. Please note that this permit from DMLW does not cover collection on State Park land, or on land managed by other state agencies.

Personal Use Permits
Title 11, Chapter 96 of the Alaska Administrative code allows for the harvest of small quantities of wild plants or other plant material for personal (non-commercial) use, under the provisions of "generally allowed uses" (11 AAC 96.020). Please note that operating under the "generally allowed uses" requires compliance with the conditions set out in 11 AAC 96.025. Under these provisions, personal use plant material collection does not require a permit from DMLW, but it may be restricted in certain special management areas or on Special Use Land.
A list of Special Use Lands is provided on the DMLW website: https://dnr.alaska.gov/mlw/lands/special-use-areas/

For more information on "generally allowed uses," please reference the following DMLW fact sheet:
https://dnr.alaska.gov/mlw/cdn/pdf/factsheets/generally-allowed-uses.pdf

Commercial Use Permits
The DMLW defines "commercial use" of plant materials as "harvested for the primary purpose of sale, resale, or use in a manufacturing process resulting in a product that will be sold or used for business activities." Commercial use collection of plant material can be authorized through the AK DNR Non-Timber Forest Product (NTFP) Commercial Harvesting Permit. In cooperation with Cooperative Extension, AK DNR has also produced a Harvest Manual, which provides harvest limits and protocols for different plant material types to ensure sustainable management.

Obtaining Permits
An official permit must be obtained from DMLW for commercial use harvest on any general state land. This permit requires a $160 fee, the maintenance of harvest records, and submission of an

end-of-season report. Detailed application information, instructions, and the full harvest manual can be found at: https://dnr.alaska.gov/mlw/lands/permitting/ntfp-commercial-harvest-permit/

Other Lands Owned/ Managed by State of Alaska Entities

It is important to note that the NTFP Commercial Harvest Permit issued by DMLW does not cover land owned or managed by state parks or other state agencies.

Department of Transportation and Public Facilities (DOT&PF)

In many cases, AK DOT&PF highways and rights-of-way function as easements through lands owned by other entities. As such, authorization or permits for plant materials collection must be issued by the owner of the parcel through which a road or right-of-way passes. However, interested parties should also work with DOT&PF to ensure that collection will not impact road use or DOT&PF operations.

University of Alaska (UA)

The University of Alaska is considered a private owner, and its lands are not considered public domain lands. All extractive uses require prior authorization via submission of a Land Use Application Form. More info about this application is available at https://www.alaska.edu/ualand/permits/land-use.php.

Alaska Mental Health Trust Authority

Commercial uses of land held by the Alaska Mental Health Trust require authorization via a Land Use Application Form, available at https://tlo.dnr.alaska.gov/tloforms/LandUseApplication/, and a $500 non-refundable application fee. Additional information and guidance about the application process is available at https://alaskamentalhealthtrust.org/trust-land-office/land-sales/land-use-application/.

Alaska Railroad (ARRC)

Access to Alaska Railroad property requires prior authorization and issuance of a permit. Information about these permits is available at https://www.alaskarailroad.com/real-estate/permitting.

Borough, Municipal, and Other Locally Owned Lands

Matanuska-Susitna Boroughs

Collection of plant materials for personal use is not authorized without prior approval via a Personal Intermittent Use Permit. The application costs $25 per person, and the permit restricts use to seven consecutive days or 21 total days in a twelve-month period. Commercial use of Mat-Su Borough land requires a Commercial Permit Application. Both permit applications are available online at https://matsugov.us/document?search_tags=132.

Kenai Peninsula Borough
The KPB Land Management Division considers personal use harvest of berries, mushrooms, and dead trees as allowable casual uses of borough land and provides guidelines for responsible harvest. However, before collecting other plant materials for personal use, parties should contact the KPB Land Management Division to ensure that their intended activity falls under casual use. Maps and more information about casual use is available at https://www.kpb.us/landmgt/casual-use-of-borough-land.

Commercial harvest of non-timber plant materials on KPB lands is not explicitly addressed. Parties interested in collecting for commercial use should contact the KPB Land Management Division to determine the appropriate process for obtaining commercial use authorization.

Native Corporation Land
A number of Native Corporations also own and manage lands throughout Southcentral Alaska. Each Native corporation has different land use policies, but many require users to obtain permits for any type of land access. Depending on the corporation, plant material harvest may not be allowed.

Ahtna, Inc.
Information related to general access of Ahtna lands, as well as contact information for commercial use permitting is available at https://www.ahtna.com/lands/land-permits/.

Chugach Alaska Corporation
No permitting information is available for Chugach Alaska Corporation currently.

Cook Inlet Region, Inc. (CIRI)
Permitting is required for all CIRI land use. Unauthorized use of CIRI land constitutes trespassing. Persons wishing to access CIRI land are advised to contact the CIRI Land and Resources Department to learn more about land use policies. Information about permit requirements is available at https://www.ciri.com/our-corporation/ciri-lands/permitting/.

Privately Owned Land
On private land, plant material collection is not allowed without explicit landowner authorization.

Appendix D – Survey/Interview Questions

Compiled by Casey Greenstein and Jake Egelhoff
Homer Soil and Water Conservation District

Homer Soil and Water Conservation District's Native Plant Materials Survey

Homer Soil and Water is collecting data on native plants and would love your feedback!

We will use this data to build collaborations, honor expertise in native plant propagation, understand potential supply and demand, and collect background information. These questions are intended to help determine how Homer Soil and Water can best help move forward the statewide native plants program, while specifically focusing on Southcentral Alaska.

* Indicates required question

1. Email *

2. Your name *

3. Name of your organization

Background questions

4. Rank your level of interest in working with native plants, on a scale of 1-5

Mark only one oval per row.

	1	2	3	4	5
Level of interest	☐	☐	☐	☐	☐

5. How would you describe the current status of how your organization utilizes native plants, and the goals you have for the future?

6. What resources do you have available regarding infrastructure, land, transportation, expertise, and workforce to implement native plants?

7. What expertise do you currently have in-house regarding botany and restoration? Do you have a need or interest in hiring someone with expertise?

8. Would you or your organization like to be involved in the Alaska Native Plants Program? If so, how would you like to be involved?

9. What services or support would you like the Alaska Native Plants program to provide? (species-specific and education-specific questions to follow)

10. Have you spoken with any partner agencies, individuals or groups about native plant production? If so, with whom, and what was discussed?

Economics

Once we collect some baseline data on native plant needs, a separate economic feasibility study will be done by a contractor. Briefly summarize the following,and be prepared to talk more in depth on these topics with the economic contractor.

- Funds available
- Funds pending
- Funding sources
- Funding limitations
- Transportation costs
- Staffing rates
- Contracting rates

11. Summarize below.

12. If available, how much would your organization be willing to pay for genetically appropriate, local plants and seeds (as opposed to out-of-state seed mixes, or nonnative nursery plants)?

    In contrast, if your organization produces these products, at what rate would you expect to sell?

    Check all that apply.

    - [ ] No more than what we already pay for out-of-state materials
    - [ ] Up to 10% more
    - [ ] Up to 25% more
    - [ ] Up to 50% more
    - [ ] Up to 100% more
    - [ ] Not sure
    - [ ] Other: ____________

Policy

13. The Alaska Weed-Free Forage and Gravel Program has faced similar challenges that the Native Plants Program is now addressing. Namely, chicken-and-egg issues with supply and demand, and how this influences policy. To best learn from past experience, we'd like to know if you're familiar with the Weed-Free Forage and Gravel Program, and are you likely to use it?

Check all that apply.

- [ ] Not familiar
- [ ] Somewhat familiar
- [ ] Familiar
- [ ] Yes, would use it
- [ ] No, would not use it

14. If you answered that you would not use weed-free forage or gravel, why not? What are potential barriers to implementation?

15. Do you have any thoughts or comments on policy regarding potential native plant material requirements or related issues?

Educational needs

16. What sort of materials would your organization be interested in, with regard to native plant knowledge? (e.g. formats, such as guidebooks, single page flyers, web resources; or topics, such as propagation, restoration, economic breakdowns)

Demand Intro

The next section is applicable to organizations that have restoration projects planned or in progress, and addresses demand for native plants. Please answer no if this does not apply, in order to skip this section.

17. Does your organization have a need for native plant materials?

Mark only one oval.

- [ ] Yes
- [ ] No *Skip to question 40*

Demand Questions

18. Do you have project(s) planned or in progress currently that need native plant materials? If so, what square footage or acreage needs planting?

19. Do you use any of the materials listed below for projects with your organization?

Check all that apply.

- [ ] Native Seed
- [ ] Non-native Seed
- [ ] Native plant materials
- [ ] Non-native plant materials

20. What geographic region does your organization work in? You can write in a description of where you work, or refer to [Level III Ecoregions of Alaska] and choose from the list below.
If you have projects planned or in progress in these regions, please make note in the answer box below.

Check all that apply.

- [ ] 113: Alaska Peninsula Mountains (Kodiak Island)
- [ ] 115: Cook Inlet
- [ ] 116: Alaska Range
- [ ] 117: Copper Plateau (Copper River Basin)
- [ ] 118: Wrangell Mountains
- [ ] 119: Pacific Coastal Mountains (Chugach-St. Elias)
- [ ] 120: Coastal Western Hemlock-Sitka Spruce Forests (Gulf of Alaska Coast, includes Homer and Seldovia)
- [ ] Statewide
- [ ] Other: ______________________

21. Include any notes on location, or projects planned or in progress.

____

____

____

____

____

22. What habitat type does your organization work in? You can write in a description or choose from the list below.
If you have projects planned or in progress in these habitats, please make note in the answer box below.

Check all that apply.

- [ ] Boreal forest
- [ ] Coastal rainforest
- [ ] Rivers and Lakes
- [ ] Wetlands
- [ ] Coastal
- [ ] Disturbed areas (roadsides, urban, industrial, residential, etc.)
- [ ] Other: ______________________________

23. Include any notes on habitat type, or projects planned or in progress.

____
____
____
____
____

24. If you have projects planned or in progress what is the approximate elevation?

____

25. Optional: define area by Level II Viereck code

Check all that apply.

- [ ] Needleleaf forest
- [ ] Broadleaf forest
- [ ] Mixed forest
- [ ] Dwarf tree scrub
- [ ] Tall scrub
- [ ] Low scrub
- [ ] Dwarf scrub
- [ ] Graminoid herbaceous
- [ ] Forb herbaceous
- [ ] Bryoid herbaceous
- [ ] Aquatic herbaceous
- [ ] Other: ______________________

26. Material needs

What types of plant material do you need? Choose:

Check all that apply.

- [ ] Graminoids (grasses, sedges, rushes)
- [ ] Forbs (non-woody herbaceous flowering plants)
- [ ] Shrubs/subshrubs
- [ ] Trees
- [ ] Other: ______________________

27. How much plant material do you need (# of plants, pounds of seed), as they apply to the plant categories above?

____

____

____

____

____

28. What type of plant would be most useful to you?

Check all that apply.

- [ ] Seed
- [ ] Hydroseed
- [ ] Seedlings in plugs or pots (3 month - 2 years old; graminoids, forbs, shrubs, or trees)
- [ ] Woody plant cuttings (e.g. willow stakes)
- [ ] Saplings or young shrubs in soil
- [ ] Bare root trees or shrubs
- [ ] Trees or shrubs grown at least two years
- [ ] Trees or shrubs grown at least five years
- [ ] Trees or shrubs grown more than five years
- [ ] Vegetation mats, sod
- [ ] Other: ______________________

29. What are your most commonly needed plant species? Are there other specific species you would like to have available?

____
____
____
____
____

30. Timelines for future work

Check all that apply.

- [ ] This year
- [ ] 1-3 years out
- [ ] 3+ years out
- [ ] Other: ______________________

31. Time of year that seeds/plant materials are needed

Check all that apply.

- [ ] Spring and summer (for outplanting)
- [ ] Fall (for outplanting, direct sowing of seeds needing cold stratification)
- [ ] Other: ______________________

32. How do you currently acquire plants/seeds?

Check all that apply.

- [ ] Grow your own
- [ ] Salvage
- [ ] Wild harvest
- [ ] Purchase from retailer in-state
- [ ] Purchase from retailer out-of-state
- [ ] Contractor
- [ ] Giveaways
- [ ] Other: ______________________

33. If you chose purchase in-state, out-of-state, or contractor, please include name.

____

____

____

____

____

34. How do you expect your organization's need for native plant materials to change over the next 10 years?

Mark only one oval.

- [ ] Increase
- [ ] Decrease
- [ ] Stay the same
- [ ] Unknown
- [ ] Other: ______________________

35. Timelines

If it hasn't already been addressed, summarize projects that are
- Pending
- In progress
- Completed (what has your historical use of plant material looked like?)

36. For past projects, were you able to acquire the amount and type of native seed/plant materials you needed?

Mark only one oval.

- [ ] Yes
- [ ] No (why not? see next question)

37. If no, please choose from below, or elaborate in the "Other" category.

Mark only one oval.

- [ ] Were native species too expensive?
- [ ] Were natives not available within project timeline?
- [ ] Were natives not available at all?
- [ ] Were other natives substituted for preferred natives?
- [ ] Were non-native species substituted for native ones?
- [ ] Other: ____________________

38. Project purpose

What types of projects do you - or do you expect to - need plant materials for?

Check all that apply.

- [ ] Post-fire rehabilitation
- [ ] Resource extraction reclamation
- [ ] Mitigation (describe below)
- [ ] Erosion control and stabilization
- [ ] Roadside vegetation
- [ ] Weed exclusion
- [ ] Improve habitat diversity
- [ ] Pollinator support
- [ ] Restoration of wildlife habitat
- [ ] Landscaping
- [ ] Other: ____________________

39. If needed, explain project purpose or elaborate.

Salvage

The next section is applicable to organizations or individuals that 1) have areas scheduled for disturbance where plants could be salvaged beforehand, 2) potentially have the capacity to salvage plants, or 3) have experience with native plant salvage. Please answer no if this does not apply, in order to skip this section.

40. Do you have experience with plant salvage?

Mark only one oval.

- [ ] Yes
- [ ] No *Skip to question 48*

Salvage questions

41. Salvage opportunities

Do you have any upcoming projects that will cause ground disturbance?

Mark only one oval.

- [ ] Yes
- [ ] No
- [ ] Possibly

42. Do you have capacity in your organization to salvage native plants before disturbing the ground?

Mark only one oval.

- [ ] Yes
- [ ] No
- [ ] Possibly

43. Would you need staffing or technical guidance in that process?

Check all that apply.

- [ ] Staffing
- [ ] Guidance

44. Do you have a site in a similar ecosystem that's in need of restoration/revegetation?

Mark only one oval.

- [ ] Yes
- [ ] No
- [ ] Possibly

45. If yes, do you plan to salvage and replant between sites?

Mark only one oval.

- [ ] Yes
- [ ] No
- [ ] Possibly
- [ ] Not applicable

46. If no, would you consider salvaging plants to share with another land management organization, contractor, or individuals?

Mark only one oval.

- [ ] Yes
- [ ] No
- [ ] Possibly
- [ ] Not applicable

47. Any additional thoughts on plant salvage?

Supply Intro

The next section is applicable to organizations that collect or grow native plant materials, and addresses supply of native plants. Please answer no if this does not apply, in order to skip this section.

48. Does your organization supply native plant materials?

Mark only one oval.

- [ ] Yes
- [ ] No *Skip to question 57*

Supply questions

49. Location

Will you be growing or collecting native plant materials?

Check all that apply.

- [ ] Growing
- [ ] Collecting
- [ ] Neither
- [ ] Unsure
- [ ] Other: ____________

50. If growing on a farm, describe geographic location, elevation, aspect, habitat type, soil characteristics, sun exposure, etc.

51. If harvesting wild materials, what ecoregion are you collecting from? Are you able to tailor collections to meet demand?

52. Experience

What's your experience with propagating native plants? Choose:

Mark only one oval.

- [ ] Little to no propagation experience -- would appreciate help from the native plants program
- [ ] Experience with agricultural or ornamental crops, but not with natives
- [ ] Some propagation experience -- successfully done native plant propagation
- [ ] Extremely experienced in native plant propagation

53. What types of plant material are you interested in producing?

Check all that apply.

- [ ] Seed
- [ ] Hydroseed
- [ ] Seedlings in plugs or pots (3 month - 2 years old; graminoids, forbs, shrubs, or trees)
- [ ] Woody plant cuttings (e.g. willow stakes)
- [ ] Saplings or young shrubs in soil
- [ ] Bare root trees or shrubs
- [ ] Trees or shrubs grown at least two years
- [ ] Trees or shrubs grown at least five years
- [ ] Trees or shrubs grown more than five years
- [ ] Vegetation mats, sod
- [ ] Other: ______________________

54. What specific species do you grow? What species are you interested in growing?

55. What is your current and/or projected production quantities?

56. Infrastructure

What do you have, and what do you need for infrastructure? For example:

- Capillary beds, in-ground planting, high tunnels
- Square footage of high tunnels, acres of land
- Power, water, irrigation, equipment, materials

Propagation expertise

The next section is applicable to organizations that have propagation expertise. Please answer no if this does not apply, in order to skip this section.

57. Do you have propagation expertise?

Mark only one oval.

- [ ] Yes *Skip to question 58*
- [ ] No *Skip to question 68*

Propagation expertise questions

58. Are you willing to share your expertise, either with the Native Plants program or with other individuals or organizations?

Check all that apply.

- [ ] With the Native Plants program
- [ ] With others
- [ ] Possibly/conditionally

59. What species have you had a high success rate with propagating?

60. What species have you had a low success rate with propagating?

61. What methods do you use to overwinter plants and what have you seen as success or failures?

62. What equipment do you use, or would like access to, for seed processing and propagation?

63. If so, please describe below

64. Rank your skills and experience for each row, where:
1 - no skills/experience
2 - some skills/experience
3 - moderate skills/experience
4 - strong skills/experience
5 - expert-level skills/experience

Check all that apply.

	1	2	3	4	5
Seed collection (wild harvest)	☐	☐	☐	☐	☐
Seed collection (agricultural/horticultural)	☐	☐	☐	☐	☐
Cuttings collection (e.g. willow stakes)	☐	☐	☐	☐	☐
Plant salvage (prior to disturbance)	☐	☐	☐	☐	☐
Seed processing/cleaning	☐	☐	☐	☐	☐
Seed storage	☐	☐	☐	☐	☐
Stem storage	☐	☐	☐	☐	☐
Propagation from seed	☐	☐	☐	☐	☐
Propagation from cuttings	☐	☐	☐	☐	☐
Propagation from roots	☐	☐	☐	☐	☐
Propagation, other methods (e.g. grafting)	☐	☐	☐	☐	☐
Propagation of plugs and pots	☐	☐	☐	☐	☐
Bare root plants	☐	☐	☐	☐	☐
Propagation outdoors	☐	☐	☐	☐	☐

Propagation in greenhouse/high tunnel	☐	☐	☐	☐	☐
Storage techniques	☐	☐	☐	☐	☐
Prescribing seed mixes	☐	☐	☐	☐	☐
Creating hydroseed mixes	☐	☐	☐	☐	☐
Growing sod	☐	☐	☐	☐	☐
Growing vegetated mats	☐	☐	☐	☐	☐
Grasses, sedges, rushes	☐	☐	☐	☐	☐
Forbs	☐	☐	☐	☐	☐
Shrubs/subshrubs/trees	☐	☐	☐	☐	☐
Mosses	☐	☐	☐	☐	☐
Mycorrhizae	☐	☐	☐	☐	☐
Other relevant skills/ experiences (describe below)	☐	☐	☐	☐	☐

65. If you need to elaborate on any sections above, please do so below.

Vegetation mats

66. Vegetation mats are sheets of native plant material commonly used in restoration. Do you have any experience using or producing them?

Mark only one oval.

- [ ] Yes
- [ ] No
- [ ] Somewhat

67. If you answered yes, please elaborate below.

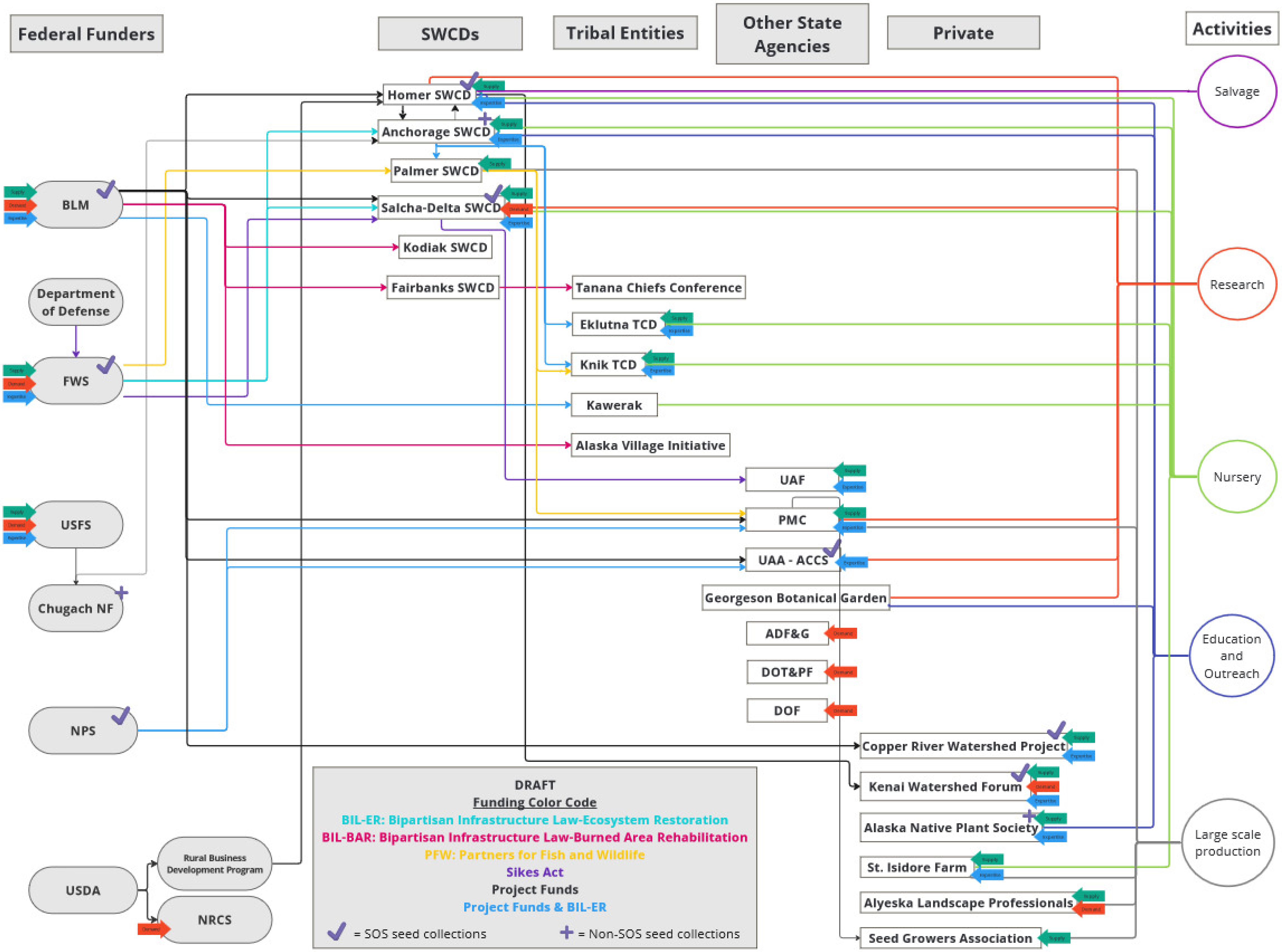
Final thoughts/notes

Please include any other thoughts you have for us below. Thank you for taking the time to do this survey! We greatly appreciate your input.

68. Notes:

Appendix E – Network Diagram

Compiled by Casey Greenstein with contributions from Jake Egelhoff
(Homer Soil and Water Conservation District)
and Lisa Dlugolecki
(US Fish and Wildlife Service)



Federal Funders
SWCDs
Tribal Entities
Other State Agencies
Private
Activities
Homer SWCD
Anchorage SWCD
Palmer SWCD
Salcha-Delta SWCD
Kodiak SWCD
Fairbanks SWCD
Tanana Chiefs Conference
Eklutna TCD
Knik TCD
Kawerak
Alaska Village Initiative
UAF
PMC
UAA - ACCS
Georgeson Botanical Garden
ADF&G
DOT&PF
DOF
Copper River Watershed Project
Kenai Watershed Forum
Alaska Native Plant Society
St. Isidore Farm
Alyeska Landscape Professionals
Seed Growers Association
BLM
Department of Defense
FWS
USFS
Chugach NF
NPS
USDA
Rural Business Development Program
NRCS
Salvage
Research
Nursery
Education and Outreach
Large scale production
DRAFT
Funding Color Code
BIL-ER: Bipartisan Infrastructure Law-Ecosystem Restoration
BIL-BAR: Bipartisan Infrastructure Law-Burned Area Rehabilitation
PFW: Partners for Fish and Wildlife
Sikes Act
Project Funds
Project Funds & BIL-ER
= SOS seed collections
= Non-SOS seed collections