



USDA

# NATIVE SEED PRODUCTION MANUAL

FOR THE PACIFIC NORTHWEST



NATURAL RESOURCES CONSERVATION SERVICE





## **Non-Discrimination Policy**

The U.S. Department of Agriculture (USDA) prohibits discrimination against its customers, employees, and applicants for employment on the bases of race, color, national origin, age, disability, sex, gender identity, religion, reprisal, and where applicable, political beliefs, marital status, familial or parental status, sexual orientation, or all or part of an individual's income is derived from any public assistance program, or protected genetic information in employment or in any program or activity conducted or funded by the Department. (Not all prohibited bases will apply to all programs and/or employment activities.)

## **To File an Employment Complaint**

If you wish to file an employment complaint, you must contact your agency's EEO Counselor (PDF) within 45 days of the date of the alleged discriminatory act, event, or in the case of a personnel action. Additional information can be found online at [http://www.ascr.usda.gov/complaint\\_filing\\_file.html](http://www.ascr.usda.gov/complaint_filing_file.html).

## **To File a Program Complaint**

If you wish to file a Civil Rights program complaint of discrimination, complete the USDA Program Discrimination Complaint Form (PDF), found online at [http://www.ascr.usda.gov/complaint\\_filing\\_cust.html](http://www.ascr.usda.gov/complaint_filing_cust.html), or at any USDA office, or call (866) 632-9992 to request the form. You may also write a letter containing all of the information requested in the form. Send your completed complaint form or letter to us by mail at U.S. Department of Agriculture, Director, Office of Adjudication, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410, by fax (202) 690-7442 or email at [program.intake@usda.gov](mailto:program.intake@usda.gov).

## **Persons with Disabilities**

Individuals who are deaf, hard of hearing or have speech disabilities and you wish to file either an EEO or program complaint please contact USDA through the Federal Relay Service at (800) 877-8339 or (800) 845-6136 (in Spanish).


Persons with disabilities who wish to file a program complaint, please see information above on how to contact us by mail directly or by email. If you require alternative means of communication for program information (e.g., Braille, large print, audiotape, etc.) please contact USDA's TARGET Center at (202) 720-2600 (voice and TDD).

## **Supplemental Nutrition Assistance Program**

For any other information dealing with Supplemental Nutrition Assistance Program (SNAP) issues, persons should either contact the USDA SNAP Hotline Number at (800) 221-5689, which is also in Spanish or call the State Information/Hotline Numbers.

## **All Other Inquiries**

For any other information not pertaining to civil rights, please refer to the listing of the USDA Agencies and Offices for specific agency information.





# Native Seed Production Guide

Corvallis PMC

# Contents

## Forbs

<i>Achillea millefolium</i> .....	14
<i>Agoseris grandiflora</i> .....	16
<i>Artemisia suksdorfi</i> .....	18
<i>Camassia leichtlinii</i> .....	20
<i>Castilleja levisecta</i> .....	22
<i>Cirsium edule</i> .....	24
<i>Clarkia amoena</i> .....	26
<i>Clarkia rhomboidea</i> .....	28
<i>Downingia elegans</i> .....	30
<i>Erigeron decumbens</i> .....	32
<i>Eriogonum nudum</i> .....	34
<i>Eriogonum umbellatum</i> .....	36
<i>Eriophyllum lanatum</i> .....	38
<i>Eryngium petiolatum</i> .....	40
<i>Galium trifidum</i> .....	42
<i>Gilia capitata</i> .....	44
<i>Iris douglasiana</i> .....	46
<i>Iris tenax</i> .....	48
<i>Lasthenia glaberrima</i> .....	50
<i>Lotus formosissimus</i> .....	52
<i>Lotus micranthus</i> .....	54
<i>Lotus unifoliolatus</i> .....	56
<i>Lupinus adsurgens</i> .....	58
<i>Lupinus albifrons</i> .....	60
<i>Lupinus bicolor</i> .....	62
<i>Lupinus latifolius</i> .....	64
<i>Lupinus oregonus</i> .....	66
<i>Lupinus polyphyllus</i> .....	68
<i>Lupinus rivularis</i> .....	70
<i>Madia elegans</i> .....	72
<i>Madia glomerata</i> .....	74
<i>Madia gracilis</i> .....	76

<i>Montia linearis</i> .....	78
<i>Myosotis laxa</i> .....	80
<i>Navarretia intertexta</i> .....	82
<i>Nemophila menziesii</i> .....	84
<i>Penstemon cardwellii</i> .....	86
<i>Penstemon procerus</i> .....	88
<i>Penstemon roezlii</i> .....	90
<i>Phlox gracilis</i> .....	92
<i>Plectritis congesta</i> .....	94
<i>Potentilla glandulosa</i> .....	96
<i>Prunella vulgaris</i> .....	98
<i>Ranunculus occidentalis</i> .....	100
<i>Rupertia physodes</i> .....	102
<i>Saxifraga oregana</i> .....	104
<i>Sidalcea campestris</i> .....	106
<i>Sidalcea nelsoniana</i> .....	108
<i>Sidalcea virgate</i> .....	110
<i>Sisyrinchium hitchcockii</i> .....	112
<i>Solidago Canadensis</i> .....	114
<i>Solidago spathulata</i> .....	116
<i>Symphyotrichum chilensis</i> .....	118
<i>Symphyotrichum hallii</i> .....	120
<i>Trifolium wormskioldii</i> .....	122
<i>Veronica peregrine</i> .....	124
<i>Viola adunca</i> .....	126
<b>Equipment Overview</b> .....	128





The USDA NRCS Corvallis Plant Materials Center (PMC) has been researching and conducting seed production of native plants on a small scale since its inception in 1957. Techniques have been developed from scratch or adapted from more conventional species and refined through experimentation or trial and error. PMC seed production efforts expanded in the 1990's and 2000's with the advent of cooperative relations with several federal land management agencies including the National Park Service, Bureau of Land Management, Forest Service, Fish and Wildlife Service, US Army, and Federal Highway Administration. Over those two decades alone, nearly 20 native grass species, 20 grass-like species, and 100 forbs were grown, evaluated, and produced for seed by the PMC.

The purpose of this manual is to summarize the seed production methods used by the PMC for many of the native species we have worked with over the years. Small scale seed

increase is typically labor intensive, lacks labels for pesticides and herbicides that could be helpful, and often requires specialized equipment or equipment modification. Nevertheless, information provided herein should prove useful at least as a starting point for both established seed growers and others interested in entering the business, or for practitioners wishing to simply collect, process, and handle seed of plants native to the Pacific Northwest, USA.

## **SEED PRODUCTION IN THE PACIFIC NORTHWEST**

The climate and soils of the Pacific Northwest, especially western Oregon, are ideal for seed production. Native plants are adapted to the local climate and usually do not need irrigation. The Willamette Valley is one of the leading seed production regions in the world. Mild, wet winters create reliable planting times for species that should be directly sown. The area's predictable spring rains and moderate temperatures are favorable for establishing fields with transplants. Most seed production can be accomplished without the use of irrigation if plants are fall sown and their establishment is coordinated with the seasons. The warm, dry summers with low humidity are ideal for seed production. Seed and plant material can be windrowed and dried in the fields or outside without special drying equipment, especially in the Willamette Valley.



## CHALLENGES OF NATIVE SEED PRODUCTION

Most agronomic crops that are grown for seed have been extensively bred and selected for traits that are beneficial for seed production such as uniform ripening and shatter resistance. As a result of this breeding, they generally have a narrow genetic base. Native seed crops on the other hand are usually grown to be used in ecological restoration. In order for these native plant materials to become successful components of a functioning ecosystem in unpredictable and changing environments, they need to have a broad genetic base, be adaptable, and non-uniform. Unfortunately, many of these traits deemed desirable in native plants are the opposite of those chosen for agronomic seed crops (Table 1). This makes seed production of native species especially challenging. It takes a different frame of mind to be a native seed farmer. It is possible to successfully produce seeds of native plants, but it requires creativity, adaptability, and a willingness to sometimes step away from the machines and chemicals of large-scale agriculture. While the conventional agronomic model relies on manipulating the genetics of a plant or animal to fit the means of production, native seed production requires changing the means of production to minimize genetic selections that can occur during seed production.

### SITE PREPARATION

Good site preparation is essential for weed control and crop establishment. When planning most aspects of native seed production, consideration should be given to the effects they will have on weed management. It is very important to reduce the weed seed in the seed bank as much as possible before establishing a production field. Get to know the weeds in your soil before attempting any seed production. This will help you plan and implement methods that will reduce problems later on. Consider using smother cover crops or chemical fallow for one to two years before attempting to establish native plants. Repeated tillage often

Agronomic Seed Crop Traits	VS.	Native Plant Traits
No Seed Dormancy	VS.	High Seed Dormancy
Rapid, Uniform Germination	VS.	Staggered Germination
Fast Growing	VS.	Slow Growing
Uniform Flowering	VS.	Indeterminate Flowering
Uniform Seed Maturity	VS.	Variable Seed Maturity
High Seed Retention	VS.	Seeds Shatter Upon Ripening

**Table 1.** Comparison of traits of agronomic seed crops and native species.

does not sufficiently deplete the weed seed bank in a one to two year period, and may cause more problems by breaking down the soil structure and reducing infiltration rates leading to surface crusting, ponding, or runoff. There are many ways to create a seed bed, but two important factors to consider are firmness and weed seeds. Most native seeds are small and need to be sown shallowly, so soil should not be too fluffy or the seed will be buried. Once weed control has been performed, it is important to disturb the soil as little as possible to avoid stirring up more weed seeds.

### ESTABLISHMENT

The predictable fall rains of the Pacific Northwest and mild winters mean that fall is the best time to directly sow seeds into production fields. Temperatures are often warm enough in the fall for the plants to grow and rains are usually sufficient and reliable enough to avoid the need for irrigation. Winters are usually mild enough for roots to grow and remain active all winter and to prepare for vigorous above ground growth when temperatures rise in the spring. Spring is usually not the best time to establish fields from direct sowing. By the time soils dry out enough to be worked and seed beds are made, seedlings often don't have enough time to become established before





**Figure 2.** Grasses can be successfully established using tilled seed beds and common seed drills

the summer drought occurs. Irrigation can help with establishment, but often compounds weed issues. However, spring sowing allows for more weed control of winter annuals. For example, it is advantageous to spring sow some

species such as yarrow. Yarrow seeds are not dormant and will germinate whenever soils are moist and warm. Seeds beds can be created in the fall, left over the winter, and weeds can be controlled (without soil disturbance) in early spring just before sowing. Seeds can be surface sown, will germinate quickly, and plants will be established before the summer drought. The most successful approach for establishing seed production fields is to transplant containerized plants (plugs). Large, healthy transplants can be placed in a weed-free field on precise spacing. Usually, a plant can be grown in a container in a couple months and be comparable in size to a plant raised in a field for an entire year. Producing and transplanting plugs is costly compared to direct seeding, but often can be more economical in the long run. At the Corvallis PMC, plugs are usually produced in a greenhouse over the winter, acclimated to outdoor conditions in early spring, and planted into fields in March. Most years, transplants will receive adequate rain and supplementary irrigation is not

Chart 1: Seeding Schedule

	
Sow in the <b>FALL</b> if Species Has	Sow in the <b>SPRING</b> if Species Has
<p><b>1.</b> Seeds that are dormant and must overwinter in the soil before they will germinate (examples - Camas, California outgrass)</p>	<p><b>1.</b> Seeds that are not dormant but require the warmth of late spring to trigger germination (example - sedges).</p>
<b>OR</b>	
<p><b>2.</b> Seeds that are not dormant but only germinate in cool temperatures and grow actively in the early winter and fall. These plants are also typically early bloomers (examples - pink seablush, clarkia).</p>	<p><b>2.</b> Seedlings that are very small and grow slowly in cool weather but vigorously in warm temperatures. (examples- goldenrod, Asters).</p>
<b>OR</b>	
<p><b>3.</b> Plants that have significantly higher summer survival or an increase in flowering if fall sown (examples - blue wildrye, California brome).</p>	<p><b>3.</b> Seedlings that have low winter establishment or survival due to wet, cold conditions or no growth advantages to fall seeding (silverleaf lipine, yarrow).</p>



needed. Weed control should occur on fields before plugs are planted. The Corvallis PMC uses Ray Leach “stubby” cone-tainers for growing transplants. These containers are re-useable, stackable, and compact. Each cone is moveable, and plants can be easily removed from the cones if the root mass has filled it. Plants grown in these containers can be transplanted by hand using a “dibble” (a tool that presses a cone-tainer shaped hole in the ground) or by using a mechanical transplanter. When deciding to establish a seed production field by direct sowing versus transplanting, consider the following factors (summarized in Table 2 below):

1. How much seed is available? Often, seed has been collected from the wild and is very limited. If the seed is very valuable and collection was difficult, it may be best to establish the field using plugs

unless the species is known to be easy to establish by directly sowing.

2. Does the species establish well from directly sowing? If this is unknown, you can probably bet that it won’t establish well.
3. How slowly does the species grow relative to the weeds on your farm? Some species establish very well from seed, but they remain an inch tall for the first growing season, making manual weed control difficult. Many species will be overtaken by weeds and never establish well if directly sown.
4. Will harvestable seed yields be significantly greater in the first or second year if established from transplants rather

Direct Seeding		Using Transplants	
Pros	Cons	Pros	Cons
<b>Practical for small or large fields.</b>	Requires significantly more seed than using plugs.	<b>Requires very little seed to establish a field.</b>	Not practical for fields over an acre in size.
<b>Uses a few pieces of common farm equipment.</b>	Risky- many factors can cause complete failure of establishment.	<b>High rate of successful establishment.</b>	Requires a high level of infrastructure to produce plugs.
<b>Very little labor required.</b>	Crops have no advantage over weeds (no "head start").	<b>Weed control can be performed prior to planting giving plants an advantage over weeds.</b>	Requires a lot of labor to produce and transplant plugs.
<b>Requires very little species specific information.</b>	Few species will produce seed in their first growing season (except annuals).	<b>Many species will produce seed in their first growing season.</b>	Requires skill and knowledge of species-specific propagation.
	Narrow timeframes to apply seed (Sept-Oct, Mar).	<b>Wide timeframes to plant plugs (Oct-Mar).</b>	

Table 2

than by direct sowing? Some species, like irises, grow very slowly in a field, and will not produce seed for up to three years if directly sown. Using transplants, irises will usually produce a very small crop in year one and increase dramatically in future years.

5. Does the species have dormancy that creates windows for weed control if directly sown? Some species must be sown in the fall for the seeds to receive cold-moist stratification to break dormancy before the seeds germinate in the spring. If the seeds do not germinate until March, weed control methods, such as spraying with a broad-spectrum herbicide, can be applied in late February to eliminate the weeds that have germinated since the site was seeded.

## WEED CONTROL

Controlling weeds is the most important aspect of seed production. It is also the most time consuming and the most frustrating. Native plants usually aren't difficult to grow, but it is very difficult to create and maintain them in a monoculture. Weeds are a problem not only because they compete with the crop for resources, therefore weakening the crop, but they can also ruin a seed crop if the weed seeds contaminate the lot during harvest. Weeds germinate and grow year round in the Pacific Northwest. Many herbicides are not labeled for native plants grown for seed. This leaves native seed producers with very few legal options for chemical weed control. There are options like glyphosate for pre-planting, overspraying dormant plants, and spot treatments within fields. Some pre-emergent herbicides are labeled for grasses grown for seed and are helpful in controlling annual weeds, but these are only labeled for use after the plants have been harvested once. For grasses, several herbicides are labeled for removal of broadleaf weeds. There are few legal herbicide options for use in forb seed production fields. This leaves



**Figure 4.** Most forb seed increase fields are weeded by hand at the Corvallis Plant Materials Center.

growers reliant on other control methods such as cultivation, use of weed fabric, mulching, and hand weeding. Some tools, like flammers and horticultural vinegar can “burn down” weeds. They usually will not kill the weeds, but will burn off their leaves and set their growth rate back considerably. These tools are generally more effective when used on small seedlings.

## FERTILIZATION

Native plants are more competitive with weeds in low nutrient environments. It is important not to add fertilizer to fields that have significant weed issues. Very few fertilization studies have been performed on native grasses and forbs. In studies at the Corvallis PMC, most native grasses did not benefit from a fall fertilizer application. Native grasses usually benefit from an early spring application of nitrogen fertilizer. Avoid over fertilizing or fertilizing grasses too late in the spring as this can cause an abundance of plant material and promote lodging, and it will not increase seed yields. No formal fertilization studies have been performed on forbs at the Corvallis PMC, but some trends have emerged through observations. Most forb species appear to benefit from an application of a balanced



**Figure 5.** Slugs are a common problem in the Pacific Northwest.

fertilizer just before their active growth phase (usually in early to late spring). Rates are dependent on soil conditions and are species specific. In general, the only species that seem to have higher yields when fall fertilized are ones that are very active in fall or winter.

### **PEST AND DISEASE MANAGEMENT**

The most common diseases that plague native plants in the Pacific Northwest are fungal diseases such as rusts, mildews, smut, and ergot. Many treatments exist for these infections. Consult your area Pest Management Guide for specific information. Insects are sometimes a problem in seed production fields. Seed weevils are probably the most devastating. However, the use of insecticides should be avoided since insects rarely completely destroy a native seed crop, and broad spectrum insecticides will kill pollinators and other beneficial insects that may be protecting your crop. If insect pest pressures are intolerably high, consider using floating row covers, bio controls, or cultural methods that can disrupt the lifecycle of the pest. Slugs are a common threat to seedlings. Control methods, such as baiting, are most successful when applied in early fall when the rains begin, before reproduction occurs.

### **HARVEST**

The majority of native grasses can be harvested efficiently with traditional harvest methods, such as combines. Sedges and forbs, however, usually require creative methods to be harvested efficiently.

***DIRECT COMBINING***- This method cuts and combines standing material. Material usually needs to be somewhat dry. If it is too green, it will clog (or foul) the combine and/or not allow the seeds to be threshed properly. This method is good for species that shatter easily when ripe, mature evenly, and do not have a lot of green material at seed maturity. This method also works well for some forbs and sedges. Seed that is directly combined usually should be laid out to dry before being cleaned.

***TRADITIONAL COMBINING***- More commonly, grass seed fields are swathed and then combined. Swathing cuts the material and lays it into compact rows where the material can dry in the field. The seed is suspended within the material as it dries. This method requires fairly dry weather, and depending on the size and thickness of the swath, it can take anywhere from 5-14 days for swaths to dry. Rain storms can cause swaths to mold and/or dislodge seed from the swaths. After drying, swaths can be combined and the seeds can be cleaned right after combining without the need for further drying. This method works very well for many native grasses and a few sedges, but very few forbs.

***SEED STRIPPING***- A seed stripper is a valuable piece of harvesting equipment. It attaches to the front of the loader arms of a tractor and is highly adjustable. The spinning brush (inside the hood) brushes the seeds from the plants and sucks them up into a hopper. The brush is surprisingly gentle and does not usually damage the plants. The tractor, however, does drive over plants if fields are not created with "lanes" for the tractor tires. This harvester works



especially well on grasses that have a wide panicle, rather than a dense spike, but can be successfully used on both kinds of seed heads. It is the best harvest method for species that have a pappus attached to the seed, such as asters. It also works well on species that have extended bloom times and require multiple harvests that do not cut the plant.

**MODIFIED SWATHER-** Many growers have fabricated some type of machine that simultaneously cuts and collects plant material and seed heads. This is simply a mechanized version of hand harvesting, but it is a one time harvest. Most seed producers modify an existing machine for this type of harvest. Some producers modify swathers to collect material as it is cut, while others have fabricated a sort of “gutted” combine. At the Corvallis PMC, a hand-crafted machine has been borrowed from fellow researchers at Oregon State University. Our machine has a front cutterbar to cut the material, and a reel on the front that bends the material as it is being cut and pushes it onto a conveyor belt where it can be stuffed into bags by a passenger. The cut material then must be laid out on tarps to dry. From there, material can be pitchforked into a combine or a thresher for

**Figure 6.** To maximize yields and capture the genetics of early-maturing plants, fields at the Corvallis Plant Materials Center are often harvested multiple times.



the first step in seed cleaning. This method is preferred for species that mature evenly but will shatter if they are left on the field to dry.

**HAND HARVESTING-** With some species, hand harvesting is the most efficient harvest method, especially those with highly variable maturity and high seed shatter. This can be accomplished using rice knives, sickles, pruners, etc. Cut material should be laid on tarps to dry before it is threshed and cleaned.

**WEED FABRIC-** Weed fabric can be used as a passive seed collector. This method is great for species that have variable ripening and seeds that shatter readily upon ripening. Seeds can shatter onto the weed fabric and be swept or vacuumed at the end of the season, or multiple times if the season is very long. For some species, there would be no other method to harvest reasonable quantities of seed than using weed fabric. For other species, it can greatly increase yields and is appropriate for small, highly managed fields. This method is recommended for many species in this manual, but may not be the best method for all seed production facilities.

Drawbacks to using weed fabric and vacuuming/sweeping up seed are as follows:

- It can be expensive, primarily due to the labor costs for laying out the fabric and collecting the seed off the fabric, especially if it is done multiple times per season. This is at least partly balanced out by the weed control that the fabric provides. Weed fabric is actually cheap compared to herbicides or machines and the fabric lasts up to 10 years.
- Weed fabric can harbor pests, create disease issues, and collect weed seeds. Mice and voles can become common pests in fields covered with weed fabric. Weed fabric creates a warmer, wetter environment in the soil and around the crown of the plant that can create more

problems with fungal diseases in some species. It is important to control weeds over a large area around the weed fabric to keep them from landing on the fabric. Even if borders are clean, weed seeds can blow or shatter onto the weed fabric from many feet away.

- Some species have a large crown that will expand over a couple years, and then remain a stable size. As the plant grows, it is important to cut the fabric away from the crown in the winter so it can expand in the spring. This is an enormous amount of work.

### **POST-HARVEST RESIDUE MANAGEMENT**

Most harvest methods leave a lot of plant material on the field. This usually needs to be minimized or managed in some way for perennial species to maintain or increase seed production. Too much residue can smother plants, decrease plant vigor, reduce the effectiveness of certain pre-emergent herbicides, and harbor pests. The four main options for post-harvest residue management include burning, baling, mowing or chopping. Mowing or chopping reduces all residues into finer pieces which are left in place to decompose and allow for nutrient recycling. Baling or “harvesting” with a forage harvester (which cuts and collects the material in a wagon) removes residues from the field. In the



**Figure 7.** Weed fabric is an essential tool for producing seed of small, vernal pool species.

past, open field burning of grass seed fields the primary method of residue management, but it is not currently permitted in western Oregon, with a few exceptions. Repeated annual removal of plant material can significantly reduce soil fertility. If possible, leave material on fields if experience shows it doesn't create pest or weed issues, reduce future seed yields, or smother plants.

### **SEED PROCESSING**

Seed processing encompasses both seed cleaning and seed conditioning. Seed cleaning is the separation of good crop seed from weed seeds, plant material, and soil. Seed conditioning involves the alteration of the outer physical characteristics of the crop seed.

The amount of seed cleaning needed is often determined by the harvest method, desired purity, seed characteristics, and eventual seeding method or equipment. The first step is usually threshing or combining to detach the seed from the flower heads and seed stalks. Threshing can be accomplished by many means, including a variety of mechanized threshers and hammermills in various sizes. Threshing can also be performed by hand, using brush machines, or by other creative methods (rolling pins, mulchers, food processors, etc.). Following threshing, you should have individual seeds with no plant material attached to them, but they will still be mixed in with a lot of other material. Some seeds will need additional conditioning in order to remove awns, hairs, or other appendages. Many grass seeds have long awns which should be removed before seed cleaning.

Seed conditioning is usually important to make the seed more useable or “flowable” through a seed drill. There are many different types of equipment for brushing, de-awning, and de-hulling seed. The most common seed conditioning machine used at the Corvallis PMC is a brush machine.

Once the seeds have been threshed and conditioned, they need to be separated from the other chaff, plant material, weed seed, and empty seeds. This is accomplished using air screen machines. These machines use one or more screens to sort material by size and then pass it through a column of air to blow out material that is lighter than the seed. These simple machines can clean seed to very high purity. There are many other types of seed cleaners that are for specialized cleaning. See Equipment Overview for some that are used at the Corvallis PMC.

### **SEED STORAGE**

Seeds will maintain good viability for many years if dried and stored properly. Seed should be dried (usually to 8-10% moisture) and stored in a cool place (less than 40°F) with low humidity (less than 40% relative humidity). Pre-fabricated, insulated units with a central brain for cooling and dehumidification systems can be bought, or units can be created using a cold storage container with a free standing commercial de-humidifier inside. For storing small amounts of seed, it can be dried and stored in tightly lidded glass mason jars in a refrigerator. Placing silica gel packets inside the jars can help absorb moisture if the jar is opened frequently.





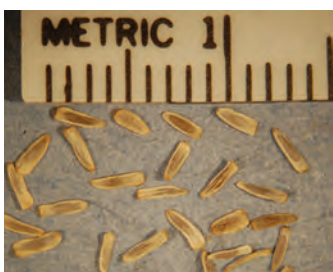
# ACHILLEA MILLEFOLIUM

*common yarrow*

**Life form:** Highly rhizomatous perennial forb

**Pollination:** This species is self-incompatible, and is reliant on insects for adequate pollination. Pollinators include native flies, wasps, sweat bees, cuckoo bees, miner bees, mason bees, bumble bees, long-horned bees, butterflies, and beetles.

**Ease of agronomic seed increase:** Moderate. This species is easy to establish and harvest, but maintaining weed-free fields can be challenging and seed can be difficult to clean to high purity.



**Native distribution/  
Habitat:** Yarrow is one of the most abundant and widely distributed wildflowers in the western United States. It is circumboreal and

grows in a variety of plant communities from Alaska across Canada and into northern Mexico from sea level to alpine. Usually found in full sun to partial shade along roadsides, forest edges, and in recently disturbed areas in prairies and open forests.

**Ease of wild seed collection:** Easy. Plants are generally abundant and easy to locate and seed does tend to shatter. Mature seed can be collected by hand-stripping the compound umbels from the stems or by cutting the flowering stalks from the plants.

**Seeds per pound:** 2,000,000–3,000,000



**Establishment:** Seeds are non-dormant and can be sown in spring or fall. Spring sowing is recommended since germination usually does not occur until soils warm in the spring. A rate of ½–1 pound per acre or 33 seeds per square foot using a seed drill set at a depth of 1/8th inch or less will produce a decent stand. Row spacing should be 22–36 inches, but is dependent on the type of planting and cultivation equipment. Adequate between-row space should be provided to perform mechanical cultivation. Plants grow vigorously and will fill in spaces between rows.

**Establishment rating:** High. Seedlings are fast-growing and quickly produce a thick stand when weed pressure is low.

**Weed control:** There are no herbicides labeled for use on yarrow when grown for seed. Therefore, good reduction in the weed seed bank and seedbed preparation is important. Fortunately, its rapid spring growth makes this species quite competitive with weeds. Hand hoeing, herbicide spot treatments, and row tillage are options. Cultivation or herbicide treatments between rows greatly reduce weed pressure and stimulate growth as plants become crowded.

**Fertilization:** Many native forbs are more competitive with weeds in low-nitrogen environments. Do not apply fertilizer to new fall or spring seedings if significant weed competition is



anticipated. Application of a balanced fertilizer (15-15-15) may be beneficial every other year.

**Pests:** This species seems to always be covered by a diverse population of insects, but no significant damage to mature plants has been observed. It appears to provide excellent habitat for beneficial insects, which may explain why it is not damaged by pests. It is very important to monitor and control slug populations until seedlings become established or the stand may be completely decimated.

**Harvest:** For a small field, mature seedheads can be cut by hand or with a modified swather and placed on a tarp to dry. For a large field, a flail vacuum seed harvester can be used to remove the seedheads from the plant, and then the material can be placed on a tarp to dry. The flail-vac harvester can be used multiple times as the seed is maturing. Swathing and combining is not recommended due to high seed shatter when plants are swathed. Direct combining can be very effective if reel settings can be adjusted to minimize shatter.

**Post-harvest residue management:** Mow the field in the fall or early spring with a flail chopper to remove residue. Cultivation between rows every 2 to 3 years is recommended to increase vigor of plants as they become crowded. This species thrives on disturbance.

**Seed cleaning:** This species can be rather

challenging to clean. Once broken up, its flower parts are the same size, shape, and weight as the seeds. After the plant material has dried, it should be agitated to cause the seeds to fall out. If the plant material is ground up with a thresher, combine, or brush machine it will make cleaning to a high purity difficult to achieve. Once seeds have been removed from the seedheads, use an air-screen machine to clean it to the desired purity.

**Average yields/Stand longevity:** 60–150 pounds per acre for mature stands. This species flowers and sets seed in its first year, especially when fall sown, but may not if spring sown; yields are usually lower in the first year. Longevity of the field may be as great as ten years if row spacing is maintained and weeds are kept under control. If yields are much lower after three years, consider creating a new field, since this species is easy to establish.

**Remarks:** This species can become an established weed and may be difficult to remove once seed increase fields are retired. Seeds remain in the seed bank for many years, and parent plants can be difficult to destroy. Grass seed crops should be planted in areas that were once used for yarrow seed production to allow for use of broadleaf herbicides to control yarrow seedlings. Leaves can cause skin irritation and odor can be offensive during harvest and initial seed cleaning.





# AGOSERIS GRANDIFLORA

*bigflower agoseris*

**Life form:** Perennial forb

**Pollination:** Cross-pollinated by native insects.

**Ease of agronomic seed increase:** Moderate to Difficult. Seeds ripen over a period of weeks and readily blow away upon ripening. Planting plugs into weed fabric aids in weed control and recovery of some seeds.

**Native distribution/Habitat:** Occurs in moist to dry meadows and on open slopes from low to middle elevations; commonly found from southwestern British Columbia south to California and east to the Rocky Mountains.

**Ease of wild seed collection:** Difficult due to the indeterminate timing and wind dispersal of ripe seed.

**Seeds per pound:** 274,000

**Establishment:** Seed is not dormant and germinates in warm temperatures. Seedlings are fairly hardy and grow moderately quickly. For best establishment, start plugs in a greenhouse in winter and transplant into a field covered with weed fabric in early spring on 1 foot by 1 foot spacing.

**Establishment rating:** Medium. Plugs are the preferred method for establishing a plot and will provide a harvestable crop the first year.

**Weed control:** There are no herbicides labeled for use on bigflower agoseris when grown for



seed. Therefore, good reduction in the weed seed bank and field preparation is important. Hand hoeing, herbicide spot treatments, and row tillage are options. Plants can also be transplanted into a field covered with weed fabric. Weed fabric excludes most weeds, but hand weeding may be needed where the soil is exposed within the holes in the fabric. Borders need to be kept clean using herbicides or tillage. Weed fabric can catch wind-borne seeds or seeds that are ejected from many feet away. Reducing these types of weeds from the seed production area will prevent weed seeds from contaminating the seed crop.

**Fertilization:** Fertilization is not recommended during the first year until the field is well-established and weeds can be controlled. Application of a balanced fertilizer (15-15-15) in subsequent years can be beneficial depending on soil fertility.

**Pests:** Plants are susceptible to leaf rusts and powdery mildew. These diseases can cause severe stunting and reduce yields.

**Harvest:** Seeds ripen from late June through early September. For small fields, ripe seedheads are harvested individually by hand or by vacuuming as they open. For a large field, a flail vacuum seed harvester can be used to remove ripe seedheads from the plant. Fields should be harvested multiple times for highest yields. Seeds are dried on a tarp and stirred by hand to decrease drying time.





**Seed cleaning:** First, use a brush machine to break pappas off seeds. Then, use an air-screen machine to separate chaff from seed.

**Average yields/Stand longevity:** 40 pounds per 1/10th acre plot. Fields established from plugs will flower their first year, usually surviving the winter and producing another crop in year two. The first year crop is usually small than the second year crop, but not always. Plants rarely live more than two years.

**Post-harvest residue management:** Remove excess plant material from bases of plants in late winter or early spring.

**Seed cleaning:** First, use a brush machine to break pappas off seeds. Then, use an air-screen machine to separate chaff from seed.

**Post-harvest residue management:** Remove excess plant material from bases of plants in late winter or early spring.



# ARTEMISIA SUKSDORFII

*coastal wormwood*

**Life form:** Perennial forb

**Pollination:** The small flowers are wind-pollinated.

**Ease of agronomic seed increase:** Moderate. This species is relatively easy to harvest, but moderately challenging to clean to high purity. Establishment is somewhat labor intensive due to the need to produce plants from plugs.

**Native distribution/Habitat:** This species occurs near the coast in clay pockets on rocky shores, and to a lesser extent on the upper parts of sandy beaches. Its native range extends from southern British Columbia to California.



**Ease of wild seed collection:** Moderate. This species holds onto its seeds when mature, but seeds are sometimes damaged by

pests. Plants are tall and relatively easy to locate. Cut flower stalks from the plant and place in paper bags to dry.

**Seeds per pound:** 2,300,000

**Establishment:** Seeds are non-dormant and germinate in warm temperatures. Seed naturally germinates in early spring. This species is best established from plugs transplanted in the fall or spring on 24 to 36-inch spacing between rows and 10 to 14-inch spacing between plants.



For direct sowing, seeds are sown as shallowly as possible at a rate of 1–2 pounds per acre (50–100 seeds per square foot) in rows 18–24 inches apart. However, direct sowing is a less desirable method to establish seed increase fields because seedlings will take at least a year or two to reach maturity and can easily be overtaken by weeds in the first year.

**Establishment rating:** Medium from plugs.

**Weed Control:** There are no herbicides labeled for use on this crop. Weed control is performed by herbicide application or cultivation between rows when there is sufficient space. Otherwise, hand weeding is the preferred method for control. However, once plants are mature they seem to resist competition from weedy vegetation.

**Fertilization:** Many native forbs are more competitive with weeds in low-nitrogen environments. Do not apply fertilizer to new fall or spring seedings if significant weed competition is anticipated. Application of a balanced fertilizer (15-15-15) may be beneficial every other year.

**Pests:** None observed.

**Harvest:** Large fields are harvested using a machine that both swaths and collects plant material at the same time. Small fields are harvested by hand, using a rice knife to remove flower panicles. Harvested material should be laid out on tarps in a covered location to dry completely prior to cleaning.





remaining plant material. High rates of purity are difficult to obtain for this species. In some seed lots it can be challenging to distinguish between filled and unfilled seed.

**Average yields/Stand longevity:** 150–250 pounds per acre. This species does not produce seed in its first year following transplanting. Yields are highly variable, but stands are moderately long-lived, remaining productive for five years or more.

**Remarks:** Seed yields are unpredictable.

**Post-harvest residue management:** Harvest methods usually remove all standing plant material. Plants enter dormancy following harvest and resprout from crown buds in spring.

**Seed cleaning:** Dry plant material is stationary combined to remove seed from the tiny flower panicles. Further cleaning is done with an air-screen machine to separate seed from any





# CAMASSIA LEICHTLINII

*large great camas*

**Life form:** Perennial herb from a lily- or onion-like bulb

**Pollination:** Cross-pollinated by generalists, especially social bees (honey and bumble bees), solitary bees, and bee flies. This species can hybridize with common (small) camas (*Camassia quamash*).

**Ease of agronomic seed increase:** Stands are relatively easy to manage for weeds and the seed is simple to process. Yields can be high but if the field is started from seed, it takes several years for

bulbs to become large enough to flower and produce a seed crop.

## **Native distribution/ Habitat:**

Great camas occurs naturally in wet meadows, moist woods, prairies, and streamside areas in full sun to

shade. Camas habitat is often ephemeral, drying up by mid-summer. Found from southern British Columbia to the Sierra Nevada Mountains of California at elevations from 100 to 10,800 feet.

**Ease of wild seed collection:** Easy. Cut off the entire flower stalk in late spring or early summer (late June to mid-July) after the seeds turn black and most of the capsules change from green to tan but are not yet open. As capsules mature on the plant, they split open at the top to reveal the



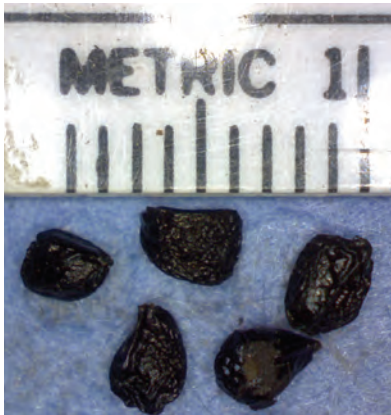
seed but remain upright. Place the stalks, capsules, and any loose seed in paper bags and keep in a warm place until dry. Threshing is unnecessary since all the pods dehisce as they dehydrate. The seed will drop to the bottom of the bag after shaking.

**Seeds per pound:** 70,000-90,000

**Establishment:** New stands can be seeded on well-drained, medium to fine-textured soils on uplands. Camas can also be grown on poorly-drained soils in seasonally wet depressions or floodplains. The seed is dormant and typically requires 60-100 days of cold moist stratification (moist chilling at 34-40°F) for maximum germination. In the fall, sow the seed at a rate of 6-10 pounds per acre in 6-14 inch wide rows and at a depth of 1/8-1/4 inch. Germination and seedling emergence occur in mid to late winter.

**Establishment rating:** Medium; Camas is relatively easy to germinate by fall seeding on clean tilled ground, but the plants are small (i.e. a single leaf) the first year and susceptible to predation and weed competition.

**Fertilization:** Optimal fertilizer rates, formulations, and timing for seed production have not been determined. However, using either balanced fertilizers or fertilizers lower in nitrogen (N) and higher in phosphorus (P) and potassium (K) in ratios designed for spring flowering bulbs is suggested.





**Weed control:** Seedlings do not typically germinate until late winter. Fall sown fields can be sprayed with glyphosate before camas germination occurs. In stands with established bulbs, another window for control is after summer leaf senescence but before winter or early spring foliage emergence. For example, shallow tillage or harrowing (less than 2 ½ -3 inches) can be used by year three over the entire surface as bulbs are typically deep enough at this age to avoid disturbance. Hand hoeing, spot treatments with a nonselective herbicide, and cultivation between rows are options during periods of active growth.

**Pests:** Bulb predation by pocket gophers is a threat to stands as substantial sections of rows can be heavily damaged if left unchecked. Voles (field mice) forage on young leaves in early spring and also consume bulbs. It may be necessary to protect young plants from slugs the first year.

**Harvest:** Seed harvesting can be done by conventional direct combining followed by seed drying. Combine when the large majority of capsules have turned from green to tan and only a small percentage have split open to reveal the black seeds. If substantial healthy green foliage is still present at the time, cut high to leave intact. Optionally, windrow mature stalks and seedheads onto tarps (using a diapered swather) and then dry the capsules and seed for a week or two. The dry capsules release the seed thus negating the need for threshing, but some shaking is required.

**Post harvest residue management:** Allow foliage to die back naturally. Green foliage left attached after harvest will benefit further bulb development.

**Seed cleaning:** Usually an air-screen machine is sufficient to remove chaff, weed seeds, and empty or immature seeds.

**Average yields/Stand longevity:** 300-750 pounds per acre. If started from seed, great camas will not flower and set seed until the third or fourth growing season. Once the bulbs are large enough to flower, seed yields are likely to increase substantially for several years thereafter. Production can eventually plateau and then start to decline as bulbs become more crowded. Individual plants may live for up to 15-20 years. As stands age, an abundance of foliage with few flowers is an indication that the bulbs have become too crowded. On a small scale, they can safely be lifted, separated, and replanted at the proper spacing and correct time of year (fall).

**Remarks:** If the bulbs are pest free and the grower has access to a mechanical lifter, the bulbs can provide an additional source of income when fields are removed, thinned, or rotated.





# CASTILLEJA LEVISECTA

*golden paintbrush*

**Life form:** Perennial forb

**Pollination:** This species is capable of self-pollination, although cross-pollination results in higher seed production. Flowers are pollinated by bumble bees and other native bees.

**Ease of agronomic seed increase:** Difficult. This species should be grown with a host to improve plant vigor. Managing fields with two target species can be challenging. Plants are low-growing and not suited to mechanical harvest. However, seed retention is very high for this species.



**Native distribution/  
Habitat:** Historically found from British Columbia south to the

Willamette Valley of Oregon. Golden paintbrush is typically found in low elevation prairies, meadows, and moist places with seasonally wet, but well-drained soils.

**Ease of wild seed collection:** Moderate. This species is rarely found in the wild. It can be challenging to locate dried stalks after flowering commences. However, seed retention is high, so seed can be collected late in the season. Cut stalks from the plant and place in paper bags to dry.

**Seeds per pound:** 3,300,000

**Establishment:** Seeds are dormant and germinate in late winter after a cold-moist period



of at least 6 weeks. Fields are best established from plugs to avoid competition from weeds and the need for irrigation. This species is a hemiparasite that thrives when grown with a host plant, though it does not appear to be host-specific. A low-growing bunchgrass, sand fescue, was chosen as a host due to its compact growth. *Eriophyllum lanatum* is a superior host but its compatibility in a seed production bed is unknown. Plugs of paintbrush are sown and stratified in a cooler (45°F) for 6 weeks, then grown in a greenhouse over winter, with the host sown into the container after the paintbrush plant is at least 1 inch tall. Plugs are transplanted out into fields in the spring. Transplanting plugs creates a cleaner field than direct sowing and results in an established productive field in the first growing season.

**Establishment rating:** Medium, when plugs are used. Establishment and longevity are best when grown with a perennial host.

**Weed control:** There are no herbicides labeled for use on paintbrushes when grown for seed. Therefore, good reduction in the weed seed bank and field preparation is important. Hand hoeing, herbicide spot treatments, and row tillage are options.

**Fertilization:** Fertilization is not recommended during the first year until field is well-established and weeds can be controlled. In subsequent year,





spring application of a balanced fertilizer (15-15-15) is recommended.

**Pests:** Voles and deer commonly predate this species.

**Harvest:** Seeds remain in the capsules for many weeks upon ripening. Cut stalks by hand after they have turned brown, but before capsules begin to open. Place material on tarps to dry. Select a host plant that be harvested separately or can easily be cleaned out of the *Castilleja* seeds.

Sand fescue is taller than the paintbrush and can be harvested before the paintbrush.

**Post-harvest residue management:** Harvest techniques remove most aboveground material and improve plant vigor and overall health.

**Seed cleaning:** A stationary thresher will remove pods from stem and break them open. Follow with a small air-screen machine to separate seed from other material. Threshers often dehull seed and may affect how easily seed can be cleaned. Dehulled seed does not appear to germinate at different rates than hulled seed.

**Average yields/Stand longevity:** 15–100 pounds per acre. Seed production of this species is limited to small fields due to the hand labor required for transplanting, weed management, and harvest. Yields can be expected to increase over time—first year yields average 2 pounds per 1/10th acre plot and increase in the following years to an average of 10 pounds per 1/10th acre. Fields can remain productive for up to five years, depending on site conditions and host species.



# CIRSIUM EDULE

*edible thistle*

**Life form:** Biennial forb

**Pollination:** This species is self-fertile, but is largely outcrossing. Pollinators include native bees, flies, Lepidoptera (butterflies and moths), and beetles.

**Ease of agronomic seed increase:** Difficult. This species is moderately easy to establish, and seed is easy to clean. However, because this species is biennial (one seed crop after two years of maintenance), and is prone to many pests and seed predators, seed increase can be quite difficult.



**Native distribution/  
Habitat:**

This species is native to western North America from

southeastern Alaska through British Columbia to Washington and Oregon, and locally inland to Idaho. Common in moist meadows, clearings, forest openings, usually at middle to high elevations, but may occur in lowlands.

**Ease of wild seed collection:** Moderate. This species blooms for a relatively long period of time, and is generally easy to find in the wild. However, large amounts of seed must be collected to establish seed increase fields because of damage caused to seed by weevils. Can be confused with non-native thistles.

**Seeds per pound:** 175,000

**Establishment:** Seeds are non-dormant and



germinate in moderate to warm temperatures. Seed naturally germinates in early spring. This species is most successfully established from large plugs (D40's) transplanted in late winter on 24–36 inch spacing between rows and 12–14 inches between plants. Wide row spacing helps field work be less painful. Plants can get quite large and are very prickly! If transplants are large and transplants respond to winter conditions, the majority of transplants will flower the first spring (about four months after transplanting). For direct sowing, seeds can be sown  $\frac{1}{4}$ – $\frac{1}{2}$  inch deep at a rate of 3–4 pounds per acre (15 seeds per square foot) in rows 24–36 inches apart. Direct sowing is a less desirable method to establish seed increase fields because seedlings will take at least a year or two more (than transplants) to reach maturity. Direct sown seedlings may grow sporadically and plants may not all flower in the same year.

**Establishment rating:** High from plugs. Seed production fields are best established from plugs; transplants grow rapidly throughout the growing season.

**Weed control:** There are no herbicides labeled for use on this crop. Weed control is performed by spot herbicide application or cultivation between rows when there is sufficient space. Otherwise, hand weeding is the preferred method for control.

**Fertilization:** Transplants are usually supplied with sufficient nutrients from a controlled-release fertilizer in the potting mix.





**Pests:** Several pests are associated with production of this species. Stem boring weevils can cause stunting, wilting, and plant death. Growing this crop as an annual reduces damage from stem borers. Seeds can be heavily predated by flocks of goldfinches prior to maturation. Bird net is recommended to prevent the finches from eating the seeds. Seed weevils are probably the most significant pest and can ruin an entire crop. Covering plants with a floating row cover can help reduce the damage from seed weevils, but may also reduce pollination. At the PMC, the weevils seemed to have a population curve that peaked when the majority of thistle flowers were in bud stage. Therefore, the best management technique is to cover the plants with a floating row cover soon after transplanting and keep them covered until the thistles are at their peak flowering stage (this should be after most of the weevils are gone). After the row cover is removed, bird net is used to cover the plants. This allows pollinators to access the flowers but keeps out the goldfinches. Insecticides are available for control of seed weevils, but were not used at the PMC due to their negative impacts on bees and other beneficial insects.

**Harvest:** Plants bloom over a period of many weeks and as seed matures it can blow away. To obtain highest yields, earliest ripening seed can be collected by hand, followed by mechanical harvest when seed maturity is at its peak. Mechanical harvest employs a machine that both swaths and collects plant material at

the same time. Collecting the material is most easily accomplished by towing a tarp behind the swather, minimizing the need to handle the spiny plant material. Harvested material is dried on tarps in a covered area following harvest.

**Post-harvest residue management:** These biennial plants die after harvest; residue will decompose over the winter, or can be removed prior to the next crop in the fall.

**Seed cleaning:** Once the harvested plant material is dry it is stationary combined to separate the seed from the flower heads and other plant material. Finally, combined plant material is separated from seed using an air-screen machine.

**Average yields/Stand longevity:** 40–60 pounds per acre without pest control; 100–200 pounds per acre could be possible with good pest control. This species is naturally a biennial and does not produce seed the first year following transplanting. Can be grown as an annual by producing large plugs in the fall/winter that are transplanted into fields in late winter so the plants can receive adequate vernalization.

**Remarks:** This species attracts a diverse array of insects. Aside from all the pests, it also creates habitat for many pollinators and beneficial insects.





# CLARKIA AMOENA

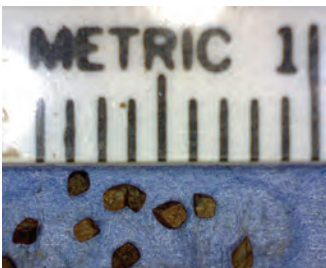
*farewell to spring*

**Life form:** Annual forb

**Pollination:** Capable of self pollination, but primarily an outcrossing species aided by honey bees, bumblebees, mason bees and butterflies.

**Ease of agronomic seed increase:** Moderate; plants establish easily from direct sowing and can be mechanically harvested.

**Native distribution/Habitat:** This species prefers relatively dry, open slopes, but is also found in meadows, prairies, seaside bluffs, coastal scrub, forest edges, roadsides and vernal-wet areas. Plants grow best in full sun to light shade and well-drained to dry soil, but also tolerate seaside



conditions, alkaline soil, salt, sand and clay. Found west of the Cascade Range from southern British Columbia south to the coast of central California and east in the Columbia River Gorge at elevations below 3000 ft.

**Ease of wild seed collection:** Easy; plants are usually found in large patches and are easy to locate when in flower. Entire stems of seed pods can be clipped from plants as they begin to split and dried in a paper bag. Seed maturity is variable and retention is high.

**Seeds per pound:** 816,000 to 1,100,000

**Establishment:** Plants are easily established from seed by direct sowing on site in the fall or



late winter. Seeds do not exhibit dormancy but germinate best in cool temperatures, and should be directly sown at a rate of 2–4 pounds per acre as shallowly as possible in rows 18–24 inches apart.

**Establishment rating:** Medium; if seedlings are protected from slugs, establishment can be quite high. Seedling vigor is moderate and plant development is rapid in late spring.

**Weed control:** No herbicides are labeled for use on this crop. Hand weeding, spot spraying, and row tillage are weed control options. Seeding into a weed-free seed bed is important for this annual crop.

**Fertilization:** Soils should not be over-fertilized or the plants will produce abundant, leggy foliage and few flowers/seeds.

**Pests:** Plants are susceptible to powdery mildew, verticillium wilt, stem rot, and leaf spot, as well as aphids, mites, and Japanese beetles, but pests usually don't affect seed yield.

**Harvest:** Seed pods slowly open as they mature. Usually, the majority of the seed produced can be captured by harvesting the entire field at once. Small fields can be harvested by swathing and collecting the material to dry on tarps, while large fields can be directly combined. This species has a sticky, gelatinous substance on green seed pods. Do not combine plants that still have green seed pods; it is nearly impossible to clean out once the





directly combined. Once seeds are released from the pods, use an air-screen machine to separate seed from chaff.

**Average yields/Stand longevity:** 150-300 pounds per acre. Yields vary depending on ecotype, weather, and general field conditions. When sown in the fall or winter, plants will flower and set seed the following summer. This species is an annual, but readily self-sows in subsequent years if seed is allowed to shatter.



Pods are crushed.

**Post-harvest residue management:** As an annual, crop aftermath and standing stubble can be left on the field after harvest.

**Seed cleaning:** A hammermill or small thresher can be used to break up pods for small lots. Stationary combining is the most efficient way to thresh out seeds from plants that were not





# CLARKIA RHOMBODIEA

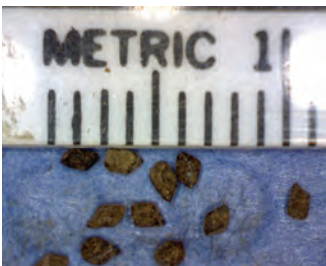
*diamond clarkia*

**Life form:** Annual forb

**Pollination:** Capable of self pollination, but flowers are mainly outcrossing via numerous species of small native bees.

**Ease of agronomic seed increase:** Moderate, plants establish easily from direct sowing and can be mechanically harvested.

**Native distribution/Habitat:** Diamond clarkia grows in open/disturbed areas in shrub-steppe habitats, pine forests, and dry woodlands from British Columbia south to California and east to the Great Basin and Southwest.



## **Ease of wild seed**

**collection:** Moderate; plants are easy to locate when in flower, entire stems of seed pods can be clipped from plants as they begin to split and dried in a paper bag. Seed maturity is variable and retention is high.

**Seeds per pound:** 582,000

**Establishment:** These annual plants are easily established from seed by direct sowing on site in the fall at a rate of approximately 4.5 pounds per acre (60 seeds/ft<sup>2</sup>) as shallowly as possible in rows 18–24 inches apart. Seeds are not dormant, typically germinating within 3 weeks and remaining small over winter, with more vigorous growth in the spring as temperatures warm. A



second flush of germination often occurs in late winter (February).

**Establishment rating:** Medium; if seedlings are protected from slugs, establishment can be quite high. Seedling vigor is moderate and plant development is rapid in late spring.

**Weed control methods:** No herbicides are labeled for use on this crop. Hand weeding, spot spraying, and row tillage are weed control options. Seeding into a weed-free seed bed is important for this annual crop.

**Fertilization:** Soils should not be over-fertilized or the plants will produce abundant, leggy foliage and few flowers/seeds.

**Pests:** Members of the genus *Clarkia* may be susceptible to powdery mildew, verticillium wilt, stem rot, and leaf spot, as well as aphids, mites, and Japanese beetles, but seed increase fields of diamond clarkia at the Corvallis PMC have been relatively free of pests and diseases.

**Harvest:** Seed pods open slowly as they mature. Usually, the majority of the seed produced can be captured by harvesting the entire field at once. Small fields can be harvested by swathing and collecting the material to dry on tarps, while large fields can be directly combined. This species has a sticky, gelatinous substance on green seed pods. Do not combine plants that still have green seed



pods; it will leave a sticky residue on the insides of the combine that is nearly impossible to clean out.

**Post-harvest residue management:** As an annual, crop aftermath and standing stubble can be left on the field after harvest.

**Seed cleaning:** A hammermill or small thresher can be used to break up pods for small lots. Stationary combining is the most efficient way to thresh out seeds from plants that were not

directly combined. Once seeds are released from the pods, use an air-screen machine to separate seed from chaff.

**Average yields/Stand longevity:** 150-350 lbs/acre. Yields vary depending on ecotype, weather, and general field conditions. When sown in the fall or winter, plants will flower and set seed the following summer. This species is an annual, but is capable of self-sowing.





# DOWNINGIA ELEGANS

*elegant calicoflower*

**Life Form:** Annual forb

**Pollination:** Most *Downingia* species must cross pollinate to produce seeds. Flowers are pollinated by small native bees, bumble bees, and flies.

**Ease of agronomic seed increase:** Moderate. Transplanting plugs is time consuming and more costly than direct seeding, but will produce higher yields. Harvesting is moderate due to the time required to vacuum seeds off of the weed fabric; seed cleaning is easy.



**Native distribution/  
Habitat:** Usually found in vernal pools of wet prairies, edges of ponds, and wet meadows from

British Columbia south to California and east to Idaho and Nevada.

**Ease of wild collection:** Moderate. Plants are often found in large patches, but are very low in stature. Seeds ripen evenly, but have only moderate retention; thin pods can easily split and shatter seed.

**Seeds per pound:** 4,000,000

**Establishment:** Seeds do not have dormancy and naturally germinate in warm temperatures in April. For best seed production, it is recommended to start plugs in a greenhouse in late winter and transplant out in the spring. Transplant into a field covered with weed fabric



with holes on 1 ft by 1 ft spacing. Seeds can also be sown into holes in the weed fabric in the spring, but this is not recommended because plants may need irrigation to become large enough to produce seed before soils dry out in the summer. Plants will thrive in warm weather combined with adequate soil moisture.

**Establishment rating:** Low if direct seeded, high if using plugs.

**Weed control:** Weed fabric excludes most weeds, but hand weeding may be needed where the soil is exposed within the holes in the fabric. Borders need to be kept clean using herbicides or tillage. Weed fabric can catch wind-borne seeds, or seeds that are ejected from many feet away. Reducing these types of weeds from the seed production area will prevent weed seeds from contaminating the seed crop.

**Fertilization:** Controlled-release fertilizer should be added to the media used to grow the plugs and this is usually sufficient for the annual crop. An additional application of balanced fertilizer may be beneficial depending on soil fertility.

**Pests:** None observed.

**Harvest:** Seeds will ripen on plants in late July or August. For a small-scale field, when plants are brown and dead, cut them at the base and collect them in large trash barrels. Any seeds left on the



weed fabric should be swept up or vacuumed with a small battery powered vacuum and put into a cloth bag to dry. For a large-scale field, seeds can be direct combined. This method is not recommended unless plants are tall enough to be combined.

**Post-harvest residue management:** The entire plant is generally harvested so no aftermath is left on the field.

**Seed cleaning:** To break open pods, feed plants into a brush machine equipped with a small mesh screen mantle. The brush machine will open the seedpods and separate seeds from the larger pieces of plant material. Use proper respiratory protection when crushing *Downingia* plant material as it contains silica which is a respiratory irritant. An air-screen machine can be used to further clean debris from the seed.

**Average yields/Stand longevity:** This annual can produce 16–30 pounds per 1/10th acre plot.

**Remarks:** The PMC has also work with *Downingia yina* and found that seed production techniques are identical for both species.





# ERIGERON DECUMBENS

*Willamette daisy*

**Life form:** Perennial forb

**Pollination:** Plants are self-fertile, but highest seed yields are obtained with outcrossing. Insect pollinators are important for seed production; primary pollinators are sweat bees and hover flies, but flowers are also visited by other native bees, flies, wasps, damselflies, and lady beetles.

**Ease of agronomic seed increase:** Difficult. Plants are low-growing and not suited to mechanized harvest. Seed matures variably and readily falls from plant as it ripens.



**Native distribution/  
Habitat:** Willamette daisy occurs only in the Willamette Valley in northwestern Oregon.

Though once found throughout the Valley, now less than twenty populations are known to exist, and it is now a federal and state listed endangered species. It inhabits both seasonally flooded bottomland prairies and well-drained upland prairies at elevations ranging from 200–1000 ft.

**Ease of wild seed collection:** Difficult. Species is rarely found and must be collected when seed is ripe but before wind dispersal. Seed can be hand-collected by plucking “puffs” as they ripen on the plants.

**Seeds per pound:** 4,000,000



**Establishment:** Seed is dormant and requires a cold-moist stratification period of 90 to 120 days to before seed will germinate. Seeds are very small and seedlings grow slowly. For best establishment, start plugs in a greenhouse in winter and transplant into a field in early spring on 1 ft by 2 ft spacing.

**Establishment rating:** Medium, when using plugs.

**Weed control:** There are no herbicides labeled for use on Willamette daisy when grown for seed. Therefore, good reduction in the weed seed bank and field preparation is important. Hand hoeing, herbicide spot treatments, and row tillage are options.

**Fertilization:** A balanced fertilizer (15-15-15) is preferred. If weeds are a problem it may be wise to refrain from using fertilizer the first year until weeds can be controlled.

**Pests:** Leaf rusts have been observed on plants, but do not appear to negatively impact seed production or plant vigor.

**Harvest:** Multiple harvests may be necessary as ripening is variable over a period of weeks. Small scale plots can be effectively harvested using a hand-held vacuum, sucking seed off the plants as it ripens.



It can be difficult to distinguish between filled and unfilled seed. High rates of purity can be challenging to achieve due to contamination of the seed lot with plant parts that are of similar size to the seeds.

**Average yields/Stand longevity:** 20–100 pounds per acre. Seed production of this species is limited to small fields. Yields can be expected to increase over time—first year fields average 2 pounds per 1/10th acre plot, and increase in subsequent years to an average of 10 pounds per 1/10th acre. Fields can be long-lived, producing high quality seed for over five years.

**Post-harvest residue management:** Allow plants to go dormant in fall before removing residue. Old stalks can be cut by hand in winter or early spring before new growth emerges.

**Seed cleaning:** Cleaning this seed can be difficult and time consuming because the seeds contain pappus, which must be broken up using a brush machine before material will flow through seed cleaning machines. Once brushed, the material can be cleaned using an air-screen machine.





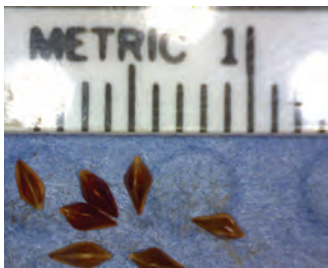
# ERIOGONUM NUDUM

*barestem buckwheat*

**Life form:** Perennial forb

**Pollination:** Native buckwheats are primarily pollinated by hover flies and small native bees, as well as honey bees, bumble bees, wasps, and flies.

**Ease of agronomic seed increase:** Moderate. Fields can be established by direct sowing if weeds are controlled. Seeds can be mechanically harvested and are relatively easy to clean. Plants are intolerant of wet or saturated soils.



**Native distribution/  
Habitat:** Common perennial that grows in abundant stands in dry open meadows, on rocky outcrops, along trails and roadsides. Prefers sandy, well drained soils and usually grows in exposed,

sunny sites in low to subalpine elevations from Washington south to California and Nevada.

**Ease of wild seed collection:** Moderate. This buckwheat is found in open spaces and holds on to its seeds for weeks after maturation.

**Seeds per pound:** 400,000 – 500,000

**Establishment:** Most populations have a high percentage of dormant seed that requires 90 days of cold/moist conditions in order to germinate, so seed should be direct sown in the fall. Seeds naturally germinate in early spring, but some populations will germinate in the fall 2 to 4 weeks after sowing. Seeds are sown  $\frac{1}{8}$  to  $\frac{1}{4}$  inch deep at a rate of 5–7 pounds per acre (50 seeds per



square foot) in rows 10–14 inches apart, unless larger row spacing is needed for between row cultivation.

**Establishment rating:** Low/Medium. Seedlings grow very slowly in cool spring temperatures and weeds can quickly overtake young plants in the first growing season. Plants will survive high levels of weed pressure, but are difficult to locate when young. As temperatures rise in summer, this species becomes more vigorous, even when soil moisture is low. This species is not tolerant of saturated or heavy soils.

**Weed control:** No herbicides are labeled for use on buckwheat grown for seed. Hand hoeing, spot treatments with a nonselective herbicide, and row tillage are weed control options.

**Fertilization:** Many native forbs are more competitive with weeds in low-nitrogen environments. Do not apply fertilizer to new fall seedings if significant weed competition is anticipated. Application of a balanced fertilizer (15-15-15) may increase yields in subsequent years.

**Pests:** Plants can quickly wilt and rot if grown in water-logged soils. Leaf rusts have been noticed on some plants, but are rarely severe enough to affect seed yields.

**Harvest:** Plants usually flower uniformly and seed retention is moderate. Highest yields have been achieved using a modified swather that both cuts



stationary combine. Seeds are cleaned using an air-screen machine. Some combines or thresher can dehull seeds.

**Average yields/Stand longevity:** 50–200 lbs per acre. During first year, flowering will be sparse and seed may not be worth harvesting. The second through fourth year yields are typically high. This species is short-lived when grown for seed in the Willamette Valley; fields do not usually remain productive longer than four years.



and collects the material. Swathing followed by combining is not recommended due to seed shattering while swathed. Harvesting with a flail-vac only collect seeds from upper or exposed areas of the plants, and is not very efficient.

**Post-harvest residue management:** Harvest method usually removes all stalks; no other residue should be removed.

**Seed cleaning:** After cutting, collecting, and drying material it can be fed into a thresher or





# ERIOGONUM UMBELLATUM

*sulphur buckwheat*

**Life form:** Perennial forb

**Pollination:** Pollinated by hover flies and small native bees (sweat bees and miner bees), as well as honey bees, bumble bees, cuckoo bees, wasps, and flies.

**Ease of agronomic seed increase:** Moderate. Fields can be established by direct sowing if weeds are controlled. Seeds can be mechanically harvested and are relatively easy to clean. Plants

are very adaptive and tolerate wet or saturated soils if established from plugs.

**Native distribution/  
Habitat:** Perennial that grows on open sites in valleys and on mountain slopes from sea level

to subalpine elevations; prefers rocky, sandy, moderately dry places. It can be found from southern British Columbia south to California and eastward to Colorado, Wyoming, and Montana.

**Ease of wild seed collection:** Moderate. This common perennial is found in open spaces and is easy to identify. Seeds ripen uniformly and will remain on the plant for a week or two after maturation.

**Seeds per pound:** 100,000–200,000

**Establishment:** Most populations have a high percentage of dormant seed that requires 70–90 days of cold/moist conditions in order to germinate, so seed should be direct sown in



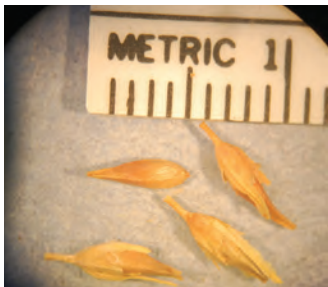
the fall. Seeds naturally germinate in early spring. Seeds are sown  $\frac{1}{8}$  to  $\frac{1}{4}$  inch deep at a rate of 10–12 pounds per acre (50 seeds per square foot) in rows 18–24 inches apart, unless larger row spacing is needed for between row cultivation. Plants are very long-lived, and can reach two feet in diameter. Avoid driving on plants as they are easily damaged. Field planning should include lanes for equipment to drive in.

**Establishment rating:** Medium. This perennial grows slowly in winter and spring. Weeding is essential during establishment to prevent weeds from taking over. Seedlings are hearty and can survive competition.

**Weed control:** No herbicides are labeled for use on buckwheat grown for seed. Hand hoeing, spot treatments with a nonselective herbicide, and row tillage are weed control options. When mature, plants can grow together and create a closed canopy that reduces weed establishment.

**Fertilization:** Many native forbs are more competitive with weeds in low-nitrogen environments, so fertilizer should not be applied during establishment. Depending on local soil conditions, fields will need an annual application of balanced fertilizer (15-15-15) in early spring if in production for more than three years.

**Pests:** In very wet years, seed will begin to mold on the plants as they are ripening due to the large







seedling

bracts. Material can be cut when seeds are mature and placed in a warm, dry place to cure.

**Harvest:** Seed is mature when the bracts are dry and papery. Seeds will remain on plant for a few weeks following maturation. For a small field, harvest seed by hand with rice knives. For a large field, a seed stripper can be used. A seed stripper will only harvest the seed heads that are upright. Plants should not be cut when harvesting. The growing points of this species are located on the

branch tips, and if they are cut or damaged, the plant will require a couple years to recover. Once seed is harvested, it should be placed on a tarp to dry.

**Post-harvest residue management:** None needed. Plants are evergreen and should not be cut.

**Seed cleaning:** Seeds are brittle and can be damaged easily when using threshers or combines. Use a hammermill or a gentle brush machine (with a fine mantle that the seed tips cannot fit in) to break the seeds from the stalks and bracts, followed by a small air-screen machine to remove chaff and weed seeds.

**Average yields/Stand longevity:** 300–700 pounds per acre. Plants do not produce seed until their second growing season, and do not reach full production until year three. Plants should remain productive for over seven years if they are not mowed or driven on.





# ERIOPHYLLUM LANATUM

*Oregon sunshine*

**Life form:** Perennial forb

**Pollination:** Cross pollinated by native sweat bees, mining bees, mason bees, hover flies, tachinid flies, and wasps.

**Ease of agronomic seed increase:** Moderate. This species is easy to establish from seed and plants are competitive with weeds. Once established, fields will remain productive for many years. The most difficult aspect of

increasing seed of this species is harvesting. Seed can be very difficult to remove from the seed heads, and may require concurrent timing of hot temperatures and dry conditions to facilitate this process.



**Native distribution/Habitat:** This species occurs in dry, open habitats, on bluffs and rocky slopes and is common at low to middle elevations on both sides of the Cascade Range from British Columbia south to Washington, Oregon and California. Its range extends east to Nevada, Idaho, northwestern Utah, western Wyoming, and western Montana.

**Ease of wild seed collection:** Moderate. Seed of this species matures late in the season, and plants are relatively low growing, but easy to locate. Oregon sunshine is easily identified, fairly widespread, and plants exhibit good seed retention. However, low seed fill may require collection of substantial amounts of material to establish seed increase fields.



**Seeds per pound:** 1,200,000

**Establishment:** Most populations have a high percentage of dormant seed that requires 90 days of cold/moist conditions in order to germinate, so seed should be direct sown in the fall. Seeds naturally germinate in early spring, but some populations have germinated in the fall 2 to 4 weeks after sowing. Seeds are sown as shallowly as possible (less than 1/8 inch deep) at a rate of 3–4 pounds per acre, or approximately 80 seeds per square foot.

**Establishment rating:** High. Seeds of this species readily germinate in the spring, seedling vigor is high, and plant development is rapid.

**Weed control:** There are no herbicides labeled for use on this crop. Hand hoeing, spot treatments with a nonselective herbicide, and row tillage are some weed control options. This species produces a weak seed crop its first growing season. If fields have a lot of annual weeds present the first year, it can be beneficial to mow down the field instead of attempting to weed or spot spray. A flail mower/shredder can be used to cut and vacuum/remove all residue laying on the ground surface, including all the annual weeds and their seeds. The Oregon sunshine plants are also cut in this process, but will quickly grow back.

**Fertilization:** Oregon sunshine responds well to additional nitrogen. Plants that were fertilized with 50 pounds N per acre in spring were taller,



produced more flowers, had a longer bloom time, and had much higher rates of filled seed.

**Pests:** Lygus bugs have been noted as serious pests for some growers, causing high levels of unfilled seed. Slugs can also be an issue when seedlings are germinating.

**Harvest:** Large fields of this species are best harvested by first swathing into a windrow, and then combining when plant material has dried. Some populations have seed that shatters more readily than others. Allowing the material to dry as much as possible before combining will aid in removing seeds from the heads. Small fields can be harvested using a machine that both swathes and collects plant material at the same time.

**Post-harvest residue management:** The remaining debris can be removed by either cutting and baling or using a flail chopper (forage harvester) equipped with a collection wagon. This species is tolerant of low mowing. Material can also be left to decompose on the field if it is not more than 4 inches thick, allowing the plants to emerge from under the material in the spring. Plants tend to enter dormancy after harvest and do not actively grow until early spring the following year.

**Seed cleaning:** Dried plant material can be fed into a stationary combine or thresher. Seed is cleaned using an air-screen machine. It may be very difficult to distinguish filled versus unfilled seed. An indent cylinder is incredibly helpful for removing small weed seeds and other debris from Oregon sunshine seed lots.

**Average yields/Stand longevity:** 100–300 pounds per acre. Seed production is usually very low the first year, sometimes not even worth harvesting, averaging 3 pounds per acre. Significantly higher yields occur in subsequent years, usually peaking in the fourth year. Stands can be short (3 years) or long-lived (over 7 years) depending on population and field conditions.

**Remarks:** Plant material can be a lung irritant when crushed. Use respiratory protection when combining or threshing this species. This is one of the easiest perennial forbs to grow for seed increase.





# ERYNGIUM PETIOLATUM

*coyote thistle*

**Life form:** Perennial deciduous forb

**Pollination:** Insect pollinated by solitary bees and small flies.

**Ease of agronomic seed increase:** Moderate. Plants need two years to get established, but are long-lived and will produce seed for many seasons. Seed cleaning is difficult because of the many machines involved.



conditions by late March. Transplant plugs into a field with or without weed fabric. Direct sowing is not recommended, but can be accomplished by sowing 6–8 pounds per acre, as shallowly as possible in rows 12–18 inches apart.

**Establishment rating:** Low when directly sown, high when using plugs.

**Weed control:** Hand weeding is the best method for weed control.

**Fertilization:** Many native forbs are more competitive with weeds in low-nitrogen environments, so fertilizer should not be applied during establishment. Depending on local soil conditions, fields may benefit from an annual application of balanced fertilizer (15-15-15) in early spring if in production for more than three years.

**Pests:** None observed.

**Harvest:** Most seeds remain on the stems after they are mature and can easily be harvested directly using a combine. The combine can cut, thresh and slightly clean the seeds without having to be handled. Small fields can be cut by hand after seeds are mature. If seed shatter is high (rare) seeds can be vacuumed from the weed fabric if present.

**Post-harvest residue management:** Plants will completely die back after harvest; if needed, remove all residue by hand if using weed fabric or by mowing or burning if not using weed fabric.

## **Native distribution/**

**Habitat:** This species only grows in the Willamette Valley of Oregon and east through the Columbia Gorge. Grows in wet prairies, vernal pools, or depressions that are flooded in the spring but dry out by summer.



**Ease of wild seed collection:** Moderate. Plants may be difficult to locate when seed is ripe. Seed maturity is variable but retention is fair. Seeds can be stripped from the plants or stems can be cut and placed in paper bags to dry. Gloves are needed since plants have small spines.

**Seeds per pound:** 550,000

**Establishment:** Seeds are dormant and need 45–70 days of cold-moist conditions to germinate. Seeds naturally germinate in mid-winter. This species is best established using plugs. Sow seeds into containers in early fall and leave outside until germination occurs, then move into a heated greenhouse. Slowly acclimate to outdoor



the first year, have a moderate yield in year two, and reach full production in year three. Plants are long-lived and will sustain decent yields for at least five years.

**Seed cleaning:** If seed remains attached to stems, use a stationary combine or a large brush machine to separate seed from stems, followed by an air-screen machine for fine cleaning. Seeds have leggy appendages that make cleaning to high levels of purity difficult. It can also be challenging to distinguish viable seed from empty seed.

**Average yields/Stand longevity:** 25–100 pounds per 1/10th acre. Plants may not produce any seed





# GALIUM TRIFIDUM

*threepetal bedstraw*



**Life form:** Usually a perennial mat-forming forb (Annual where summer moisture is limiting)

**Pollination:** Cross-pollinated by small flies and bees.

**Ease of agronomic seed increase:** Difficult. This species is easy to harvest and clean on a small scale, but establishment takes a moderate amount of effort. Large scale seed increase on this species is not practical because of its low growth habit. Because

seed ripens unevenly and shatters as it ripens, seed production without weed fabric would not be feasible.



**Native distribution/  
Habitat:** Native to most of northern and western

North America from Alaska and eastern Canada to Mexico. This species is found in moist areas along stream banks and pond margins and in saline and freshwater marshes.

**Ease of wild seed collection:** Difficult. Plants are usually 2–4 inches tall which make them challenging to locate, and seeds shatter when mature. Threepetal bedstraw is easily confused with other native and non-native Galium species.

**Seeds per pound:** 350,000–500,000

**Establishment:** Seeds do not have dormancy and germinate in warm temperatures. Start plugs in a greenhouse in late winter and transplant out in the spring. Transplant into a field covered with

weed fabric with holes on 1- by 1-ft spacing. Seeds can also be sown into holes in the weed fabric in the spring, but this is not recommended because plants may need irrigation to become large enough to produce seed before soils dry out in the summer.

**Establishment rating:** Medium, if established from plugs.

**Weed control:** Weed fabric excludes most weeds, but hand weeding may be needed in the holes in the fabric. Borders need to be kept clean using herbicides or tillage. Weed fabric can catch wind-borne seeds or seeds that are ejected from many feet away. Reducing these types of weeds from the seed production area will prevent weed seeds from contaminating the seed crop.

**Fertilization:** Controlled-release fertilizer should be added to the media used to grow the plugs and is usually sufficient for this annual crop. An application of balanced fertilizer may be beneficial depending on soil fertility.

**Pests:** None observed.

**Harvest:** Seeds fall from the plant as they mature over a period of weeks. Remove plants and place them on a tarp to dry (many seeds will remain attached to the plants when ripe). Vacuum the fabric and holes to collect seed that has shattered. Post-harvest residue management: The entire plant is generally harvested so no residue is left on the field.



described above can yield 20 to 50 pounds per tenth acre. Plants grown on upland sites usually act as annuals. In situations with sufficient summer moisture plants can be perennial.

**Remarks:** This species is not weedy but will sometimes self-sow.



**Seed cleaning:** Easy. Use a brush machine to remove seed from plants, then use an air-screen machine to remove plant material and unfilled seed.

**Average yields/Stand longevity:** A 200–400 pounds per acre. Fields are usually small, no more than 1/10th acre, and if grown under conditions





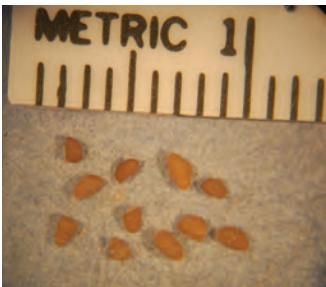
# GILIA CAPITATA

*blue gilia*

**Life form:** Annual forb

**Pollination:** This species is self compatible, but insects are needed for adequate pollination and seed set. Bees attracted to blue gilia include honey bees, common leaf-cutters, Andrenids, and very small native bees. Flowers have blue pollen, so bees will have blue pollen sacs after visiting many flowers.

**Ease of agronomic seed increase:** Moderate; seeds mature over a period of weeks and shatter as they mature; using weed fabric as a passive seed collector is highly recommended. In cultivated settings, plants are much larger than those found in the wild.



**Native distribution/Habitat:** This species can be found in the wild in dry, open spaces like fields and prairies. It is native to much of western North America from Alaska to northern Mexico, and it can be found on the eastern side of the continent as an introduced species. It grows in many habitats, especially in sandy or rocky soils.

**Ease of wild seed collection:** Moderate; if plants are large, they will have an extended flowering period and produce seed over a period of a week or two, creating a window of time for collection (small or stunted plants flower and set seed quickly, making timing for collections more difficult). Capsules may shatter easily upon maturity; capsules may be collected individually,



or entire branches may be collected and placed in paper bags to dry.

**Seeds per pound:** 900,000 – 1,300,000. Seed size varies considerably among populations.

**Establishment:** Seeds naturally germinate in cool temperatures in late fall through early spring. Plants benefit from earlier sowing dates. After fall weeds have germinated, perform weed control, then sow seeds directly into fields through holes in weed fabric in late fall. Place 15–25 seeds per hole (1–2 pounds per acre). For direct seeding a field without weed fabric, use a rate of 50 seeds per square foot or 2–4 pounds per acre. Sow in fall or late winter as shallowly as possible ( $\frac{1}{8}$  inch or less) into rows 12–24 inches apart.

**Establishment rating:** Medium; if seedlings are protected from slugs, establishment can be quite high. Seedling vigor is medium and plant development is rapid in late spring.

**Weed control:** Weed fabric excludes most weeds, but hand weeding may be needed where the soil is exposed within the holes in the fabric. Borders need to be kept clean using herbicides or tillage. Weed fabric can catch wind-borne seeds, or seeds that are ejected from many feet away. Reducing these types of weeds from the seed production area will prevent weed seeds from contaminating the seed crop.



**Fertilization:** This annual species is tolerant of low nutrient environments, but may benefit from late spring fertilization depending on soil conditions.

**Pests:** None observed.

**Harvest:** Seeds are ejected from the capsule as they mature and can shatter over a period of weeks. For small to medium sized fields, when seeds begin to ripen, cut plants at the base by hand or by using a modified swather that cuts and collects material at the same time. Place material

on tarps to dry, and then thresh or stationary combine plant material. Additionally, the seeds can be vacuumed up from the weed fabric. Large fields, with or without weed fabric, can be directly combined. Direct combining without weed fabric will result in lower yields due to high rates of shatter prior to and during harvest. Rate of shatter differs among populations. Some populations will produce high yields when mechanically harvested due to very low seed shatter, while other populations must be grown on weed fabric to obtain a decent yield if shatter is high.

**Post-harvest residue management:** As an annual, crop aftermath and standing stubble can be left on the field after harvest.

**Seed cleaning:** After threshing or combining, seed is easily cleaned using an air screen machine to remove chaff and other material.

**Average yields/ Stand longevity:** 100–500 pounds per acre. Yield for this species has been highly variable depending on the density of the stand and the mature size of the plants in a given year. The yield may fall between 20 pounds per  $\frac{1}{10}$  acre and 40 pounds per  $\frac{1}{10}$  acre when using weed fabric. Yields will be lower on fields without weed fabric. This species is an annual, but can self-sow the following year.





# IRIS DOUGLASIANA

*Douglas iris*

**Life form:** Rhizomatous perennial forb

**Pollination:** This species is self-compatible and is mainly pollinated by long tongued, nectar collecting bees, and bumble bees

**Ease of agronomic seed increase:** Moderate. Plants are hardy once established, long-lived, and can usually be harvested mechanically. Plants may take several years to reach peak seed production.

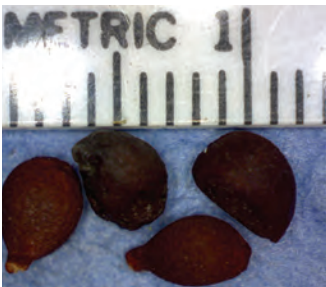


Plugs are grown in a greenhouse overwinter, and transplanted out into fields in the spring. To overcome seed dormancy, sow seeds in containers and place in a warm location for 2-4 weeks then move containers to a cold location (45 degrees or lower) for at least eight weeks. Alternately, containers can be placed outside in early September through December. Move containers to a greenhouse set between 50-60 degrees in late December. Seeds should germinate within 2-4 weeks. Temperatures warmer than 65 degrees can halt germination. Greenhouse temperatures can be raised after seeds have germinated. Grow in a greenhouse and transplant out into fields in spring on 2 foot by 1 foot spacing. Direct seeding is not recommended but can be accomplished by sowing in early September at a rate of 18 pounds per acre (20 seeds per foot) into rows 18-24 inches apart.

**Establishment rating:** Medium. Fields should be started with plugs grown in a greenhouse during the previous year. Some plants may flower in year three, but they take at least four years to reach full maturity.

**Weed control:** There are no herbicides labeled for irises grown for seed. Weed control can be performed by hand weeding and spot applications of glyphosate. Cultivation is an option if adequate row space is available.

**Fertilization:** Many native forbs are more competitive with weeds in low-nitrogen



**Native distribution/  
Habitat:** Grows in pastures, grassy slopes, coastal cliffs, usually less than 300 feet above sea level. Douglas iris is only found on the southern Oregon and northern California coasts.

**Ease of wild seed collection:** Easy. Plants usually occur in large patches. Seeds remain in pods and mature relatively uniformly. Pods are ripe when they are tan in color and feel dry. Seeds per pound: 25,000

**Establishment:** Seeds are dormant and need a 90 day cold period before germinating as temperatures warm in the spring. Seeds of some populations may also need a 2 week warm stratification prior to the cold treatment for optimum germination. It is recommended to establish fields from plugs to avoid competition from weeds and the need for irrigation. Plants will flower a full year earlier if plugs are used.



environments, so fertilizer should not be applied during establishment. Depending on local soil conditions, fields may benefit from an annual application of balanced fertilizer (15-15-15) in early spring if in production for more than three years.

**Pests:** None observed.

**Harvest:** Small fields can be hand harvested with pruners or rice knives to remove seed pods. Large fields may be direct combined. Pods usually

ripen over a period of two weeks but do not immediately split open as they ripen, they will remain closed for days while mature, providing a larger window for collection. For maximum yields, hand harvest pods as they ripen.

**Post harvest residue management:** Plants should be mowed or cut back after they have gone dormant in late summer.

**Seed cleaning:** Use a hammer mill or thresher to remove seed from pods. Then use an air screen machine to remove stems, chaff and unfilled seeds to reach desired purity standards.

**Average yields/Stand longevity:** 10-200 pounds per acre. Plants usually do not produce the seed the first year and only a small amount on the second year. Plant usually reach peak production on the third year and will maintain this level of production for many years.





# IRIS TENAX

*Oregon iris*

**Life form:** Rhizomatous perennial forb

**Pollination:** This species is self compatible and is pollinated by butterflies and long tongued bees.

**Ease of agronomic seed increase:** Moderate. Plants are hardy once established, long-lived, and can usually be harvested mechanically, but may take three years to reach peak seed production.

**Native distribution/Habitat:** Naturally occurs in open areas (grassy meadows, fields, pastures, roadsides, logged areas) and open deciduous and coniferous woodlands at low to middle elevations. The range of *I. tenax* ssp. *tenax* extends from southwestern Washington to southern Oregon

west of the Cascade Mountains. *Iris tenax* ssp. *klamathensis* is found in the Klamath Mountains of Northern California.

**Ease of wild seed collection:** Medium. Seeds remain in pods when mature and large stands of plants may be found. Capsules can be collected as they turn from green to light brown.

**Seeds per pound:** 46,000

**Establishment:** Seeds are dormant and need to experience warm early fall temperatures followed by cold winter temperatures to initiate germination in early spring as soils warm (warm-cold-warm cycle). It is recommended to establish fields from plugs to avoid competition from

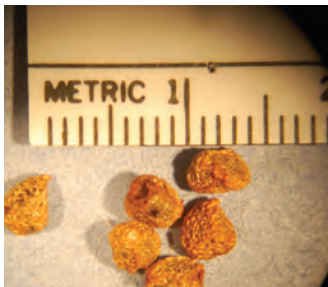


weeds and the need for irrigation. Plugs are grown in a greenhouse overwinter, and transplanted out into fields in the spring. To overcome seed dormancy, sow seeds in containers and place in a warm location for 2-4 weeks then move containers to a cold location (45 degrees or lower) for at least eight weeks. Alternately, containers can be placed outside in early September through December. Move containers to a greenhouse set between 50-60 degrees in late December. Seeds should germinate within 2-4 weeks. Temperatures warmer than 65 degrees can halt germination. Greenhouse temperatures can be raised after seeds have germinated. Grow in a greenhouse and transplant out into fields in spring on 2 foot by 1 foot spacing. This method creates cleaner fields and results in an established productive field in the first growing season. Direct seeding is not recommended but can be accomplished by sowing in early September at a rate of 9 pounds per acre (20 seeds per foot) into rows 18-24 inches apart.

**Establishment rating:** High from plugs. If soil moisture is sufficient, plants will grow vigorously in the first growing season but usually will not flower.

**Weed control:** There are no herbicides labeled for irises grown for seed. Weed control can be performed by hand weeding and spot applications of glyphosate. Cultivation is an option if adequate row space is available.

**Fertilization:** Many native forbs are more competitive with weeds in low-nitrogen





environments, so fertilizer should not be applied during establishment. Depending on local soil conditions, fields may benefit from an annual application of balanced fertilizer (15-15-15) in early spring of the second growing season.

**Pests:** None observed. Leaf rusts have been observed on this species, but do not seem to affect seed production.

**Harvest:** Small fields can be hand harvested with pruners or rice knives to remove ripe seed pods. Large fields may be direct combined if capsules

ripen uniformly. Capsules usually ripen over a period of many weeks and sometimes split open within two days of ripening. For maximum yields, capsules should be hand harvested as they ripen and placed in a warm dry place. Capsules will open completely and release the seeds if properly dried.

**Post harvest residue management:** Allow foliage to senesce naturally, then cut back before plants begin to grow in spring.

**Seed cleaning:** Use a hammer mill or thresher to remove seed from pods if needed. Then use an air screen machine to remove stems, chaff and unfilled seeds to reach desired purity standards.

**Average yields/Stand longevity:** 60-400 pounds per acre. If fields are established using plugs, a few plants will flower on the first year, most of the plants will flower in the second year, and reach peak yields on year three. This species is long-lived and should maintain high levels of seed production for at least three more years.





# LASTHENIA GLABERRIMA

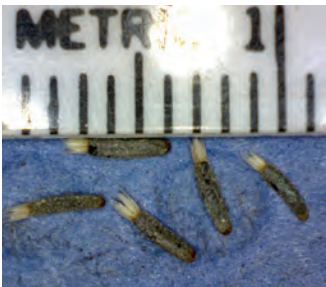
*smooth goldfields*

**Life form:** Annual forb

**Pollination:** Non-showy flowers are self pollinating.

**Ease of agronomic seed increase:** Moderate. These annuals are best established using plugs and weed fabric, but harvest and seed cleaning is easy.

**Native distribution/Habitat:** Found in vernal pools and wet spring meadows, usually below 900 feet in western North America from British Columbia to California.



**Ease of wild seed collection:** Difficult. Plants are difficult to locate due to their small size, but seed can remain in the sepals for weeks after they mature.

**Seeds per pound:** 1,000,000–1,300,000

**Establishment:** Seeds are not dormant and readily grow when placed in warm conditions (over 65°F). Seeds naturally germinate in the late spring. Fields are best established using plugs that were grown in a greenhouse over the winter and transplanted out into fields covered with weed fabric in the spring. Holes in the weed fabric should be on 1 ft by 1 ft spacing. Using plugs creates larger plants and cleaner fields; the use of weed fabric is necessary to have reasonable yields. Establishing seed increase



fields by directly sowing is not recommended, but can be accomplished by sowing seeds in the spring at a rate of 4 pounds per acre (100 seeds per square foot) ½ inch deep in rows 10–12 inches apart.

**Establishment rating:** High from plugs, low if direct seeding.

**Weed control:** There are no herbicides labeled for use on this species for seed production. Weed fabric excludes most weeds, but hand weeding is needed where soil is exposed. Weed seeds may blow or shatter onto weed fabric, so field borders need to be kept clean.

**Fertilization:** A slow-release fertilizer added to the container media will supply the plants with sufficient nutrients for their lifecycle.

**Pests:** None observed.

**Harvest:** Seeds remain in the cup-like sepals after they ripen, but can easily be dislodged by shaking the plants. Seeds ripen variably over a period of a few weeks. For harvesting small plots, agitate plants to spill the seed onto the weed fabric, then vacuum. Larger plots could be harvested with a seed stripper, but yields may be unpredictable due to variable ripening.

**Post-harvest residue management:** As annuals, residue can be left on the field after harvest or



removed in the fall for the subsequent crop.

**Seed cleaning:** Use a small air-screen machine to blow out chaff, empty seeds, and weed seeds.

**Average yields/Stand longevity:** 25–35 pounds from a  $\frac{1}{10}$  acre plot. This species is restricted to small scale production. It is an annual and does not self-sow, so plots will have to be re-established each year.





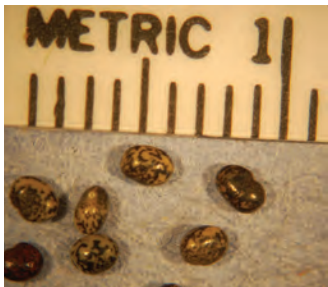
# LOTUS FORMOSISSIMUS

*seaside bird's foot trefoil*

**Life form:** Deciduous perennial legume

**Pollination:** Thought to be primarily cross-pollinated by honey bees, bumble bees, and other native bees.

**Ease of agronomic seed increase:** Moderate. Plants are hardy and long-lived once established. Seeds ripen unevenly and are expelled from pods as soon as they are mature. Weed fabric is needed to obtain a worthwhile amount of seed.



**Native distribution/  
Habitat:** Native to western North America west of the Cascade Mountains from southern British Columbia to Oregon and west of the Sierra Nevada Mountains to Monterey County in

California at elevations up to 2,100 ft. Usually found in wetland areas within shore pine forests, northern coastal scrub, and in other wetland and riparian areas; occasionally found in non-wetland areas.

**Ease of wild seed collection:** Difficult. Seeds ripen unevenly and when mature, are expelled from the pod. Plants are showy when in flower, but are short-statured and may be difficult to locate when not flowering.

**Seeds per pound:** 200,000–300,000

**Establishment:** Seeds are dormant and usually need scarification and up to 120 days of wet,



cool conditions to trigger germination in spring. For best establishment, sow scarified seeds in containers and stratify in a cooler for 120 days, then move plugs to a greenhouse in late winter, and transplant out in spring. Transplant into a field covered with weed fabric containing holes on 1 ft by 1 ft spacing. Scarified seeds can also be sown into holes in the weed fabric in the fall. Place 10 seeds per hole (1.7 pounds per acre) and cover them lightly with soil or vermiculite. Seedlings will germinate in the spring, but may need irrigation to become established on upland areas.

**Establishment rating:** Medium, plugs are preferred.

**Weed control:** Weed fabric excludes most weeds, but hand weeding may be needed where the soil is exposed within the holes in the fabric. Borders need to be kept clean using herbicides or tillage. Weed fabric can catch wind-borne seeds, or seeds that are ejected from many feet away. Reducing these types of weeds from the seed production area will prevent weed seeds from contaminating the seed crop.

**Fertilization:** Application of a balanced fertilizer such as 16-16-16 at a rate of 50 pounds per acre in mid-May can be beneficial.

**Pests:** Slugs can damage seedlings. Watch for rodent activity when seeds begin to mature and collect on the weed fabric.



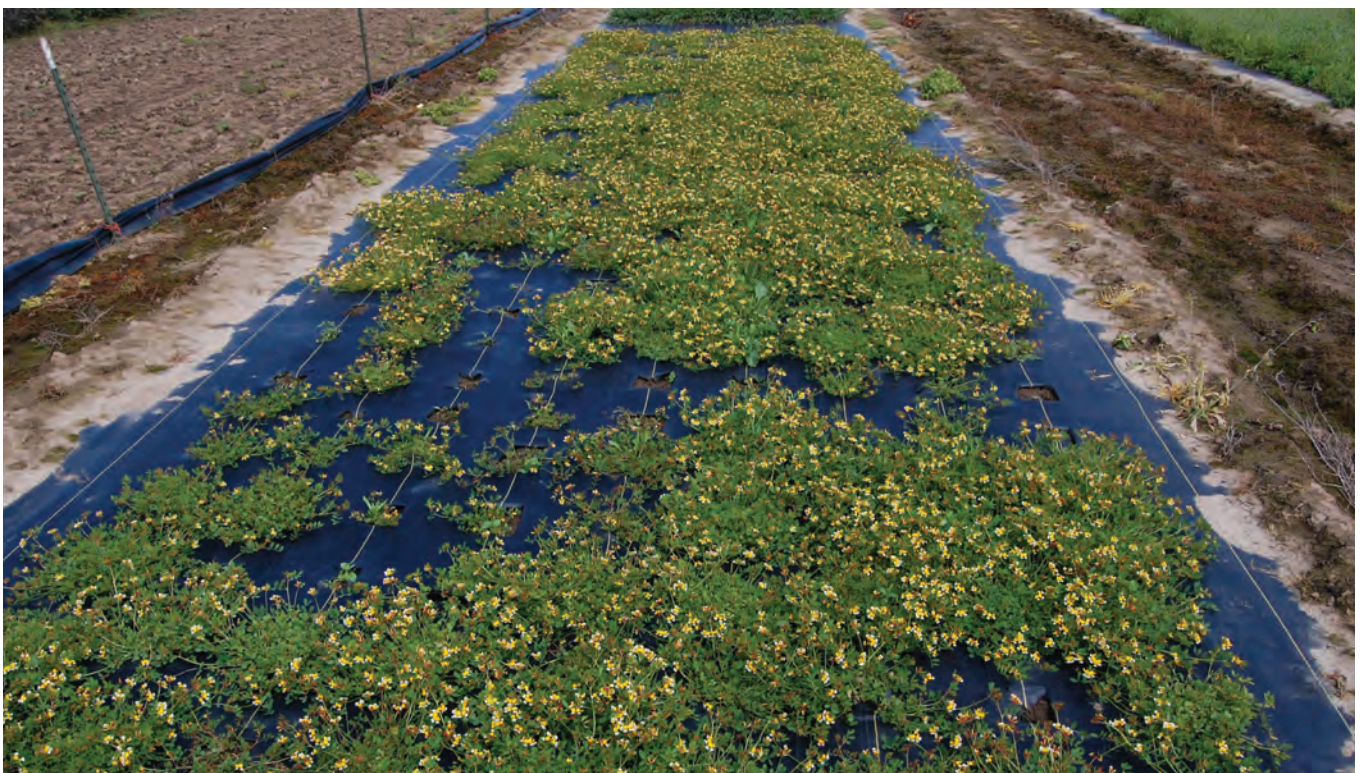
**Seed cleaning:** Use an air-screen machine to remove empty pods, plant material, chaff, and soil to reach the desired level of purity.

**Average yields/Stand longevity:** 110–340 pounds per acre. Fields established from transplants sometimes flower sparsely in their first year. A two year old field produced 11 pounds per  $\frac{1}{10}$  acre and 34 pounds per  $\frac{1}{10}$  acre on year three. If establishing a plot from seed it may take three years before plants flower. Plants appear to be long-lived.

**Remarks:** This species is not weedy and does not self-sow.

**Harvest:** When seed dispersal has ended for the season, vacuum or sweep seeds from the fabric. A large amount of seed may have collected in the holes and can be vacuumed out. If plants are very dense, they may need to be cut away before sweeping or vacuuming.

**Post-harvest residue management:** If plants are not cut back during harvest, allow plants to naturally senesce in the fall and cut plants to the ground before new growth appears in the spring.





# LOTUS MICRANTHUS

*small-flowered deervetch*

**Life form:** Annual leguminous forb

**Pollination:** Frequented by small native bees and other pollinators. The genus *Lotus* has complex breeding systems; it is unknown whether this species is self-fertile or out-crossing.

**Ease of agronomic seed increase:** Difficult. These annual plants need to be established every year. Seeds ripen unevenly and are expelled from pods as soon as they mature. Weed fabric

is needed to obtain a worthwhile amount of seed.

**Native distribution/  
Habitat:** Found from British Columbia to Southern California, in open disturbed areas, meadows, and woodlands

at low to mid elevations.

**Ease of wild seed collection:** Difficult. Collection must occur when pods are ripe but before dispersal. Pods ripen unevenly and make collection at any one given time a challenge.

**Seeds per pound:** 150,000

**Establishment:** Seeds germinate in moderate temperatures, naturally emerging in late fall or spring. Scarified seeds can be sown directly into holes in the weed fabric in late fall. Place 10 seeds per hole (3–4 pounds per acre) and cover them lightly with soil or vermiculite. For direct seeding a field without weed fabric (not recommended),



use a rate of 50 seeds per square foot or 12–14 pounds per acre. Sow in fall or spring at a depth of ¼ inch or less into rows 10–14 inches apart.

**Establishment rating:** Moderate. Slugs can damage seedlings during establishment.

**Weed control:** Weed fabric excludes most weeds, but hand weeding may be needed where the soil is exposed within the holes in the fabric. Borders need to be kept clean using herbicides or tillage. Weed fabric can catch wind-borne seeds, or seeds that are ejected from many feet away. Reducing these types of weeds from the seed production area will prevent weed seeds from contaminating the seed crop.

**Fertilization:** Plants perform well in low-nutrient environments, but a balanced fertilizer may be beneficial depending on site.

**Pests:** Slugs and mice are common pests for this species. Traps and baiting can be effective management techniques for these pests. Mice and birds are attracted to the seeds on weed fabric in late summer, multiple harvests can help reduce seed loss. Powdery mildew is often observed on plants in late summer; infections usually occur after plants have produced seed, so do not seem to affect yields.

**Harvest:** When seed dispersal has ended for the season, vacuum or sweep seeds from the fabric. A large amount of seed may have collected in the





Seeds are relatively heavy, making separation of seed from other organic material fairly easy.

**Average yields/Stand longevity:** 50–150 pounds per acre (using weed fabric). Seed production can fluctuate dramatically due to environmental conditions and erratic establishment. Plants are annuals but self-sow.

holes and can be vacuumed out. If plants are very dense, they may need to be cut away before sweeping or vacuuming.

**Post-harvest residue management:** As an annual, crop aftermath and standing stubble can be left on the field after harvest.

**Seed cleaning:** A stationary thresher is used to loosen the few remaining seeds from pods, followed by an air-screen machine to separate seed from plant material and organic debris.





# LOTUS UNIFOLIOLATUS

*American bird's-foot trefoil*

**Life form:** Annual leguminous forb

**Pollination:** Frequented by small native bees and other pollinators. The genus *Lotus* has complex breeding systems; it is unknown whether this species is self-fertile or out-crossing. This species is known to have very unpredictable yields, therefore it may not be self fertile and pollinators may be necessary for adequate seed set.

**Ease of agronomic seed increase:** Difficult. These annual plants need to be established every year. Seeds ripen unevenly and are expelled from pods as soon as they mature. Weed fabric is needed to obtain a worthwhile amount of seed.

**Native distribution/Habitat:** Native to the Pacific Northwest, from BC throughout Washington, Oregon, and into northern California. This species can be found on coastal bluffs and mountainsides as well as in roadside ditches and alpine forests.

**Ease of wild seed collection:** Difficult. Collection must occur when pods are ripe but before dispersal. Pods ripen unevenly and make collection at any one given time a challenge.

**Seeds per pound:** 80,000–100,000

**Establishment:** Seeds germinate in moderate temperatures, naturally emerging in late fall or spring. Scarifying the seeds will make germination more rapid and uniform. Seeds can be sown directly into holes in weed fabric on 2 ft by 2 ft spacing in late fall. Place 10 seeds per hole (3–4 pounds per acre) and cover them lightly



with soil or vermiculite. For direct seeding a field without weed fabric, use a rate of 50 seeds per square foot or 10–12 pounds per acre. Sow in fall or spring at a depth of ¼ inch or less into rows 16–24 inches apart.

**Establishment rating:** Moderate from direct seeding.

**Weed control:** Weed fabric excludes most weeds, but hand weeding may be needed where the soil is exposed within the holes in the fabric. Borders need to be kept clean using herbicides or tillage. Weed fabric can catch wind-borne seeds, or seeds that are ejected from many feet away. Reducing these types of weeds from the seed production area will prevent weed seeds from contaminating the seed crop.

**Fertilization:** Plants perform well in low-nutrient environments, but a balanced fertilizer may be beneficial depending on site.

**Pests:** Slugs and mice are common pests for this species. Traps and baiting can be effective management techniques for these pests. Powdery mildew is often observed on plants in late summer; infections usually occur after plants have produced seed, so do not seem to affect seed yields.

**Harvest:** When seed dispersal has ended for the season, vacuum or sweep seeds from the fabric. A large amount of seed may have collected in the holes and can be vacuumed out. If plants are very



dense, they may need to be cut away before sweeping or vacuuming. If not using weed fabric, plants can be swathed and collected or hand-harvested once seedpods turn tan and leathery, or direct combined if maturity across the field is uniform (very rare). Spread harvested material on tarps or in paper bags to dry. Seeds can be expelled many feet from the pods, so cover material as it is drying.

**Post-harvest residue management:** These plants are annuals and will begin to die after

producing seed. The harvest process will remove most of the plant biomass from the plot. Residual plant stems can be mowed off, or if left, will decay over the winter.

**Seed cleaning:** After initial collection, it may be necessary to feed material through a brush machine or thresher to extract seed from pods. Follow with an air-screening machine to separate seed from other organic debris.

**Average yields/Stand longevity:** 20–150 pounds per acre. This is an annual crop; the field will need to be re-planted each year of production. Some growers have reported a lack of pod formation after flowering; this species may rely on pollinators for cross pollination. Abundant water and fertilizer may grow large plants with few flowers. Yields can be unpredictable for this species in cultivation.





# LUPINUS ADSRGENS

*Drew's silky lupine*

**Life form:** Deciduous perennial legume

**Pollination:** Cross pollinated by insects, especially bumblebees.

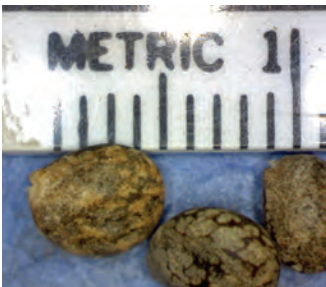
**Ease of agronomic seed increase:** Difficult. This lupine is intolerant of saturated soils. Plants flower variably over a period of weeks and seed retention is very low (seeds shatter immediately upon ripening), making harvest time-consuming or low-yielding.



seeds in containers and maintain in a greenhouse over winter, then transplant to the field in the spring. Lupines do not always thrive when grown in a greenhouse; they can be sensitive to root rot and other pathogens. Direct seeding is not recommended because weeds can out-compete seedlings in the spring. Additionally, seedlings are intolerant of wet conditions. If direct sowing is desired, sow in spring in 16–30 inch wide rows at 10–12 lb/acre and a depth of ½–¾ inch. Wider spacing allows for initial tillage or herbicide application between rows. Establishment and subsequent growth may also be improved by inoculating with nitrogen fixing bacteria (*Rhizobium lupini*) prior to planting to aid in formation of root nodules.

**Establishment rating:** Low. This species requires well-drained soil. If grown from seed, growth will be slow and slugs will damage seedlings. Fields should be established from plugs, but plugs can still be difficult to grow and establish.

**Weed control:** There are no herbicides labeled for use on lupines when grown for seed. Therefore, good reduction in the weed seed bank and field preparation is important. Hand hoeing, herbicide spot treatments, and row tillage are options. Plants are completely dormant in winter, usually emerging in mid-spring. This dormant period allows for chemical weed control in fields. Weed fabric can be used with this species, but is generally not recommended due to the rhizomatous nature



**Native distribution/  
Habitat:** Native to the Sierra Nevada and Coast Ranges of California and southwestern Oregon. Grows on dry slopes and in montane forests at elevations from 1,640–11,500 ft.

**Ease of wild seed collection:** Difficult due to variable ripening of the pods and high rates of shatter. Pods are mature when they turn a light tan color and can be collected in paper bags to dry.

**Seeds per pound:** 16,000–20,000

**Establishment:** Seeds are not dormant and naturally germinate in winter or spring. Scarification can improve uniformity of germination. Preferred establishment method for this species is to transplant plugs on wide spacing (24–36 inches) to allow for mature plant size and weed management. Sow scarified





of the plant. Large holes will need to be cut in the fabric for new shoots to emerge.

**Fertilization:** An application of a balanced fertilizer (16-16-16) in early spring as new growth appears may be beneficial depending on soil nutrient levels.

**Pests:** Slugs are an issue with young seedlings. Plants can become infected with various pathogens when grown in heavy or saturated soils.

**Harvest:** Pods are ripe when they turn a light tan color and feel very dry. Stalks of pods can be hand harvested as they mature, or directly combined if maturity across the field is very uniform. Combined materials should be laid out in a warm, dry place to cure before cleaning. Seeds can be expelled many feet from the pods, so cover material as it is drying.

**Post-harvest residue management:** Allow plants to naturally senesce in the fall and cut plants down to the ground before new growth appears in the spring. If using weed fabric, it may need to be cut away from the crowns as they grow.

**Seed cleaning:** Use a large brush machine to break up any unopened pods. A small air-screen machine can then be used to blow out inert material, weed seeds, and empty seeds.

**Average yields/Stand longevity:** 150–300 pounds per acre. In the first growing season, expect little to no seed production. Yields typically peak in the second year, and then drop in the third year due to individual mortality. Plants will have higher rates of over winter survival when grown on well-drained soils.





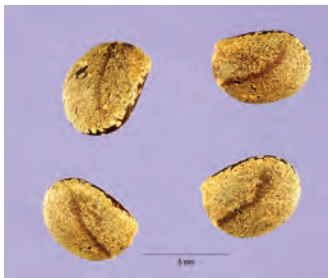
# LUPINUS ALBIFRONS

*silver bush lupine*

**Life form:** Perennial evergreen legume

**Pollination:** Pollinated by bumble bees and other native bees and butterflies.

**Ease of agronomic seed increase:** Difficult. This lupine is intolerant of saturated soils. Plants flower variably over a period of weeks and seed retention is low (seeds shatter immediately upon ripening), making harvest time-consuming or low-yielding.



**Native distribution/  
Habitat:** Uncommon lupine found in dry open meadows, prairies, and forest openings in coastal sage scrub, chaparral, and oak woodland habitats from southwestern Oregon to

southern California at elevations from sea level to 6,600 ft. This lupine is also a larval host plant for the endangered mission blue butterfly (*Aricia icarioides missionensis*).

**Ease of wild seed collection:** Difficult due to variable ripening of the pods and high rates of shatter. Pods are mature when they turn a light tan color and can be collected in paper bags to dry.

**Establishment:** Seeds are non-dormant and naturally germinate throughout the winter and spring. Scarification can improve uniformity of germination. The preferred establishment method for this species is to transplant plugs on wide spacing (24–36 inches) to allow for



mature plant size and weed management. Sow scarified seeds in containers and maintain in a greenhouse over winter, then transplant to the field in the spring. Lupines do not always thrive when grown in a greenhouse; they can be sensitive to root rot and other pathogens. Direct seeding is not recommended because weeds can outcompete seedlings in the spring. However, if direct sowing is desired, sow in spring in 16–30 inch wide rows at 10–12 lb/acre at a depth of 1/2–3/4 inch. Wider spacing allows for initial tillage or herbicide application between rows. Establishment and subsequent growth may also be improved by inoculating with nitrogen fixing bacteria (*Rhizobium lupini*) prior to planting to aid in formation of root nodules.

**Establishment rating:** Low. This species requires well-drained soil. If grown from seed, growth will be slow and slugs will damage seedlings. Fields should be established from plugs, but plugs can still be difficult to grow and establish.

**Weed control:** There are no herbicides labeled for use on lupines when grown for seed. Therefore, good reduction in the weed seed bank and field preparation is important. Hand hoeing, herbicide spot treatments, and row tillage are options. Once plants are established they are very large and prevent weed invasion. These plants could also be grown on weed fabric to control weeds and aid in harvest, but it is not known if the weed fabric would create a more favorable environment for diseases.





**Fertilization:** An application of a balanced fertilizer (16-16-16) in early spring as new growth appears may be beneficial depending on soil nutrient levels.

**Pests:** Slugs are an issue with young seedlings. Plants can become infected with various pathogens when grown in heavy or saturated soils.

**Harvest:** Seeds ripen over a period of weeks and pods shatter readily when fully mature. Pods are

ripe when they turn a light tan color and feel very dry. Stalks of pods can be hand harvested as they mature, or directly combined if maturity across the field is very uniform. Harvested materials should be laid out in a warm, dry place to cure before cleaning. Seeds can be expelled many feet from the pods, so cover material as it is drying.

**Post-harvest residue management:** This plant is considered a sub-shrub and can become woody. It should not be cut very low, although it can re-sprout from the base.

**Seed cleaning:** Use a hammermill or thresher to separate any seed left in the pods. Seeds can be separated from plant material or other organic matter using an air-screen machine. Seeds are large, easily identifiable, and easily separated from other materials in the lot.

**Average yields/Stand longevity:** 200–300 pounds per acre. In the first growing season, expect little to no seed production. Yields should increase in the second and third years. Depending on site conditions, these plants can be long-lived. Plants will have higher rates of survival when grown on well-drained soils.





# LUPINUS BICOLOR

*miniature lupine*

**Life form:** Annual leguminous forb

**Pollination:** This species is primarily self-pollinated, but some plants also outcross. Flowers are visited by many small bees and other insects.

**Ease of agronomic seed increase:** Difficult. These annual plants need to be established every year. Seeds ripen unevenly and are expelled from pods as soon as they are mature. Weed fabric is needed to obtain a worthwhile amount of seed.

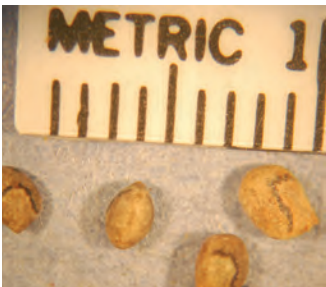


(1 pound per acre) and cover them lightly with soil or vermiculite. Holes in the weed fabric should be placed on 1 ft by 1 ft spacing. For direct seeding a field without weed fabric (not recommended), use a rate of 30 seeds per square foot or 3 pounds per acre. Sow in fall or spring at a depth of ¼ inch or less into rows 10-14 inches apart. Establishment and subsequent growth may also be improved by inoculating with the appropriate nitrogen fixing bacteria (*Rhizobium lupini*) prior to planting to aid in formation of root nodules.

**Establishment rating:** Medium. This species establishes well from plugs or direct sowing, but germination can be sporadic if seeds are not properly scarified. Slugs can destroy seedlings when direct sown.

**Weed control:** There are no herbicides labeled for use on lupines when grown for seed. Therefore, good reduction in the weed seed bank and field preparation is important. Weed fabric excludes most weeds, but hand weeding may be needed where the soil is exposed within the holes in the fabric. Borders need to be kept clean using herbicides or tillage. Weed fabric can catch wind-borne seeds, or seeds that are ejected from many feet away. Reducing these types of weeds from the seed production area will prevent weed seeds from contaminating the seed crop. For fields without weed fabric, hand hoeing, herbicide spot treatments, and row tillage are options.

**Fertilization:** These are nitrogen-fixing annuals and will not need fertilization in most situations.



**Native distribution/  
Habitat:** Found from British Columbia south to Southern California in open, gravelly, and sandy sites at low elevations up to 3000 feet.

### **Ease of wild seed**

**collection:** Difficult. Plants flower for a period of weeks and will often have shattered pods, ripe pods, flowers, and flower buds on the same plant. Pods shatter upon ripening making harvest time consuming and low yielding. This species is abundant and easy to find.

**Seeds per pound:** 45,000–50,000

**Establishment:** Seeds are generally non-dormant, naturally germinating at moderate temperatures in late fall or spring; however, scarification can improve uniformity of germination. Seed increase fields can be established using plugs or direct seeding. Scarified seeds can be sown directly into holes in the weed fabric in late fall. Place 10 seeds per hole



**Pests:** Mice can predate seed as it accumulates on weed fabric. Slugs can be very damaging to seedlings. Traps and baiting can be effective management techniques for these pests. Powdery mildew is often seen on the plants, but occurs late in the season and does not affect plant health or seed production. Other foliar diseases (black leaf spot) that cause mortality have been observed.

**Harvest:** If using weed fabric, harvest when seed dispersal has ended for the season, by vacuuming or sweeping seeds from the fabric. A large amount of seed may have collected in the holes and can be vacuumed out. If plants are

very dense, they may need to be cut away before sweeping or vacuuming. For fields without weed fabric, harvest seeds by hand once seedpods turn tan or directly combine if maturity across the field is uniform (very rare). Spread harvested material on tarps or in paper bags to dry.

**Post-harvest residue management:** As annuals, crop aftermath and standing stubble can be left on the field after harvest.

**Seed cleaning:** Use a hammermill or thresher to separate seeds from pods that have not shattered, followed by a small air-screen machine to separate seed from chaff, empty seeds, and weed seeds.

**Average yields/Stand longevity:** 100–700 pounds per acre. Yields vary considerably from year to year depending on site conditions. Using weed fabric will provide the highest yields. Yields from direct combining or hand harvesting can be unpredictable.

**Remarks:** The PMC has also worked with *Lupinus affinis* and *Lupinus polycarpus* which look very similar to *L. bicolor*. Seed production techniques are identical for these species.





# LUPINUS LATIFOLIUS

*broadleaf lupine*

**Life-form:** Deciduous perennial legume

**Pollination:** This species is cross pollinated by bumblebees and other insects.

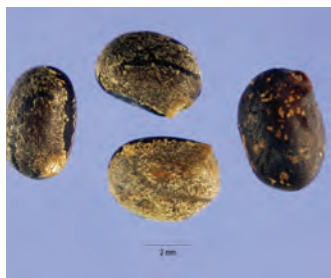
**Native distribution/Habitat:** Broadleaf lupine is found in open areas at all elevations, but is most commonly found at middle to subalpine elevations. It occurs from British Columbia, south to California, and east to Utah, Nevada, and New Mexico.



Lupines do not always thrive when grown in a greenhouse; they can be sensitive to root rot and other pathogens. However, when compared to direct seeding, transplants have better first season survival, larger plants, and greater seed production in the first year. Direct seeding is not recommended because weeds can outcompete seedlings in the spring. However, if direct sowing is desired, scarified seeds can be sown directly into holes in weed fabric in late fall. Place 10 seeds per hole (6–7 pounds per acre) and cover them lightly with soil or vermiculite. Holes in the weed fabric should be placed on 2 ft by 1 ft spacing. For direct seeding a field (without weed fabric), use a rate of 30 seeds per square foot or 25–30 pounds per acre. Sow in fall or spring at a depth of ¼ inch or less into rows 24–36 inches apart. Wider spacing allows for initial tillage or herbicide application between rows. Establishment and subsequent growth may also be improved by inoculating seed with nitrogen fixing bacteria (*Rhizobium lupini*) prior to planting to aid in formation of root nodules.

**Establishment rating:** Low. These lupines are sensitive to root disturbance and can be difficult to establish using transplants. When directly sown, seedlings are intolerant of saturated soil conditions.

**Weed control:** There are no herbicides labeled for use on lupines when grown for seed. Therefore, good reduction in the weed seed bank and field preparation is important. Weed fabric excludes most weeds, but hand weeding may be needed where the soil is exposed within the holes in



**Ease of agronomic seed increase:** Difficult. For highest yields, this lupine should be grown on weed fabric. Seeds ripen unevenly and are expelled from pods as soon as they mature. Plants may flower the first year, but yields

are low. Plants also are not well adapted to heavy, saturated soils and can be short-lived under these conditions.

**Ease of wild seed collection:** Difficult. Collection must occur when pods are ripe, but before they shatter. Pods ripen unevenly and make collection at any one given time a challenge.

**Seeds per pound:** 38,000

**Establishment:** Seeds are non-dormant and germinate in moderate temperatures, naturally germinating in late fall or spring; scarification can improve uniformity of germination. Seed increase fields should be established using plugs.

the fabric. Borders need to be kept clean using herbicides or tillage. Weed fabric can catch wind-borne seeds or seeds that are ejected from many feet away. Reducing these types of weeds from the seed production area will prevent weed seeds from contaminating the seed crop. For fields without weed fabric, hand hoeing, herbicide spot treatments, and row tillage are options.

**Fertilization:** An application of a balance fertilizer (16-16-16) in early spring as new growth appears may be beneficial depending on soil nutrient levels.

**Pests:** Mice can predate seed as it accumulates on weed fabric. Slugs can be very damaging to seedlings. Powdery mildew is often seen on the plants, but occurs late in the season and does not affect plant health or seed production. Seed weevils are common with this species in the wild, but much less common in seed production fields.

**Harvest:** For fields without weed fabric, harvest seeds by hand once seedpods turn brown to black or directly combined if maturity across the field is uniform (very rare). If using weed fabric, harvest when seed dispersal has ended for the season, by vacuuming or sweeping seeds from the fabric. A large amount of seed may have collected in

the holes and can be vacuumed out. If plants are very dense, they may need to be cut away before sweeping or vacuuming.

**Post-harvest residue management:** Allow plants to naturally senesce in the fall and cut plants down to the ground before new growth appears in the spring.

**Seed cleaning:** Use a Hammermill or thresher to break up unopened pods. Then use an air-screen machine to remove chaff.

**Average yields/Stand longevity:** 25–100 pounds per acre. In the first growing season, expect little to no seed production. Yields should increase in the second and third years. Plants are short-lived in seed production fields and many will not survive the first winter. This species tends to have higher rates of survival when grown on well-drained soils.

**Remarks:** This species is common and abundant. Wild stands are often larger and more vigorous than cultivated stands. Even in the most favorable cultivated settings, it still may be more efficient to collect seed from the wild than grow seed of this species.





# LUPINUS OREGANUS

*Kincaid's lupine*

**Life form:** Deciduous perennial legume

**Pollination:** Capable of self pollination, but strongly outcrossing and reliant on pollination service by native insects such as bumble bees, other native bees, and butterflies.

**Native distribution/Habitat:** This endangered species is found mainly in the Willamette Valley of Oregon, where it occupies grassland habitats. There are also a few sites in Washington and in the Umpqua River Basin of Oregon. This lupine is the primary larval host plant for the endangered Fender's blue butterfly (*Icaricia icarioides fenderi*).

**Ease of agronomic seed increase:** Difficult. Best established using plugs, which can be difficult to grow. Plants flower variably over a period of weeks, and seed retention is very low (seeds shatter immediately upon ripening), making harvest time-consuming or low-yielding. Plants are rhizomatous, which can complicate weed control.

**Ease of wild seed collection:** Difficult. This lupine has seed that ripens variably and shatters upon ripening, making it difficult to collect a lot of seed at one time.

**Seeds per pound:** 20,000–30,000

**Establishment:** Seeds are not dormant and naturally germinate in late winter. Seed lots have a high percentage of hard seed. Therefore, seed should be mechanically scarified (abraded with sandpaper) to improve uniformity of germination. Sow scarified seeds in containers and place in an unheated greenhouse over winter and transplant



to the field in the spring. Preferred planting method for this species is to transplant plugs on wide row spacing (24–36 inches) to allow for mature plant size and weed management. Lupines do not always thrive when grown in a greenhouse; they can be sensitive to root rot and other pathogens. Direct seeding is not recommended because weeds can outcompete seedlings in the spring. If direct sowing is desired, sow in spring in 16–30 inch wide rows, at 10–12 lb/acre, and at a depth of ½–¾ inch. Wider spacing allows for initial tillage or herbicide application between rows. Establishment and subsequent growth may also be improved by inoculating seed with nitrogen fixing bacteria (*Rhizobium lupini*) prior to planting to aid in formation of root nodules.

**Establishment rating:** Low. These lupines are sensitive to root disturbance and can be difficult to establish using transplants. When directly sown, seedlings are intolerant of saturated soil conditions.

**Weed control:** There are no herbicides labeled for use on lupines when grown for seed. Therefore, good reduction in the weed seed bank and field preparation is important. Hand hoeing, herbicide spot treatments, and row tillage are options. Plants are sometimes completely dormant in winter, usually emerging in early spring. This dormant period can allow for chemical weed control.

**Fertilization:** An application of a balanced fertilizer (16-16-16) in early spring as new growth appears





may be beneficial depending on soil nutrient levels.

**Pests:** Slugs can damage seedlings. Plants can become infected with various pathogens when grown in heavy or saturated soils.

**Harvest:** Seeds ripen over a period of weeks and pods shatter readily when fully mature. Pods are

ripe when they turn a light tan color and feel very dry. Stalks of pods can be hand harvested as they mature, or directly combined if maturity across the field is very uniform (not likely). Harvested materials should be laid out in a warm, dry place to cure before cleaning. Seeds can be expelled many feet from the pods, so cover material as it is drying.

**Post-harvest residue management:** Allow plants to naturally senesce in the fall and cut plants down to the ground in the spring. Shoots will emerge from the original crown as well as up to two feet away.

**Seed cleaning:** Use a brush machine to remove seeds from pods that have not already shattered, followed by a small air-screen machine to remove chaff, empty seeds, and weed seeds.

**Average yield/Stand Longevity:** 120–300 pounds per acre. In the first growing season, expect little to no seed production. Yields should increase in the second and third years. On well-drained fields, plants can be very long-lived, producing for seven years or more. In heavy or saturated soils, plants may begin to die off after three years.





# LUPINUS POLYPHYLLUS

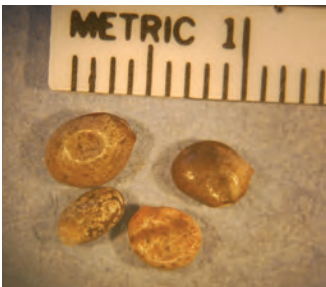
*big leaf lupine*

**Life form:** Rhizomatous perennial legume

**Pollination:** Pollinated by bumble bees as well as long-horned bees, sweat bees, butterflies, and hover flies.

**Ease of agronomic seed increase:** Moderate. This species is easy to establish, but weed management and harvest can be challenging.

**Native distribution/Habitat:** Native to western North America from southern Alaska and British Columbia east to Alberta and western Wyoming, and south to Utah and California. Commonly found in vernal pools, dry or wet meadows, stream banks, bogs, ditches, and moist woods.



**Ease of wild seed collection:** Easy. Plants are common and may be found in large bunches. Pods may be collected when beginning to turn ripe (light tan to dark brown) and pods will remain on the stem as seeds continue to ripen and harden. Pods should be placed in a warm place to dry and kept covered to prevent seed loss from bursting pods. Many lupines hybridize with other lupine species.

**Seeds per pound:** 25,000–30,000

**Establishment:** Seeds are not dormant and typically germinate in the winter and spring,



but scarification can improve uniformity of germination. Preferred planting method for this species is to plant plugs on wide row spacing (24 to 36 inches) to allow for plant size and weed management. Direct seeding is not recommended because weeds can outcompete seedlings in the spring. If direct sowing is desired, sow in spring in 16–30 inch wide rows, at 10–12 lbs per acre, and at a depth of  $\frac{1}{2}$ – $\frac{3}{4}$  inch. Wider spacing allows for initial tillage or herbicide application between rows. Establishment and subsequent growth may also be improved by inoculating with nitrogen fixing bacteria (*Rhizobium lupini*) prior to planting to aid in formation of root nodules.

**Establishment rating:** Medium from transplants. Plants are hearty and will grow throughout the first year and reach maturity the second year.

**Weed control:** There are no herbicides labeled for use on lupines when grown for seed. Therefore, good reduction in the weed seed bank and field preparation is important. Fortunately, because of its rapid spring growth, this species can be quite competitive with weeds if established from transplants. Hand hoeing, herbicide spot treatments, and row tillage are options.

**Fertilization:** An application of balanced fertilizer (15-15-15) is recommended for this species in early spring if seed yields are falling after year three.

**Pests:** Aphids and powdery mildew are known



to be problematic for this species. High rates of infestation can weaken plants, and can lower seed yields.

**Harvest:** Pods are ripe when they turn a deep gray to black color and feel very dry. Stalks of pods can be hand harvested as they mature, or directly combined if maturity across the field is very uniform. Combined materials should be laid out in warm, dry place to cure before cleaning. Seeds can be expelled many feet from the pods, so cover material as it is drying.

**Post-harvest residue management:** Combining during harvest takes much of the bulk plant material off the field, but plants may tolerate an additional mowing before winter. Plants are mostly dormant in late summer and throughout the winter. New leaves begin to emerge from the crown in early spring.

**Seed cleaning:** A stationary combine or thresher will break open the seed pods. Seeds can be separated from plant materials or other organic matter using an air-screen machine. Seeds are large, easily identifiable, and easily separated from other materials in the lot.

**Average yields/Stand longevity:** 200–300 pounds per acre, depending on harvest methods. Plant usually do not flower their first growing season. Plants are long-lived and can produce for over five years if field conditions are favorable.

**Remarks:** This species is highly variable. Some plants grow a single large crown and can reach 5 feet tall, while others are highly rhizomatous, spreading many feet, but growing only a couple feet tall. This species was crossed with *Lupinus arbustus* to create ornamental varieties of lupine, namely the “Russell Hybrids”.





# LUPINUS RIVULARIS

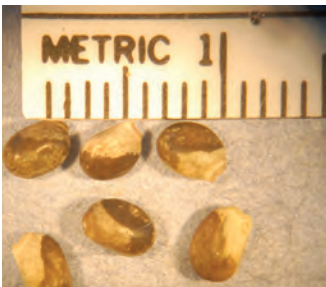
*river lupine*

**Life form:** Short-lived, perennial legume

**Pollination:** Cross-pollinated by bumble bees and other insects, and likely self-pollinated as well. Species is known to hybridize extensively with the invasive *Lupinus arboreus*, as well as certain native lupines.

**Ease of agronomic seed increase:** Generally easy for stands that mature uniformly. Evergreen plants compete well and shade out many weeds,

seed set is dependable and prolific, and seed is simple to clean. However, fields are limited to one seed crop per planting and labeled herbicides are lacking.



**Native distribution/  
Habitat:**

Occurs along the

Pacific Coast of North America, from southwestern British Columbia to northwestern California at elevations below 6,000 ft. on moderately moist to dry sites with well-drained, coarse-textured (gravelly, sandy) soils in full sun to light shade. Species occurs in prairies and open woods, but prefers disturbed locations with soils low in nitrogen, such as sand dunes, creek banks, cut slopes along roadsides, or dredge spoils where competition is reduced.

**Ease of wild seed collection:** Easy if seed is collected before seedpods turn completely black and split open. Seed is best collected by cutting off and placing maturing seedheads in paper sacks. Sacks should be stored in a warm place to dry and kept closed to prevent seed loss from bursting pods.



**Seeds per pound:** 15,000–31,000, depending on population and environmental conditions.

**Establishment:** Seed lots have a high percentage of hard seed. Therefore, seed should be mechanically scarified (abraded with sandpaper) or soaked in hot water (180°F) to enhance germination rates. Establishment and subsequent growth may also be improved by inoculating with nitrogen fixing bacteria (*Rhizobium lupini*) prior to planting to aid in formation of root nodules. Seeding is typically done in early fall or spring in 16–30 inch wide rows, at 10–12 lbs per acre, and at a depth of 1/2–3/4 inch. Wider spacing allows for initial tillage between rows, but narrower rows allow for earlier canopy closure and shade suppression of weeds. Spring or summer-seeded irrigated fields should produce a seed crop the following year, but fall seeding (with or without irrigation) will not produce a good seed crop until the second full growing season.

**Establishment rating:** High due to dependable germination (if seed is properly scarified) and ability of plants to compete with weeds. Slugs and damping off can be a problem in particularly wet fields.

**Weed control:** There are no herbicides labeled for use on riverbank lupine when grown for seed. Therefore, good reduction in the weed seed bank and seedbed preparation is important. Fortunately, because of its rapid spring growth, this lupine shades out a majority of weeds and

lessens the need for intense weed control after establishment. Hand hoeing, herbicide spot treatments, and row tillage during early development are options.

**Fertilization:** Fertilizer of any kind is generally not needed for new seedings or established stands in western Oregon. However, phosphorus (P) or sulfur (S) may be limiting on certain soils. Apply according to soil test at rates generally suggested for red clover in your area. Given the species' requirement for acidic soils, the addition of lime is likely unwarranted if soil pH is above 5 or 5.5.

**Pests:** Lupines under seed production are known to be attacked by several insect pests. They can be seed, pod, or foliage feeders and sucking insects. Some are generalists such as lygus bugs, some are legume specific, and others are lupine specific like the lupine aphid. Pests of riverbank lupine include cucumber beetles which feed on leaves and blossoms and lygus bugs which cause damage by sucking out the juices of developing flowers and fruit. Slugs can devour rows of seedlings. Diseases such as powdery mildew and leaf spot are common in some years, but are usually not considered a problem. The species may be susceptible to root rot diseases on heavy, poorly-drained soils.

**Harvest:** Compared to other lupines, seed retention of riverbank lupine is generally high after pods have matured. For fields that mature more uniformly, harvest by direct combining the seedheads when most seedpods have turned from green to black. For fields that mature unevenly, it may be necessary to windrow the field onto wide paper strips (rolled out from underneath the swather) or windrow and immediately rake the windrows onto tarps. The paper strips or tarps are needed to catch most of the seed when it is expelled from the pods as they continue to dry. Cure the stalks and seedheads in the field for at least 2 weeks, and then combine. Most "green" seeds with high initial moisture content will eventually dry, turn dark, and exhibit good germination.

**Post-harvest residue management:** Since this lupine typically acts like a biennial under seed production, crop aftermath and any standing stubble can be flail chopped or mowed and left on the field to be tilled into the soil.

**Seed cleaning:** Fully threshed seed is generally easy to clean because of its large size and smooth, rounded surface. Use an air-screen machine to remove fines, coarse plant fragments, immature or damaged seed, and weed seeds. Optional equipment includes an indent cylinder to remove long narrow weed seed such as grass seeds and/or a velvet roll to remove weed seeds with rough surfaces.

**Average yields/Stand longevity:** 200–450 pounds per acre. This species typically does not flower the first summer if spring sown and only flowers sparsely the summer following a fall seeding. The largest seed crop occurs when the stand has gone through one winter if spring sown or two winters if fall sown. While the species normally lives 2 to 4 years in the wild, plants do not generally re-sprout after they are cut, so only one seed crop can be produced per planting.

**Remarks:** One of the few wild lupines native to the Pacific Northwest that can be readily grown for seed with large scale mechanization and without herbicides.





# MADIA ELEGANS

*common madia*

**Life form:** Annual forb

**Pollination:** Pollinated by bumble bees, honey bees, butterflies, and other native insects.

**Ease of agronomic seed increase:** Moderate; seeds mature over a long period and shatter as they mature, so using weed fabric as a passive seed collector is highly recommended. In cultivated settings, plants are much larger than those found in the wild.



1 ft spacing. Place 10 seeds per hole (2 pounds per acre) and cover them lightly with soil or vermiculite. For direct seeding a field without weed fabric, use a rate of 50 seeds per square foot or 11 pounds per acre. Sow in fall or spring at a depth of ¼ inch or less into rows 12–24 inches apart.

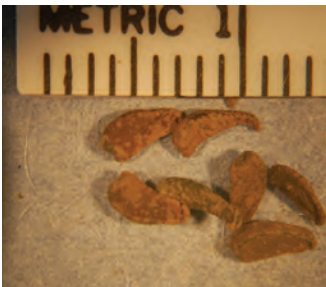
**Establishment rating:** Medium. If seedlings are protected from slugs, establishment can be quite high. Seedling vigor is high and plant development is rapid.

**Weed control:** Weed fabric excludes most weeds, but hand weeding may be needed where the soil is exposed within the holes in the fabric. Borders need to be kept clean using herbicides or tillage. Weed fabric can catch wind-borne seeds, or seeds that are ejected from many feet away. Reducing these types of weeds from the seed production area will prevent weed seeds from contaminating the seed crop.

**Fertilization:** Application of a balanced fertilizer is recommended during early spring as plants begin to grow rapidly, usually in mid March in the Willamette Valley.

**Pests:** Slugs must be controlled when seedlings are small.

**Harvest:** Seeds fall from the plant as they mature and can shatter over a period of weeks. After most of the seeds are ripe, cut plants at the base and place on tarps to dry, then thresh or stationary



**Native distribution/  
Habitat:** This species occurs in grasslands and open forest below 7000 ft in elevation from southwestern Washington to Baja California.

**Ease of wild seed collection:** Moderate. If plants are large, they flower and produce seed over a period of several weeks, creating a large window of time for collection (small or stunted plants flower and set seed quickly, making timing for collections more difficult). Plants can be shaken or beaten over a bag to release mature seed. Plants usually occur in patches, but may be difficult to locate as plant communities change over time.

**Seeds per pound:** 150,000–200,000

**Establishment:** Seeds are not dormant and germinate in warm temperatures in early fall or late spring. Seeds should be directly sown in late fall into holes cut in weed fabric on 1 ft by



combine plant material. Additionally, shattered seeds can be vacuumed up from the weed fabric. Large fields, with or without weed fabric, can be directly combined, but this method will result in much lower yields due to high rates of shatter prior to and during harvest. Plants can be very sticky when green and should not be combined until sufficiently dried and less sticky.

**Post-harvest residue management:** As an annual, crop aftermath and standing stubble can be left on the field after harvest.

**Seed cleaning:** Use a thresher, combine, or hammer mill to break seeds loose from plant material. Use an air-screen machine to remove stems, chaff, and unfilled seeds to reach desired purity standards. Distinguishing filled seed from non-filled seeds can be challenging with this species.

**Average yields/Stand longevity:** Highly variable. 50–150 pounds per acre without weed fabric, 200–1,000 pounds per acre with weed fabric. Yield for this species depends on the density of the stand and the mature size the plants reach in a given year. The yield may fall between 20 and 100 lbs per 1/10th acre plot. This species is an annual, but readily self-sows.

**Remarks:** This species can be weedy in production areas, but does not become a persistent weed.





# MADIA GLOMERATA

*mountain tarweed*

**Life form:** Annual forb

**Pollination:** Pollinated by bumble bees, honey bees, butterflies, and other native insects.

**Ease of agronomic seed increase:** Moderate. Seeds mature over a long period and shatter as they mature, so using weed fabric as a passive seed collector is highly recommended. In cultivated settings, plants are much larger than those found in the wild.



**Native distribution/  
Habitat:** *Madia glomerata* is the most widely distributed of all *Madia* species. Its native range covers much of western and northern North America from Alaska to the Southwestern U.S.,

most of southern Canada, and into the Great Lakes region. It grows in openings in grasslands, meadows, swales, shrublands, woodlands, forests, edges of marshes, lakes, and disturbed sites; often in coarse, sandy or gravelly soils; 0–12,000 ft.

**Ease of wild seed collection:** Moderate. Plants are usually easy to identify and are moderately abundant in the wild. If plants are large, they flower and produce seed over a period of several weeks, creating a large window of time for collection (small or stunted plants flower and set seed quickly, making timing for collections more difficult). Plants can be shaken or beaten over a bag to release mature seed.

**Seeds per pound:** 200,000–250,000



**Establishment:** Seeds are not dormant, but naturally do not germinate until temperatures warm in the spring. For best establishment, start plugs in a greenhouse in late winter and transplant out in spring. Fresh seed may need a brief cold-moist period before germinating in warm temperatures. Transplant into a field covered with weed fabric containing holes on 1 ft by 1 ft spacing. Plants can be cold sensitive, we aim to outplant them in late March. Seeds can also be sown directly into holes in the weed fabric in spring. Place 10 seeds per hole (2 pounds per acre) and cover them lightly with soil or vermiculite. For direct seeding a field without weed fabric, use a rate of 50 seeds per square foot or 10 pounds per acre. Sow in spring at a depth of ¼ inch or less into rows 12–24 inches apart.

**Establishment rating:** Medium. Greenhouse-grown transplants can be sensitive to cold temperatures in spring, even if properly hardened. Direct seeding in early spring can be successful if soil moisture remains high during late spring and early summer.

**Weed control:** Weed fabric excludes most weeds, but hand weeding may be needed where the soil is exposed within the holes in the fabric. Borders need to be kept clean using herbicides or tillage. Weed fabric can catch wind-borne seeds, or seeds that are ejected from many feet away. Reducing these types of weeds from the seed production area will prevent weed seeds from contaminating the seed crop.



non-filled seeds can be challenging with this species.

**Average yields/Stand longevity:** 100–1,700 pounds per acre. Yield for this species has been highly variable depending on the density of the stand and the mature size the plants reach in a given year. The yield may fall between 10 and 170 pounds per  $\frac{1}{10}$  acre. This species is an annual, but can self-sow.

**Remarks:** This species can be weedy in production areas, but does not become a persistent weed.

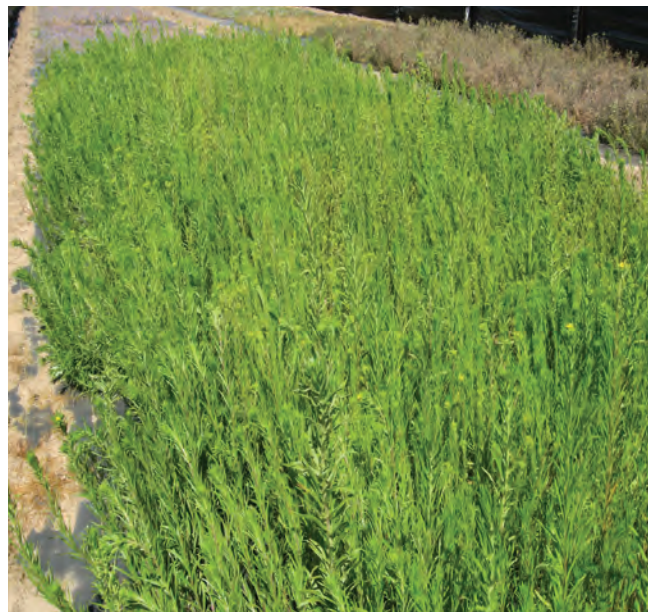
**Fertilization:** If started as plugs, controlled-release fertilizer should be added to the media and this is usually sufficient for the annual crop. For direct seeding, application of a balanced fertilizer is recommended during early spring as plants begin to grow rapidly, usually in mid March in the Willamette Valley.

**Pests:** Slugs can damage seedlings when fields are established from seed.

**Harvest:** Seeds fall from the plant as they mature and can shatter over a period of weeks. When seeds begin to ripen, cut plants at the base and place on tarps to dry, then thresh or stationary combine plant material. Additionally, the seeds can be vacuumed up from the weed fabric. Large fields, with or without weed fabric, can be directly combined, but this method will result in much lower yields due to high rates of shatter prior to and during harvest. Plants can be very sticky when green and should not be combined until sufficiently dried and less sticky.

**Post-harvest residue management:** As an annual, crop aftermath and standing stubble can be left on the field after harvest.

**Seed cleaning:** Use a thresher, combine, or hammer mill to break seeds loose from plant material. Use an air-screen machine to remove stems, chaff, and unfilled seeds to reach desired purity standards. Distinguishing filled seed from





# MADIA GRACILLIS

*grassy tarweed*

**Life form:** Annual forb

**Pollination:** Pollinated by bumble bees, honey bees, butterflies, and other native insects.

**Ease of agronomic seed increase:** Moderate. Seeds mature over a long period and shatter as they mature, so using weed fabric as a passive seed collector is highly recommended. In cultivated settings, plants are much larger than those found in the wild.



**Seeds per pound:** 250,000–400,000

**Establishment:** Seeds are not dormant and naturally germinate in cool temperatures in late fall. Seeds should be directly sown in late fall into holes cut in weed fabric on 1 ft by 1 ft spacing. Plants are highly winter active and will benefit from fall sowing. Place 10 seeds per hole (1–2 pounds per acre) and cover them lightly with soil or vermiculite. For direct seeding a field without weed fabric, use a rate of 50 seeds per square foot or 9 pounds per acre. Sow in fall at a depth of ¼ inch or less into rows 12–24 inches apart.

**Establishment rating:** Medium. If seedlings are protected from slugs, establishment can be quite high. Seedling vigor is high and plant development is rapid.

**Weed control:** Weed fabric excludes most weeds, but hand weeding may be needed where the soil is exposed within the holes in the fabric. Borders need to be kept clean using herbicides or tillage. Weed fabric can catch wind-borne seeds, or seeds that are ejected from many feet away. Reducing these types of weeds from the seed production area will prevent weed seeds from contaminating the seed crop.

**Fertilization:** A small application of a balanced fertilizer is recommended during early spring as plants begin to grow rapidly, usually in mid March in the Willamette Valley.



**Native distribution/  
Habitat:** Native to western North America from British Columbia to Baja California and east to Utah. It grows in open or partially shaded slopes or flats in grasslands, meadows, shrublands,

woodlands, and forests, disturbed sites, stream banks, and roadsides; coarse to fine textured soils, sometimes serpentine; 0–7000 ft. This species is found in full sun along roadsides and in other openings created by natural or manmade disturbance.

**Ease of wild seed collection:** Moderate. Plants are usually easy to locate and are moderately abundant. If plants are large, they flower and produce seed over a period of several weeks, creating a large window of time for collection (small or stunted plants flower and set seed quickly, making timing for collections more difficult). Plants can be shaken or beaten over a bag to release mature seed.



**Pests:** Slugs must be controlled when seedlings are small.

**Harvest:** Seeds fall from the plant as they mature and can shatter over a period of weeks. When seeds begin to ripen, cut plants at the base and place on tarps to dry, then thresh or stationary combine plant material. Additionally, the seeds can be vacuumed up from the weed fabric. Large fields, with or without weed fabric, can be directly combined, but this method will result in much lower yields due to high rates of shatter prior to and during harvest. Plants can be very sticky when green and should not be combined until

sufficiently dried and less sticky. Seeds are often enclosed in a Velcro-like casing which causes the seeds to adhere to clothing, shoes, etc.

**Post-harvest residue management:** As an annual, crop aftermath and standing stubble can be left on the field after harvest.

**Seed cleaning:** Use a thresher, combine, or hammer mill to break seeds loose from plant material. Use an air-screen machine to remove stems, chaff, and unfilled seeds to reach desired purity standards. Distinguishing filled seed from non-filled seeds can be challenging with this species.

**Average yield/Stand longevity:** Highly variable. 100–200 pounds per acre without weed fabric, 400–1,200 pounds per acre with weed fabric. Yield for this species has been highly variable depending on the density of the stand and the mature size the plants reach in a given year. The yield may fall between 40 and 120 pounds per  $\frac{1}{10}$  acre plot. This species is an annual, but readily self-sows.

**Remarks:** This species can be weedy in production areas, but does not become a persistent weed.





# MONTIA LINEARIS

*narrowleaf minerslettuce*

**Life form:** Annual forb

**Pollination:** Early-blooming flowers usually do not open and are self-pollinated. Later flowers do open and are capable of self-pollinating or out-crossing.

**Ease of agronomic seed increase:** Moderate. This species can be directly sown into a field covered with weed fabric. Harvest and seed cleaning are easy.

**Native distribution/  
Habitat:**

Found in standing water of meadows and prairies, vernal pools, and wet to dry fields from British Columbia, east to Saskatchewan, south along the west coast of the United States to

Southern California, and is also found in some states in the southeastern United States.

**Ease of wild seed collection:** Difficult. This species is abundant in the wild, but plants are usually quite small and can be difficult to locate. Seeds ripen variably depending on temperature and soil moisture and immediately shatter from the plant when ripe. As sepals turn light brown, seeds can be stripped from the plant and placed in paper bags to dry.

**Seeds per pound:** 250,000–300,000

**Establishment:** Seeds are non-dormant, but need exposure to cool temperatures to



germinate. Seeds naturally germinate in mid-winter. For best establishment, directly sow seeds in the fall into a field covered with weed fabric with holes cut on 1 ft by 1 ft spacing. This species is winter active and benefits from fall sowing. Weed fabric is necessary for obtaining a decent harvest. Put approximately 10 seeds per hole (2 pounds per acre) and cover lightly with soil, fine compost, or vermiculite. Seeds germinate in the winter and will grow considerably during the winter and early spring. Direct seeding is not recommended, but can be accomplished in late fall by sowing at a rate of 10 pounds per acre (50 seeds per square foot)  $\frac{1}{8}$  inch deep in rows 10–12 inches apart.

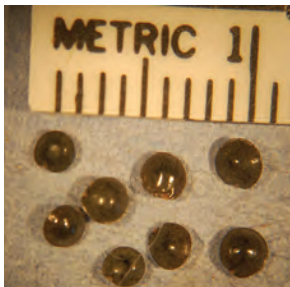
**Establishment rating:** Medium from direct sowing.

**Weed control:** There are no herbicides labeled for use on this species for seed production. Weed fabric excludes most weeds, but hand weeding is needed where soil is exposed. Weed seeds may blow or shatter onto weed fabric, so field borders need to be kept clean.

**Fertilization:** This species thrives in low nutrient environments and usually does not need fertilizer.

**Pests:** None observed.

**Harvest:** Seeds fall readily from capsules as soon as they ripen over a period of a few weeks. Seeds will





**Average yields/Stand longevity:** This species is limited to small scale production, but can yield 10–30 pounds per  $\frac{1}{10}$  acre plot.



fall onto the fabric where they can be swept or vacuumed. For fields without weed fabric, plants may be cut and collected onto tarps, but yields will be low due to the small amount of seed that is ripe at one time on this species.

**Post-harvest residue management:** As an annual, crop aftermath can be left on the field after harvest.

**Seed cleaning:** Use a small air-screen machine to blow out chaff and weed seeds.





# MYOSOTIS LAXA

*small flowered forget me not*

**Life form:** Annual or short-lived perennial forb

**Pollination:** Members of the genus *Myosotis* are generally self-compatible and are pollinated by small native bees, flies, and Lepidoptera (moths and butterflies).

**Ease of agronomic seed increase:** Moderate. This species establishes best using plugs and weed fabric. Harvest and seed cleaning are also moderately difficult.



**Native distribution/**

**Habitat:** Grows in wet prairies, especially vernal pools, ditches, and along edges of pools, ponds, and sloughs. It grows in clusters at low elevations throughout the Pacific Northwest, especially

west of the Cascades, and in the eastern U.S.

**Ease of wild seed collection:** Difficult. Seeds ripen variably over a period of weeks and shatter when ripe. Seeds can be stripped from the plant and placed in paper bags to dry.

**Seeds per pound:** 1,200,000

**Establishment:** Seeds are not dormant and readily grow when placed in warm conditions (over 65°F). Seeds naturally germinate in the late spring. Fields are best established using plugs that were grown in a greenhouse over the winter and transplanted out into fields covered with weed fabric in the spring on 1 ft by 1 ft spacing. Using plugs creates larger plants and cleaner



fields; the use of weed fabric is necessary to have reasonable yields. Establishing seed increase fields by directly sowing is not recommended, but can be accomplished by sowing seeds in the spring at a rate of 2 pounds per acre (50 seeds per square foot) 1/8 inch deep in rows 10–12 inches apart. Plants will require irrigation for establishment and seed production if directly sown.

**Establishment rating:** Medium from plugs.

**Weed control methods:** There are no herbicides labeled for use on this species for seed production. Weed fabric excludes most weeds, but hand weeding is needed where soil is exposed. Weed seeds may blow or shatter onto weed fabric, so field borders need to be kept clean.

**Fertilization:** A controlled-release fertilizer added to the media used to grow plugs will supply the plants with sufficient nutrients for their lifecycle.

**Pests:** Container plants can become infected with grey mold (*Botrytis*). Spacing plants out to increase airflow when they become large and leafy will decrease this problem.

**Harvest:** Most seeds fall readily from capsules as soon as they ripen over a period of many weeks. Seeds will fall onto the fabric where they can be swept or vacuumed. To maximize yields, after all seed has shattered, plants can be cut and collected and dried on tarps to capture seed retained in the plants. Fields without weed fabric may be cut and



collected onto tarps, but yields will be low due to loss from shatter.

**Post-harvest residue management:** The harvest process will remove most of the plant biomass from the plot. Residual plant stems can be mowed off, or if left, will decay over the winter.

**Seed cleaning:** If entire plants were cut and dried, the material should be threshed using a large brush machine or a thresher that will not grind the material. Seeds are easily damaged and

should not be dehulled. Use a small air-screen machine to blow out chaff and weed seeds.

**Average yields/Stand longevity:** 15–25 pounds for a  $\frac{1}{10}$  acre plot. This species is limited to small scale production. In upland areas, this species will act as an annual. In wet areas or extremely wet years, it can survive the summer drought through dormancy and emerge the following year in early spring.





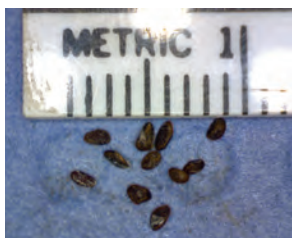
# NAVARRETIA INTERTEXTA

*needleleaf navarretia*

**Life form:** Annual forb

**Pollination:** Self-compatible, but depends on insects for out-crossing; usually pollinated by small flies and bees.

**Ease of agronomic seed increase:** Moderate. This species establishes best using plugs planted into weed fabric. Harvest and seed cleaning are also moderately difficult.



**Native distribution/  
Habitat:** *N. intertexta* is found throughout western North America from British Columbia south to Baja California and east through the Midwest. It grows in open, moist meadows and vernal pools from sea

level to 6,000 ft. *N. willamettensis* only occurs in moist meadows and vernal pools in the southern Willamette Valley of Oregon.

**Ease of wild seed collection:** Moderate. Seeds do not shatter from the plant, allowing a large collection window. Plants are low-statured, making them challenging to locate, but often occur in dense patches. Plants are spiny and it is advised to wear gloves when handling them. Seeds can be collected by clipping entire heads and drying in paper bags.

**Seeds per pound:** 1,100,000

**Establishment:** Seeds germinate best in cool



temperatures. For best establishment, sow seeds in containers outside in mid-November. Seeds will germinate within 4–6 weeks. After seeds germinate, move containers to a greenhouse for the winter and transplant out in spring. Transplant into a field covered with weed fabric containing holes on 1- by 1-ft spacing. Fields established from plugs contain large, uniform plants. Direct sowing is not recommended for establishing seed increase fields, but can be accomplished by sowing seeds in late winter at a rate of 2 pounds per acre (50 seeds per square foot) 1/8-inch deep in rows 10–12 inches apart. Plants will require irrigation for establishment and seed production if directly sown.

**Establishment rating:** Establishment rating: High from plugs.

**Weed control:** Weed fabric excludes most weeds, but hand weeding may be needed where the soil is exposed within the holes in the fabric.

**Fertilization:** When started as plugs, controlled-release fertilizer added to the media usually supplies sufficient fertility for these annual crops.

**Pests:** None observed.

**Harvest:** Seeds remain on the plant after ripening so entire plants can be cut after all seed has matured. Place material on tarps to dry. This plant is not suited to mechanized harvest due to its low stature.



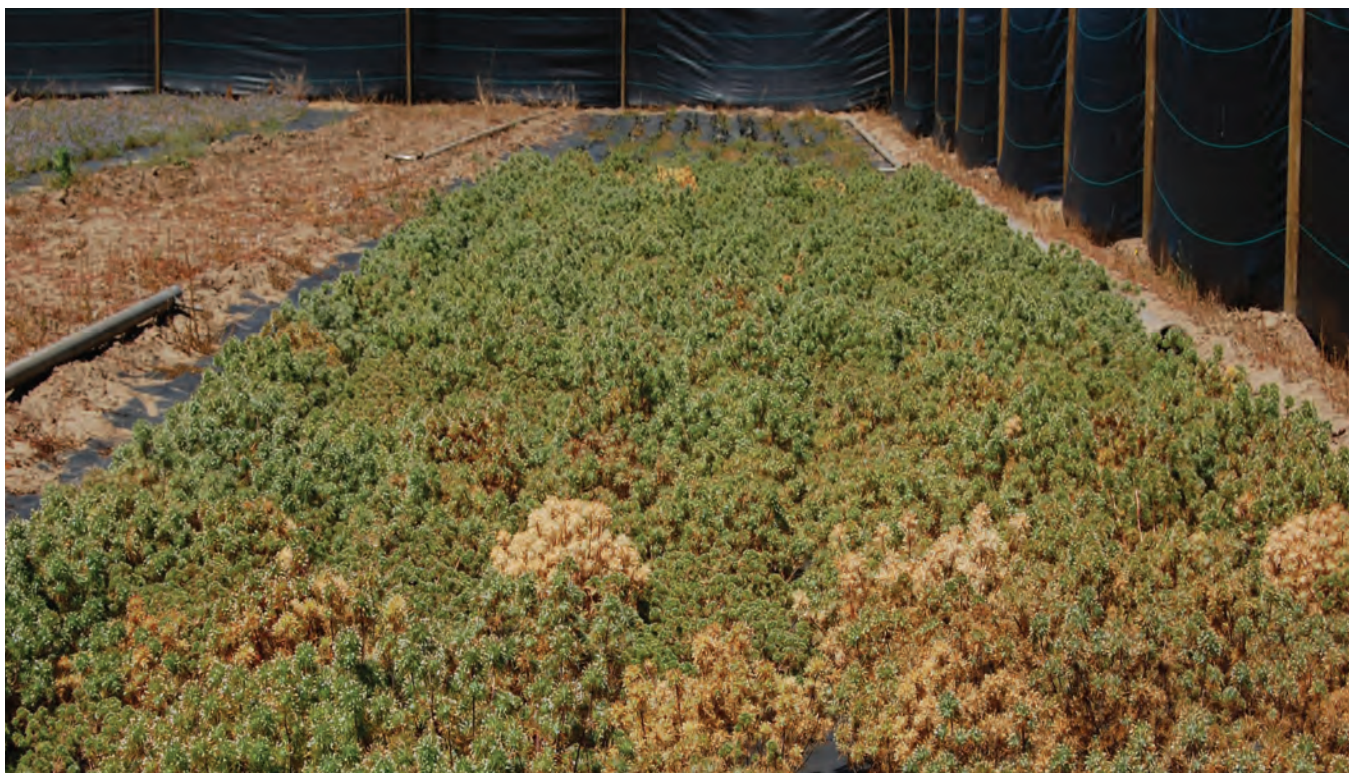
separating seeds from the heads. Follow with a small air-screen machine to separate seed from other material.

**Average yields/Stand longevity:** 20–40 pounds per 1/10th-acre plot. This species is limited to small scale production.

**Remarks:** The Corvallis PMC has grown both *Navarretia intertexta* and *N. willamettensis*, Willamette navarretia. Production methods are the same for both species.

**Post-harvest residue management:** The harvest process removes most of the plant biomass from the plot and any residual material will decay over the winter.

**Seed cleaning:** These species have oddly shaped, non-symmetrical seeds of various sizes. Some seeds are found in cylindrical clusters, while others are larger, single oval seeds. A brush machine or stationary thresher is helpful for





# NEMOPHILA MENZIESII

*baby blue eyes*

**Life form:** Annual forb

**Pollination:** This species is capable of self-pollination, but relies on mining bees and syrphid flies for outcrossing.

**Ease of agronomic seed increase:** Difficult. This species must be grown on a field covered with weed fabric for decent yields. However, harvest and seed cleaning are easy.



**Native distribution/**

**Habitat:** Baby blue eyes is native to Oregon and California, but has been introduced to other states. It is found in many open, sunny habitats that are moist in the spring, such as coastal grasslands, vernal pools,

and woodlands. This species has three varieties with differing flower colors.

**Ease of wild seed collection:** Difficult. Plants are usually quite small and can be difficult to locate after flowering. Seeds ripen variably in large capsules that turn under the plant and open, spilling the seed.

**Seeds per pound:** 190,000

**Establishment:** Seeds are non-dormant, but need cool temperatures to germinate. Seeds naturally germinate in mid-winter. For best establishment, in the fall directly sow seeds into a field covered with weed fabric with holes cut



on 1 ft by 1 ft spacing. Weed fabric is necessary for obtaining a decent harvest. Put approximately 10 seeds per hole (2.3 pounds per acre) and cover lightly with soil, fine compost, or vermiculite. Seeds germinate in the winter and will grow considerably during the winter and early spring. Direct seeding in fields without weed fabric is not recommended, but can be accomplished in late fall by sowing at a rate of 11 pounds per acre (50 seeds per square foot)  $\frac{1}{8}$ -inch deep in rows 10–12 inches apart. Fields can be established using plugs transplanted into a field covered with weed fabric. However, it can be difficult to acclimate greenhouse grown transplants to outdoor conditions in early spring when this species flowers. Plants also have a single delicate stem that is easily damaged when transplanting. If slugs are a major pest, consider growing small, winter-acclimated plugs and transplant into fields by February 1.

**Establishment rating:** Medium from direct sowing. Medium from plugs.

**Weed control:** There are no herbicides labeled for use on this species for seed production. Weed fabric excludes most weeds, but hand weeding is needed where soil is exposed. Weed seeds may blow or shatter onto weed fabric, so field borders need to be kept clean.

**Fertilization:** This species thrives in low nutrient environments and usually does not need fertilizer.



**Pests:** Slugs can destroy entire plantings. Powdery mildew can sometimes affect plants, but usually doesn't lower seed yields.

**Harvest:** Seeds spill out off capsules as soon as they ripen over a period of a few weeks. Seeds will fall onto the fabric where they can be swept or vacuumed. For fields without weed fabric, plants may be cut and collected onto tarps, but yields would be very low due to the small amount of seed that is ripe at one time on this species.

**Post-harvest residue management:** As a small

annual species, crop aftermath can be left on the field after harvest.

**Seed cleaning:** Seeds usually spill easily from the capsules and do not need to be threshed. Use a small air-screen machine to blow out chaff and weed seeds. Seeds look like dirt or small rocks, especially if the white elaiosome is removed (the elaiosome is a fleshy structure attached to the tip of the seed).

**Average yields/Stand longevity:** 100-200 pounds per acre. This species is limited to small scale production, but can yield between 10-20 pounds per 1/10th acre plot depending on field conditions and harvest methods. It is an annual and does not self-sow.





# PENSTEMON CARDWELLII

*Cardwell's penstemon*

**Life form:** Perennial subshrub/forb

**Pollination:** Capable of self-pollination and cross-pollination. Cardwell's penstemon is pollinated by bumble bees, mason bees, long-horned bees, and sweat bees, as well as wasps and hover flies. Pollinators are needed for adequate seed set. These species can hybridize with other similar penstemons.

**Ease of agronomic seed increase:** Moderate.

This species is best established using plugs. Seeds are retained in capsules that open slowly, creating a wide window for harvest.

#### **Native distribution/**

**Habitat:** Cardwell's penstemon can be found

in central and western Washington and Oregon. It prefers rocky, sloping soils or disturbed sites; often mountains or mid-elevation forests. Bush penstemon (*Penstemon fruticosus*) is native to inland North America from Alberta and BC south through central Washington and Oregon and east to Montana and Wyoming. It prefers well-drained to rocky soils in steppe, alpine, or subalpine climates.

**Ease of wild seed collection:** Easy. Plants are often easy to locate and found abundantly. Seeds are retained on the plant in capsules that can be clipped from the plants and dried in paper bags.

**Seeds per pound:** 700,000–900,000

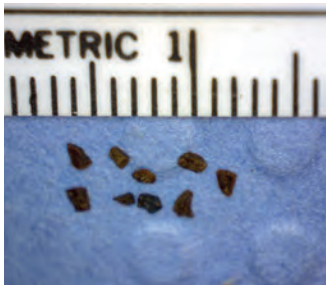


**Establishment:** Most populations have a high percentage of dormant seed that requires 70 to 90 days of cold/moist conditions in order to germinate, so seed should be direct sown in the fall. Seeds naturally germinate in early spring. Seeds are sown on the surface or up to 1/8 of an inch deep at a rate of 3–5 pounds per acre (50–75 seeds per square foot) in rows 18–24 inches apart unless larger row spacing is needed for between row cultivation. Plants are very long-lived, and can reach two feet in diameter. In saturated or heavy soils, it is better to establish fields using plugs. Seeds should be sown into containers in early fall, placed in a walk-in cooler or left outside for 70–90 days, then brought into a warm greenhouse. Seeds should germinate quickly in a warm greenhouse and plants will be ready for transplanting into fields in the spring.

**Establishment rating:** Low to medium from direct sowing, high from plugs.

**Weed control:** No herbicides are labeled for use on penstemons grown for seed. Hand hoeing, spot treatments with a nonselective herbicide, and row tillage are weed control options.

**Fertilization:** Depending on field conditions, plants will need an application of balanced fertilizer (15-15-15) in early spring if in production for more than three years. This species will typically not need annual applications.





**Pests:** Plants can be sensitive to root rot in saturated soils.

**Harvest:** Seeds remain in capsules when ripe. Capsules slowly open as they mature. Small plots may be harvested by hand, using a cutting tool (rice knife, clippers) to remove the upper stem containing the seed pods. Larger fields may be swathed, collected, and laid out to dry following harvest. If using equipment for cutting, be careful not to cut the plants too low as this will damage the next year's growth and seed production.

**Post-harvest residue management:** None needed. Plants are evergreen and should be cut as little as possible when harvested.

**Seed cleaning:** A hammermill or thresher will separate seeds from pods. Follow with an air-screening machine to further separate seed from plant materials and other organic debris.

**Average yields/Stand longevity:** 20–400 pounds per acre. If plugs are used to establish the field, it will most likely produce the first year and reach peak yields in year two. If established by direct seeding, fields will not produce seed the first growing season, will have a small harvest in year two, and reach peak yields in year three.

**Remarks:** The PMC has also worked with *Penstemon fruticosus* (bush penstemon) which looks very similar to *P. cardwellii*. The seed production techniques are identical for these species.





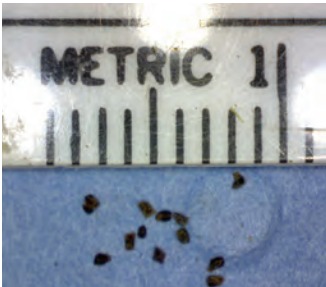
# PENSTEMON PROCERUS

*littleflower penstemon*

**Life form:** Deciduous perennial forb

**Pollination:** Capable of self-pollination, but insect pollinators are needed for adequate seed set. Mainly pollinated by native bees (bumble bees, long-horned bees, and mason bees), as well as wasps and hover flies.

**Ease of agronomic seed increase:** Moderate. Seeds require extra care in the beginning due to dormancy and establishment issues, but once established, *P. procerus* is well-suited to large scale agronomic seed increase.



**Native distribution/**

**Habitat:** This species is found throughout inland North America from the West Coast through the Midwest. It prefers

well-drained to rocky soils in steppe, alpine, or subalpine climates.

**Ease of wild seed collection:** Easy. Plants are often easy to locate and found abundantly. Seeds are retained on the plant in capsules that can be clipped from the plants and dried in paper bags.

**Seeds per pound:** 800,000–1,000,000

**Establishment:** Most populations have a high percentage of dormant seed that requires 70 to 90 days of cold/moist conditions in order to germinate; seedlings naturally germinate in early spring. Direct sowing is not recommended due to the tiny size of the seeds. Fields can be reliably established using plugs. Seeds should be sown



into containers in early fall, placed in a walk-in cooler or left outside for 70–90 days, then brought into a warm greenhouse. Seeds should germinate quickly in a warm greenhouse and plants will be ready for transplanting into fields in the spring. If direct seeding, seeds should be sown in the fall to allow for natural stratification. Sow on the surface or up to 1/8 of an inch deep at a rate of 3–5 pounds per acre (50–75 seeds per square foot) in rows 12–18 inches apart unless larger row spacing is needed for between row cultivation.

**Establishment rating:** High from plugs, low from direct seeding.

**Weed control:** No herbicides are labeled for use on penstemons grown for seed. Hand hoeing, spot treatments with a nonselective herbicide, and row tillage are weed control options.

**Fertilization:** Depending on field conditions, plants may need an application of balanced fertilizer (15-15-15) in early spring if in production for more than three years. This species typically does not require annual applications.

**Pests:** May be sensitive to root rot in saturated soils.

**Harvest:** Seeds remain in capsules when ripe. Capsules slowly open as they mature. Small plots may be harvested by hand, using a cutting tool (rice knife or clippers) to remove the upper stem containing the seed pods. Larger fields may be





swathed and collected, with materials being laid out to dry following harvest. Depending on how green the plant material is at harvest time, direct combining may be a viable harvest option. Seeds are very small and careful adjustments on the combine are required to avoid seed loss.

**Post-harvest residue management:** This species is deciduous and mostly dies back in the fall.

**Seed cleaning:** A thresher or brush machine will break open capsules to release seed. Follow with an air-screen machine to separate seed from other plant debris. This species is easily cleaned to high levels of purity.

**Average yields/Stand longevity:** 100–500 pounds per acre. When established using transplants, expect no to minimal yields in the first year, with peak yields in the second year. Plants should remain highly productive for many years.

**Remarks:** This is one of the highest yielding penstemons.





# PENSTEMON

## ROEZLII

*Roezl's penstemon*

**Life form:** Perennial forb with a woody stem.

**Pollination:** Capable of self-pollination, but insect pollinators are needed for adequate seed set. Mainly pollinated by bumble bees, but also visited by sweat bees and miner bees.

**Ease of agronomic seed increase:** Moderate. This species establishes well from plugs. Seeds are retained in capsules that open slowly, creating a wide window for harvest.

**Native distribution/Habitat:** This species is native to southern Oregon, western Nevada, and northern California, where it grows in dry sagebrush and conifer forests at mid to high elevations.

**Ease of wild seed collection:** Moderate. Plants are moderately abundant. Seeds are retained on the plant in capsules that can be clipped from the plants and dried in paper bags.

**Seeds per pound:** 600,000–700,000

**Establishment:** Most populations have a high percentage of dormant seed that requires 70 to 90 days of cold/moist conditions in order to germinate; seedlings naturally germinate in early spring. In saturated or heavy soils, establishment is best using plugs. Seeds should be sown into containers in early fall, placed in a walk-in cooler or left outside for 70–90 days, then brought into a warm greenhouse. Seeds should germinate quickly in a warm greenhouse and plants will be ready for transplanting into fields in the spring. If direct seeding in the fall, sow seeds on the surface or up to 1/8 of an inch deep at a rate of



3–5 pounds per acre (50 seeds per square foot) in rows 12–18 inches apart unless larger row spacing is needed for between row cultivation. Plants are very long-lived.

**Establishment rating:** High from plugs, low to medium from direct sowing.

**Weed control:** No herbicides are labeled for use on penstemons grown for seed. Hand hoeing, spot treatments with a nonselective herbicide, and row tillage are weed control options.

**Fertilization:** Depending on field conditions, plants may need an application of balanced fertilizer (15-15-15) in early spring if in production for more than three years. This species typically does not require annual applications.

**Pests:** None observed.

**Harvest:** Seeds remain in capsules when ripe. Capsules slowly open as they mature. Small plots may be harvested by hand, using a cutting tool (rice knife or clippers) to remove the upper stem containing the seed pods. Larger fields may be swathed and collected, with materials being laid out to dry following harvest. Depending on how green the plant material is at harvest time, direct combining may be a viable harvest option. Inflorescences are more upright in this species than other *Penstemon* making it more suited to mechanized harvest.



may decrease in year three depending on field conditions. Plants usually do not live longer than five years.



**Post-harvest residue management:** None needed. Plants are evergreen and should be cut as little as possible when harvested.

**Seed cleaning:** A thresher or hammermill will break open capsules to release seed. Follow with an air-screen machine to separate seed from other plant debris.

**Average yields/Stand longevity:** 25–400 pounds per acre. Expect minimal yields in the first year, with the peak yield in the second year. Yields





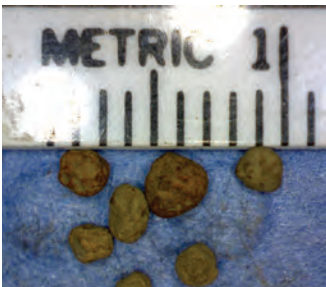
# PHLOX GRACILIS

*slender phlox*

**Life form:** Annual forb

**Pollination:** Many species of Phlox are self-incompatible; their narrow, trumpet-shaped flowers are mostly pollinated by flies and lepidopterans (moths and butterflies).

**Ease of agronomic seed increase:** Difficult. Plants are annuals and must be established every year. The seeds have a long maturation period and shatter readily, requiring the use of weed fabric to harvest worthwhile amount of seed.



**Ease of wild seed collection:** Difficult. Seeds mature at variable times on each plant and when mature, are expelled from the capsule.

Plants are somewhat showy when in flower, but are short-statured and may be difficult to locate among other vegetation.

**Native distribution/Habitat:** This species is native to western North America from northwestern Canada, south to Mexico, as well as parts of South America and the Midwest. It grows in ditches, stream banks, open grassy places, forests, seeps, springs, and moist soils. Found in full sun to part shade from sea level to 10,000 ft.

**Seeds per pound:** 300,000–400,000

**Establishment:** Seeds germinate in cool temperatures and naturally germinate in late



winter to early spring. For best establishment, sow seeds in containers outside in late fall, and then move to a greenhouse in late winter after germination occurs. In the spring, transplant into a field covered with weed fabric containing holes on 1 ft by 1 ft spacing. Seeds can also be sown directly into holes in the weed fabric in late fall to early spring. Place 10–20 seeds per hole (2–3 pounds per acre) and cover them lightly with soil or vermiculite. If late spring moisture is not limiting, direct-seeded plants will be as vigorous and large as transplants.

**Establishment rating:** Medium. Most reliable from plugs, but can be successfully established by direct sowing.

**Weed control:** Weed fabric excludes most weeds, but hand weeding may be needed where the soil is exposed within the holes in the fabric. Borders need to be kept clean using herbicides or tillage. Weed fabric can catch wind-borne seeds, or seeds that are ejected from many feet away. Reducing these types of weeds from the seed production area will prevent weed seeds from contaminating the seed crop.

**Fertilization:** Transplants are usually supplied with sufficient nutrients from a controlled-release fertilizer in the potting mix. Directly-sown plants may benefit from a balanced fertilizer in the spring as they begin to grow rapidly, usually in mid-March in the Willamette Valley.



**Pests:** Foliar pathogens such as powdery mildew can destroy plants and limit seed production.

**Harvest:** When seed dispersal has ended for the season, vacuum or sweep seeds from the fabric. A large amount of seed may have collected in the holes and can be vacuumed out. If plants are very dense, they may need to be pulled out before sweeping or vacuuming. Seeds contain

a gelatinous coating that glues them to the weed fabric when wet; harvest prior to summer rainstorms to keep seeds from adhering. If seeds do become stuck to the fabric, they can be scraped off.

**Post-harvest residue management:** As an annual, crop aftermath and standing stubble can be left on the field after harvest.

**Seed cleaning:** Since only the seeds and capsules are harvested, there is no need for threshing. Seeds can easily be cleaned using a small air-screen machine.

**Average yields/Stand longevity:** 100-500 pounds per acre. The yield for this species varies widely between 15 and 51 pounds per  $\frac{1}{10}$  acre plot depending on size of plants and harvest methods. Plants are annuals and usually self sow.





# PLECTRITIS CONGESTA

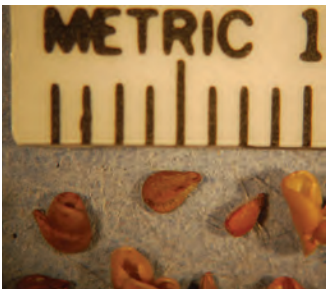
*shortspur seablush*

**Life form:** Annual forb

**Pollination:** Capable of self pollination. Pollinated by many small native bees, bumble bees, flies, and butterflies.

**Ease of agronomic seed increase:** Moderate. This species can be directly sown and mechanically harvested with moderate yields.

**Native distribution/Habitat:** Found in wet meadows, seeps, and rocky cliffs from southwestern British Columbia through California west of the Cascades at elevations below 6,300 ft.



**Ease of wild seed collection:** Difficult.

Seeds ripen variably and shatter when ripe. Plants are often small in the wild and difficult to locate when they are not flowering. Distribution is patchy and ephemeral. Seeds can be hand stripped from the plant or the plants can be shaken over a bag to dislodge the seed.

**Seeds per pound:** 1,300,000

**Establishment:** Seed lacks dormancy and germinates best in cool temperatures. Seeds naturally germinate in November. This species is easily established by direct sowing in the fall on the soil surface at a rate of 2 pounds per acre in rows that are 6–12 inches apart. The use of weed fabric as a seed collector can greatly increase yields. Seeds can be sown September through



February into holes cut in the weed fabric on 1 ft by 1 ft spacing at a rate of 10 seeds per hole (approximately 0.7 pound of seed per acre). This species is active in cold temperatures and will grow steadily throughout the winter. Earlier sowing will result in larger plants at flowering time, which will increase yields.

**Establishment rating:** High from direct seeding, medium from plugs.

**Weed control:** No herbicides are labeled for use on this crop. Hand weeding, spot spraying, and row tillage are weed control options. Seeding into a weed-free seed bed is important for this annual crop. Seeding into weed fabric excludes most weeds, but hand weeding is needed where soil is exposed. Weed seeds may blow or shatter onto weed fabric, so field borders need to be kept clean.

**Fertilization:** Depending on soil fertility, a light application of a balanced fertilizer in late winter/early spring may improve yields.

**Pests:** Seedlings must be protected from slugs.

**Harvest:** Seeds ripen variably and shatter when mature. For large fields without weed fabric, the plants can be directly combined when the majority of seed is mature on the plants. Seeds will not continue to ripen after they are harvested. Fields with weed fabric should be swept or vacuumed after all seeds have fallen from the plants. The



**Average yields/Stand longevity:** 200-1,000 pounds per acre. Yields vary greatly depending on field conditions and harvest method. This species generally self-sows.



plants may need to be agitated to release all the seeds.

**Post-harvest residue management:** As an annual, residual plant stems can be mowed off, or if left, will decay over the winter.

**Seed cleaning:** This species can produce seeds of two different shapes. One is a simple teardrop shape and the other is a teardrop with large, curled wings. This can complicate seed cleaning. Unfilled seed may be difficult to distinguish.





# POTENTILLA GLANDULOSA

*sticky cinquefoil*

**Life form:** Perennial forb

**Pollination:** Plants are capable of self pollination and out-crossing, and are highly insect pollinated. Flowers attract a wide variety of small native bees, flies, wasps and beetles.

**Ease of agronomic seed increase:** Moderate. Best established by plugs, but once established, plants are hardy and extremely productive. Fields can be mechanically harvested and seeds are easy to clean.



**Native distribution/  
Habitat:** Sticky cinquefoil occurs from Alberta and British Columbia to California, Arizona, New Mexico, and northern Baja California, and east to South Dakota. This

species can be found on moist soils in grasslands, meadows, and in the sagebrush desert, or in moist, open woodlands below an elevation of 12,000 ft.

**Ease of wild seed collection:** Moderate. This species has variable ripening and low seed retention, but is usually easy to find and collect. Many *Potentilla* species look similar at the time of seed collection, so species identification in the wild should occur while plants are flowering.

**Seeds per pound:** 1,135,000

**Establishment:** Seeds are dormant and usually need a cold-moist period of at least 70 days to break dormancy before they will germinate in the



spring. Seeds germinate in warm temperatures. Because seedlings are very small, grow slowly in their first year, and are easily overcome by weeds, this species is best established from plugs. Grow plugs over winter in a heated greenhouse and transplant out into fields on 2-ft by 1-ft spacing in the spring. If direct sowing, seeds should be sown in fall as shallowly as possible (1/8th inch or less) at a rate of 4 pounds per acre (100 seeds per square foot) in rows 10–14 inches apart.

**Establishment rating:** Medium from plugs, but very low from direct seeding.

**Weed control:** There are no herbicides labeled for use on *Potentilla* when grown for seed. Therefore, good reduction in the weed seed bank and field preparation is important. This species is much more competitive with weeds if established from transplants. Hand hoeing, herbicide spot treatments, and row tillage are weed control options.

**Fertilization:** Plants are competitive in low nutrient environments; however, seed production will increase with a spring application of a balanced fertilizer (15-15-15). Do not apply fertilizer until weeds have been controlled.

**Pests:** None observed.

**Harvest:** Seeds ripen in small upright capsules and remain in the capsules if they are undisturbed. Ripening is moderately uniform. Flower stalks are



usually dry and brown when seeds are ripe and can easily be directly combined or cut with a modified swather (one that cuts and collects the material at the same time). A traditional swather is not advised for this species because seeds would spill out of the capsules and onto the ground when swathed.

**Post-harvest residue management:** Harvest techniques usually remove the residue, but if a large amount of material is still present after harvest, plants can be mowed to a height of six inches. Take care not to damage the crown by low mowing.

**Seed cleaning:** Cut material can be threshed or stationary combined after drying. After threshing or combining, the seeds are very easy to clean using an air-screen machine.

**Average yields/Stand longevity:** 100–500 pounds per acre. Yields are variable depending on harvest methods and stand condition. Plants may not flower their first growing season, but yields will steadily increase in future years, peaking around year three or four. Production generally remains high for at least five years.





# PRUNELLA VULGARIS

*common self-heal*



**Life form:** Perennial forb

**Pollination:** Capable of self-pollinating as well as out-crossing; does not require insects for pollination. Visited by many types of small native bees such as sweat bees and mining bees, as well as bumble bees, wasps, hover flies, and butterflies.

**Ease of agronomic seed increase:** Moderate to easy. Fields can easily be established by direct seeding and can be harvested mechanically. Weed control can be problematic.



**Native distribution/  
Habitat:** Lance selfheal is native to North America and its distribution is circumboreal. Usually

associated with disturbance, it is found in moist areas including meadows, pastures, forest openings, roadsides, and lawns at elevations below 8,000 ft.

**Ease of wild seed collection:** Easy. This species is usually easy to locate and seeds do not shatter when ripe. Inflorescences can be cut and placed in paper bags to dry. This species can be easily confused with the non-native, weedy *Prunella vulgaris ssp. vulgaris*.

**Seeds per pound:** 400,000

**Establishment:** Seeds are not dormant and can be sown in spring or fall. Fall sowing is recommended since germination can occur in the fall if temperatures are sufficiently warm. A rate of 4–5 pounds per acre (50 seeds per square foot) using a seed drill set at a depth of  $\frac{1}{8}$  inch or less will produce a decent stand. Row spacing should range between 12 to 24 inches. Plugs can also be used to establish seed increase fields. Seeds should be sown into containers in mid-winter and grown in a greenhouse. Plants should be transplanted into fields in early spring.

**Establishment rating:** High from plugs, medium when directly sown.

**Weed control:** There are no herbicides labeled for use on lance selfheal when grown for seed. Therefore, good reduction in the weed seed bank and seedbed preparation is important. Fortunately, because of its rapid spring growth, this species can be quite competitive with weeds. Hand hoeing, herbicide spot treatments, and row tillage are options.

**Fertilization:** This short-lived crop usually doesn't require additional fertilizer.

**Pests:** Slugs can be damaging to seedlings.

**Harvest:** Seeds remain in flower spike when mature, and ripening is moderately uniform. Flower stalks are usually dry and brown when seeds are ripe and can easily be directly combined



or cut with a modified swather (one that cuts and collects the material at the same time). A traditional swather is not advised for this species because seeds would spill out of the capsules and onto the ground when swathed.

**Post-harvest residue management:** Plants usually behave as biennials in seed production fields and will not survive after harvest. However, some fields survive the winter after harvest

and produce a fair amount of seed the following growing season.

**Seed cleaning:** Cut material can be threshed or stationary combined after drying. A thresher or hammermill can be used to release the seeds from the plant material. An air-screen machine can be used to screen out debris, weeds, and empty seeds.

**Average yields/Stand longevity:** 100–300 pounds per acre. Fields often only produce one crop. Fields usually do not flower in the first year, even when using transplants. A large crop is produced in year two. Some fields survive and produce a crop in year three.





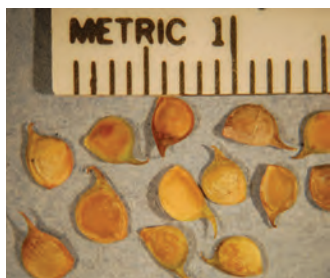
# RANUNCULUS OCCIDENTALIS

*western buttercup*

**Life form:** Perennial forb

**Pollination:** Pollinated by native sweat bees and mining bees, as well as mason bees, cuckoo bees, bumble bees, and hover flies.

**Ease of agronomic seed increase:** Moderate. Plants are easily established by direct seeding, although they tend to be short-lived. Harvesting can be difficult due to very low seed retention and variable maturation.



**Native distribution/  
Habitat:** Western buttercup is found from Alaska south to California in a variety of habitats from coastal prairies and bluffs to disturbed areas, meadows, and forested areas. This species prefers

seasonally moist soils from sea level to 7,200 ft.

**Ease of wild seed collection:** Moderate. Plants can easily be found in large stands, but they are often intermingled with other species making collection difficult. Seeds shatter easily from plants when agitated. Seed is easily stripped from plants by hand and placed in paper bags to dry.

**Seeds per pound:** 200,000

**Establishment:** Seeds are not dormant, and germinate best in cool temperatures in late fall. Sow seeds 1/8th to 1/4 inch deep at a rate of 6–7 pounds per acre (40 seeds per square foot) in rows 10–14 inches apart. For highest yields sow seeds on 1 ft by 1 ft spacing into fields covered



with weed fabric to aid in harvest.

**Establishment rating:** High. Seedlings germinate 4 to 6 weeks after fall planting, grow throughout winter, and begin flowering and producing seed the first spring.

**Weed control:** There are no herbicides labeled for use on this crop. Hand hoeing, spot treatments with a nonselective herbicide, and row tillage are weed control options.

**Fertilization:** A balanced fertilizer (15-15-15) is recommended when the field is well established and weeds have been controlled.

**Pests:** None observed.

**Harvest:** For fields without weed fabric, a flail vac seed harvester is the most efficient harvest method. It will strip green, unripe seed as well as ripe ones, so choose a harvest time that will yield the highest amount of ripe seed. If growing plants on weed fabric, vacuum or sweep seeds from the fabric when seed dispersal has ended for the season. A large amount of seed may have collected in the holes and can be vacuumed out.

**Post-harvest residue management:** Flail mowing in late summer (early September) may improve field vigor and aid with weed control the following year.



**Seed cleaning:** An air-screen machine is used to separate seed from other organic debris. This species is easy to clean.

**Average yields/Stand longevity:** 50–100 pounds per acre. Fields with weed fabric will have the highest yields.





# RUPERTIA PHYSODES

*forest scurfpea*

**Life form:** Deciduous rhizomatous perennial legume

**Pollination:** Pollinated by small native insects and bumblebees.

**Ease of agronomic seed increase:** Moderately difficult. Plants are hardy and long lived once established. Plugs usually will not flower until their second summer. Seeds ripen unevenly and fall from the plants as they are mature. Weed fabric is needed to obtain a worthwhile amount of seed.



**Native distribution/  
Habitat:** Forest scurfpea is found from British Columbia south to California and east to Idaho. This species is

found in open woods and prairies up to 7,500 ft.

**Ease of wild seed collection:** Difficult. This species can be found in dense stands, but seed readily shatters if plants are agitated. Seeds ripen unevenly over a period of a couple weeks. Seeds can be stripped by hand from the plants and placed in paper bags to dry.

**Seeds per pound:** 20,000–30,000

**Establishment:** Seeds are not dormant, but usually benefit from scarification to hasten germination in spring. For best establishment, sow scarified seeds in containers placed in a greenhouse in late winter and transplant plugs out



in spring into a field covered with weed fabric containing holes on 1 ft by 2 ft spacing. Scarified seeds can also be directly sown into holes in weed fabric in the spring. Place 10 seeds per hole (15–20 pounds per acre) and cover them lightly with soil or vermiculite. Seedlings will germinate in the spring and grow slowly when soils are moist. Plants are drought tolerant and usually enter dormancy when soils become dry.

**Establishment rating:** Low. Plugs are preferred, but have only moderate survival. Direct sowing can be moderately successful if pests are controlled, but plants grow slowly.

**Weed control:** Weed fabric excludes most weeds, but hand weeding may be needed where the soil is exposed within the holes in the fabric. Borders need to be kept clean using herbicides or tillage. Weed fabric can catch wind-borne seeds or seeds that are ejected from many feet away. Reducing these types of weeds from the seed production area will prevent weed seeds from contaminating the seed crop.

**Fertilization:** Plants may benefit from an every other year application of a balanced fertilizer such as 16-16-16 in spring.

**Pests:** Slugs eat seedlings as they emerge; rodents eat and stash seeds.





**Harvest:** When seed dispersal has ended for the season, vacuum or sweep seeds from the fabric. A large amount of seed may have collected in the holes and can be vacuumed out. If plants are very dense, they may need to be cut away before sweeping or vacuuming.

**Post-harvest residue management:** If plants are not cut back during harvest, allow stems to naturally senesce and remove before new growth emerges in early April. Weed fabric may have to be cut away from the expanding crowns to allow

room for growth and keep stems growing on top of the fabric.

**Seed cleaning:** Plant material may need to be fed through a thresher or stationary combine to dislodge the seeds from the pod. Seeds can be damaged easily, so exercise care when using seed cleaning machines. An air-screen machine should be used to separate dried plant material from good seed.

**Average yields/Stand longevity:** 50–400 pounds per acre. When grown from plugs, this species can flower and produce seed in its first year. Plants continue to grow larger and have steadily increasing yields in subsequent years. A 1/10th acre plot produced 5, 10, 21, and 32 lbs in years one through four, respectively. Plants are very long-lived, remaining productive at least 10 years.

**Remarks:** Plants have a deep woody taproot that can be mildly persistent and difficult to remove when seed production plots are to be retired. This species does not self-sow and is not considered weedy.





# SAXIFRAGA OREGANA

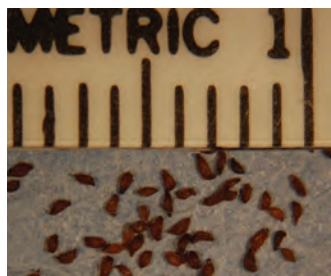
*Oregon saxifrage*

**Life form:** Perennial forb

**Pollination:** Pollinated by a variety of small native flies and wasps, as well as mason bees and sweat bees.

**Ease of agronomic seed increase:** Difficult. Plants need to be established using plugs and usually will not flower until their second summer, but are long-lived once established. Seeds ripen unevenly and shatter from the plants as they

mature, so weed fabric is needed to obtain a worthwhile amount of seed.



**Native distribution/  
Habitat:**

Found in wet prairies and moist meadows, seasonally wet soils, and vernal pools

throughout the Pacific Northwest.

**Ease of wild seed collection:** Moderate. Plants flower in mid-spring and are generally easy to locate. It can be difficult to collect a large amount of this tiny seed as seeds shatter easily when mature and seed maturation is highly variable among plants. Entire stalks can be cut and placed in paper bags to dry.

**Seeds per pound:** 14,000,000–15,000,000

**Establishment:** Seeds germinate best when exposed to late summer/early fall temperatures. Seed germinates after 2 weeks exposure to warm temperatures (above 65°F) followed by cool



temperatures (below 50°F). Seeds are very small and seedlings grow slowly. For best establishment, sow seeds in containers placed outside in early September until germination occurs. Then move containers into greenhouse to grow throughout the winter. In spring, transplant into a field covered with weed fabric containing holes on 1- by 1-ft spacing. Plants grow vigorously in the cool, wet fall and winter months and bloom in early spring. Direct seeding is not recommended for this species. If attempted, seeds should be sown early in the fall to allow for natural stratification (warm plus cold). Sow on the surface or up to 1/8 of an inch deep at a rate of 1-2 pounds per acre (100 seeds per square foot) in rows 12–18 inches apart unless larger row spacing is needed for between row cultivation.

**Establishment rating:** Low to medium. Plants grow slowly and can be difficult to transplant.

**Weed control:** Weed fabric excludes most weeds, but hand weeding may be needed where the soil is exposed within the holes in the fabric. Borders need to be kept clean using herbicides or tillage. Weed fabric can catch wind-borne seeds or seeds that are ejected from many feet away. Reducing these types of weeds from the seed production area will prevent weed seeds from contaminating the seed crop. Oregon saxifrage plants bloom in spring and must be weeded before flower stalks emerge. The tall, fragile stalks make weeding this species a challenge.



**Fertilization:** A balanced fertilizer (15-15-15) is recommended.

**Pests:** None observed.

**Harvest:** Seed heads ripen unevenly; individual stalks may be harvested by hand once the majority of the seed is ripe. For highest yields, vacuum seed from the weed fabric once all stalks have been harvested.

**Post-harvest residue management:** Plants go dormant in mid- to late summer. Holes in the weed fabric should be cut larger to accommodate plant crowns in the fall as they begin to grow again following their summer dormancy.

**Seed cleaning:** A brush machine or stationary thresher will remove seeds from seed heads. Follow with a small air-screen machine to separate seed from other organic material. Seed is very small and it can be difficult to distinguish between filled and unfilled seed.

**Average yields/Stand longevity:** 30–100 pounds per acre. Yields vary year to year based on harvest method and early spring weather. Plants produce many small corms around the base, forming a large clump of plants. This species can take a long time to become established, but is long-lived and productive for over five years.





# SIDALCEA CAMPESTRIS

*meadow checkerbloom*

**Life form:** Perennial forb

**Pollination:** Self or cross-pollination by bumble bees, sweat bees, and mining bees. Hybridization may occur among the different *Sidalcea* species, so it is necessary to isolate one species from another.

**Ease of agronomic seed increase:** Moderate. Plants establish well, are competitive with weeds, and will remain productive for many years

once established. The most difficult aspect of increasing seed of this species is harvesting due to inconsistent ripening and high seed shatter.

Fields can be established without weed fabric, but yields will be reduced and inconsistent.



**Native distribution/Habitat:** Meadow checkerbloom grows in meadows, grassy slopes, prairies, edges of woodlands and riparian areas, wetlands, and along roadsides throughout Oregon's Willamette Valley.

**Ease of wild seed collection:** Moderate. It may be possible to locate a large stand, but seeds mature and fall to the ground making wild collection largely impractical. Can be confused with other *Sidalcea* species.

**Seeds per pound:** 100,000

**Establishment:** Seeds are not dormant, but may benefit from scarification. Seeds sown in the



fall will germinate naturally in late winter to early spring. This species is most successfully established from transplanted plugs on 2ft by 3ft spacing in the fall or spring. Transplanting plugs creates cleaner fields and results in an established productive field in the first growing season. If direct seeding, sow at a depth of ¼ to ½-inch in the fall or spring at a rate of 4–6 pounds per acre (approximately 30 seeds per square foot). Establish fields on 24–36 inch row spacing. For smaller plots, it is beneficial to plant into weed fabric which will aid in harvest and weed control. Larger plots may be grown without fabric, but yields may suffer.

**Establishment rating:** Low to medium from direct seeding, high from plugs.

**Weed control:** There are no herbicides labeled for use on this crop. Hand hoeing, spot treatments with a nonselective herbicide, and row tillage are other options. If weed fabric is used it can exclude most weeds, but hand weeding may be needed where the soil is exposed within the holes in the fabric. Borders need to be kept clean using herbicides or tillage. Weed fabric can catch wind-borne seeds or seeds that are ejected from many feet away. Reducing these types of weeds from the seed production area will prevent weed seeds from contaminating the seed crop.

**Fertilization:** Plants respond well to additional nitrogen. Plants that were fertilized with 50 lbs/acre N in the spring had a longer bloom time and much higher rates of filled seed.



**Pests:** Seed weevils can decimate yields. Leaf rust and vole, mouse, and rabbit predation can be very detrimental to other *Sidalcea* species, but do not seem to affect this one.

**Harvest:** Plants typically have highly variable seed maturation. It is very common to find plants that have flower buds, open flowers, immature seed, and seed that has already shattered. For highest yields, direct combine fields with weed fabric when latest maturing seed is in hard dough stage. Very tall plants may be difficult to direct combine. After combining, use a flail-vac harvester to sweep up all the seed remaining on the weed fabric. It can be difficult to determine an optimal harvest time for fields not grown on weed fabric; directly

combine the field when the peak amount of seed is between soft dough and hard dough stage. Dry all material on tarps after harvest.

**Post-harvest residue management:** Direct combining doubles as mowing the field. During harvest, straw materials and debris from the back of the combine should be collected on a tarp and removed from the field or flail-chopped to prevent plant smothering and allow access to seed on the weed fabric. Weed fabric may have to be cut away from the expanding crowns on a yearly basis to allow room for growth and keep stems growing on top of the fabric.

**Seed cleaning:** Harvesting with a combine will separate seed from most other plant material. In lieu of combining (for smaller plots), a thresher would provide the same service. Seeds are then sent through an air-screen machine to separate remaining plant debris from seed. Some seed lots contain a high amount of unfilled seed, so be sure to check inside the hulls for seed fill.

**Average yields/Stand longevity:** 200–400 pounds per acre. Fields typically produce a crop the first year if established from plugs, but yields usually peak between years two and three, and are maintained for many years. Plants can become very large and remain productive for over five years.





# SIDALCEA NELSONIANA

*Nelson's checkerbloom*

**Life form:** Rhizomatous perennial forb

**Pollination:** Capible of self- and cross-pollination. Pollinated by native bumble bees and long-horned bees, as well as hover flies, wasps, and butterflies. Hybridization may occur among the different *Sidalcea* species, so it is necessary to isolate one species from another.

**Ease of agronomic seed increase:** Moderate.

Plants establish well, are competitive with

weeds, and will remain productive for many years once established.

The most difficult aspect of increasing seed of this species is harvesting due to inconsistent ripening and high seed shatter.

Fields can be established

without weed fabric, but yields will be reduced and inconsistent.

**Native distribution/Habitat:** Found in low to mid-elevations from southwest Washington throughout western Oregon interior valleys and foothills. Usually found on fields, roadsides, grassy hillsides, and lower mountains.

**Ease of wild seed collection:** Moderate. It may be possible to locate a large stand, but seeds readily fall to the ground when mature, making wild collection largely impractical. Can be confused with other *Sidalcea* species.

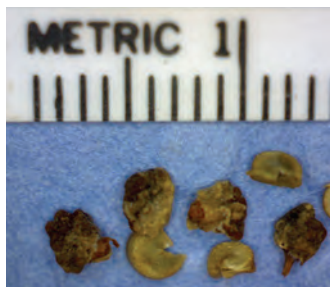
**Seeds per pound:** 100,000–150,000



**Establishment:** Seeds are not dormant, but may benefit from scarification. Seeds sown in the fall will germinate naturally in late fall to late winter. This species is most successfully established from transplanted plugs in the fall or spring. Transplanting plugs creates cleaner fields and results in an established productive field in the first growing season. If direct seeding, sow at a depth of 1/4–1/2 inch in the fall or spring at a rate of 4–6 pounds per acre (approximately 30 seeds per square foot). Establish fields on 24- to 36-inch row spacing. For smaller plots, it is beneficial to plant on 2 ft by 3 ft spacing into weed fabric which will aid in harvest and weed control. Larger plots may be grown without fabric, but yields may suffer.

**Establishment rating:** Medium, from plugs. Plants are hearty and can tolerate adverse conditions and flourish under stress.

**Weed control:** There are no herbicides labeled for use on this crop. Hand hoeing, spot treatments with a nonselective herbicide, and row tillage are weed control options. If weed fabric is used it can exclude most weeds, but hand weeding may be needed where the soil is exposed within the holes in the fabric. Borders need to be kept clean using herbicides or tillage. Weed fabric can catch wind-borne seeds or seeds that are ejected from many feet away. Reducing these types of weeds from the seed production area will prevent weed seeds from contaminating the seed crop.





**Fertilization:** Plants respond well to additional nitrogen. Plants that were fertilized with 50 lbs/acre N in the spring had a longer bloom time and much higher rates of filled seed.

**Pests:** Seed weevils can decimate yields. Vole, mouse, and rabbit predation, and leaf rust can also be very detrimental to this species.

**Harvest:** This species has highly variable seed maturation. It is very common to find plants that have flower buds, open flowers, immature seed, and seed that has already shattered. It can be difficult to determine an optimal harvest time if harvesting a field that does not have weed fabric. For highest yields, direct combine fields with weed fabric when latest maturing seed is in

hard dough stage. After combining, use a flail-vac harvester to sweep up all the seed remaining on the weed fabric. In fields without weed fabric, direct combine when the peak amount of seed is between soft dough and hard dough stage. Dry all material on tarps after harvest.

**Post-harvest residue management:** Direct combining doubles as a mowing of the field. During harvest, straw materials and debris from the back of the combine should be collected on a tarp and removed from the field or flail-chopped to prevent plant smothering and allow access to seed on the weed fabric. Weed fabric may have to be cut away from the expanding crowns on a yearly basis to allow room for growth and keep stems growing on top of the fabric.

**Seed cleaning:** Harvesting with a combine will separate seed from most other plant material. In lieu of combining (for smaller plots), a thresher would provide the same service. Seeds are then sent through an air-screen machine to separate remaining plant debris from seed. Some seed lots contain a high amount of unfilled seed, be sure to check inside the hulls for seed fill.

**Average yields/ Field longevity:** 130–270 pounds per acre. Fields typically produce a crop the first year if established from plugs, but yields usually peak between years two and three, and are maintained for many years. Plants remain productive for over five years.





# SIDALCEA VIRGATA

*rose checkermallow*

**Life form:** Rhizomatous perennial forb

**Pollination:** Capible of self- or cross-pollination. Pollinators include native bumble bees, sweat bees, long-horned bees, mason bees, cuckoo bees, hover flies, wasps, and butterflies. Hybridization may occur among the different *Sidalcea* species, so it is necessary to isolate one species from another.

**Ease of agronomic seed increase:** Moderate.

Plants establish well, are competitive with weeds, and will remain productive for many years once established. The most difficult aspect of increasing seed of this species is harvesting due to inconsistent ripening and high seed shatter.

Fields can be established without weed fabric, but yields will be reduced and inconsistent.

**Native distribution/ Habitat:** Found in low to mid elevations from southwest Washington throughout western Oregon interior valleys and foothills. Usually found on fields, roadsides, grassy hillsides, and lower mountains.

**Ease of wild seed collection:** Moderate. It may be possible to locate a large stand, but seeds mature and fall to the ground making wild collection largely impractical. Can be confused with other *Sidalcea* species.

**Seeds per pound:** 100,000–150,000



**Establishment:** Seeds are not dormant, but may benefit from scarification. Seeds sown in the fall will germinate naturally in late fall to late winter. This species is most successfully established from transplanted plugs in the fall or spring. Transplanting plugs creates cleaner fields and results in an established productive field in the first growing season. If direct seeding, sow at a depth of  $\frac{1}{4}$  to  $\frac{1}{2}$  inch in the fall or spring at a rate of 4–6 pounds per acre (approximately 30 seeds per square foot). Establish fields on 24–36 inch row spacing. For smaller plots, it is beneficial to plant into weed fabric on 2 ft by 3 foot spacing which will aid in harvest and weed control. Larger plots may be grown without fabric, but yields may suffer.

**Establishment rating:** Low to medium from direct seeding, high from plugs.

**Weed control:** There are no herbicides labeled for use on this crop. Hand hoeing, spot treatments with a nonselective herbicide, and row tillage are weed control options. If weed fabric is used it can exclude most weeds, but hand weeding may be needed where the soil is exposed within the holes in the fabric. Borders need to be kept clean using herbicides or tillage. Weed fabric can catch wind-borne seeds or those ejected from many feet away. Reducing these types of weeds from the seed production area will prevent weed seeds from contaminating the seed crop.

**Fertilization:** Depending on soil conditions, plants respond well to additional nitrogen. Plants that



were fertilized with 50 lbs/acre N in the spring had a longer bloom time and contained much higher rates of filled seed. In older fields, fall applications of fertilizer greatly improved spring vigor and increased yields. Fields that were older than five years, maintained high yields when fertilized with 50lbs/acre N in the fall and 50 lbs per acre of a balanced fertilizer (16-16-16) in the spring.

**Pests:** Seed weevils can decimate yields. Vole, mouse, and rabbit predation, and leaf rust can be very detrimental to this species.

**Harvest:** Plants have highly variable seed maturation. It is very common to find plants that have flower buds, open flowers, immature seed, and seed that has already shattered. It can be difficult to determine an optimal harvest time if harvesting a field that does not have weed

fabric. For highest yields, direct combine fields with weed fabric when latest maturing seed is in hard dough stage. After combining, use a flail-vac harvester to sweep up all the seed remaining on the weed fabric. In fields without weed fabric, direct combine when most of seed is between soft dough and hard dough stage. Dry all material on tarps after harvest.

**Post-harvest residue management:** Direct combining doubles as a mowing of the field. During harvest, straw materials and debris from the back of the combine should be collected on a tarp and removed from the field or flail-chopped to prevent plant smothering and allow access to seed on the weed fabric. Weed fabric may have to be cut away from the expanding crowns on a yearly basis to allow room for growth and keep stems growing on top of the fabric.

**Seed cleaning:** Harvesting with a combine will separate seed from most other plant material. In lieu of combining (for smaller plots), a thresher would provide the same service. Seeds are then sent through an air-screen machine to separate remaining plant debris from seed. Some seed lots contain a high amount of unfilled seed, so be sure to check inside the hulls for seed fill.

**Average yields/ Field longevity:** 130–270 pounds per acre. Fields typically produce a crop the first year if established from plugs, but yields usually peak between years two and three, and are maintained for many years. Plants remain productive for over five years.





# SISYRINCHIUM HITCHCOCKII

*Hitchcock's blue-eyed grass*

**Life form:** Perennial forbs

**Pollination:** These species all require out-crossing for adequate seed set. Pollination is by solitary bees.

**Ease of agronomic seed increase:** Moderate. Harvesting is easy using a machine that both swaths and collects the plant material at the same time. When grown on weed fabric, seeds that have shattered prior to harvest can be recovered by vacuuming, and competition from weeds is minimal.



**Native distribution/**

**Habitat:** These species are found in moist meadows and the edges of wetlands, in a range of elevations, but mostly

in subalpine climates and east-side forests. *Sisyrinchium idahoense* is very common and found throughout the western United States and Canada. *S. bellum* is common in southern Oregon on both sides of the Cascades, and California. *S. hitchcockii* is found in a narrow range from northern California to western Oregon and south central Washington along the Columbia River.

**Ease of wild seed collection:** Moderate. Seed retention is fair and plants mature relatively uniformly. Plants are moderately easy to find and harvest in fair amounts. If caught too late, seed may shatter and be unavailable.

**Seeds per pound:** 250,000–350,000 (seeds of all three species are about the same size)



**Establishment:** Seeds are dormant and need to experience warm early fall temperatures followed by cold winter temperatures to initiate germination in early spring as soils warm (*S. hitchcockii* does not need a warm treatment prior to a cold treatment to break dormancy). It is recommended to establish fields from plugs to avoid competition from weeds and the need for irrigation. To overcome seed dormancy, sow seeds in containers and place in a warm location for 2 to 4 weeks, and then move containers to a cold location (45°F or lower) for at least 8 weeks. Alternately, containers can be placed outside from early September through December. Move containers to a greenhouse set between 50 and 60°F in late December. Seeds should germinate within 2–4 weeks. Temperatures warmer than 65°F can halt germination. Greenhouse temperatures can be raised after seeds have germinated. Maintain plugs in a greenhouse over the winter, and in spring transplant out into fields covered with weed fabric on 1-ft by 1-ft spacing. Transplanting plugs creates cleaner fields and results in an established productive field in the first growing season. These species can be established by direct sowing in early fall, but it is not recommended for seed production fields. For direct seeding into a field, seeds should be sown at a rate of 60 seeds per square foot, or 6–7 pounds per acre. Sow as shallowly as possible (surface to 1/8th inch) in rows 10–14 inches apart.

**Establishment rating:** High from plugs.



**Weed control:** Weed fabric excludes most weeds, but hand weeding may be needed where the soil is exposed within the holes in the fabric. Borders need to be kept clean using herbicides or tillage. Weed fabric can catch wind-borne seeds or those ejected from many feet away. Reducing these types of weeds from the seed production area will prevent weed seeds from contaminating the seed crop.

**Fertilization:** A balanced fertilizer (15-15-15) is recommended for this species.

**Pests:** None observed.

**Harvest:** This species can easily be harvested using a modified swather or any machine that can cut and collect material at the same time. As capsules open, seed will fall out. If using weed fabric, cut field as the latest seeds are maturing.

Seeds that have shattered onto the weed fabric may be swept up using a flail-vac seed stripper or vacuumed from the fabric. If not using weed fabric, harvest field when the most seeds are mature but have not shattered. Material should be placed on tarps to dry completely prior to cleaning.

**Post-harvest residue management:** Harvest methods usually remove standing plant material, so no other management is needed. If using weed fabric, it may need to be cut in year two to allow for expansion of crowns as they grow in the spring.

**Seed cleaning:** A stationary combine or thresher works well to break seeds free from capsules. Follow with an air-screen machine to separate chaff from seed. The round seeds are relatively heavy and easily separated from other debris.

**Average yields/Stand longevity:** 10–700 pounds per acre. First year harvests are usually minimal at around 10 lbs/acre. Yields steadily increase in years two and three, reaching up to 700 lbs/acre depending on harvest method and use of weed fabric. Plants are long-lived, remaining highly productive after five years.

**Remarks:** The PMC has also worked with two other similar species: *Sisyrinchium bellum* and *Sisyrinchium idahoensis*. Seed production techniques are identical for all three species unless noted.





# SOLIDAGO CANADENSIS

*Canada goldenrod*

**Life form:** Rhizomatous perennial forb

**Pollination:** Obligate out-crosser, pollinated by various wasps, flies, small bees (especially sweat bees and mason bees), bumble bees, lady beetles, and butterflies.

**Ease of agronomic seed increase:** Moderately difficult. Seed increase fields are best established from plugs, but plants grow relatively fast and are vigorous once established. Harvesting

and cleaning seed can be difficult and time consuming and often requires specialized equipment.



**Native distribution/**

**Habitat:** Canada goldenrod is found across Canada and throughout

the United States. This species often grows in disturbed areas of fields and roadsides, meadows, thickets, bluffs, and forest openings or edges at low to middle elevations.

**Ease of wild seed collection:** Moderate. Seeds mature at variable times on each plant and within populations, so collecting a large amount of seed at one time can be challenging. Seed fill is often low and large amounts of material may need to be collected in order to obtain a useable amount of seed.

**Seeds per pound:** 4,600,000

**Establishment:** Seed is not dormant and germinates in warm to hot temperatures in



spring. Fields are best established from plugs to avoid competition from weeds and the need for irrigation for establishment in late spring/early summer. Plugs can be grown in a greenhouse over winter and transplanted out in the spring or grown outside over the summer and transplanted in the fall on 2-ft by 2-ft spacing. For direct seeding a field (not recommended), seeds should be surface sown in spring at a rate of 100 seeds per square foot, or 1 pound pure live seed per acre. Seedlings will emerge when soil has warmed sufficiently, but will grow very slowly throughout the first growing season.

**Establishment rating:** Medium, from plugs.

**Weed control:** There are no herbicides labeled for use on goldenrod when grown for seed. Therefore, good reduction in the weed seed bank and field preparation is important. Hand hoeing, herbicide spot treatments, and row tillage are options. Cultivation or herbicide treatments between rows can greatly reduce weed pressure. Goldenrod will spread via rhizomes and care should be taken not to damage expanding plants when cultivating.

**Fertilization:** Plants may benefit from fertilization every other year with a balanced fertilizer such as 16-16-16 in the spring.

**Pests:** Cucumber beetles are often observed in high numbers feeding on the plants, but they do not appear to significantly damage plants or affect seed yields.



**Harvest:** As seed matures, pappas expands and seeds fly away from the plants. Plants can flower for many weeks and fields often contain plants that have mature seed that is blowing away, open flowers, and flower buds. To maximize yields, all the early maturing seedheads are hand harvested multiple times. Once the plants reach peak maturity, they are seed stripped. The seed stripper appears to damage goldenrod flowers so should not be used when many flowers are present. However, it is a great method once the plants are mostly done flowering, but are still forming seeds. The machine does not seem to damage the plants or remove immature or “green” seed.

**Post-harvest residue management:** Mow the field as low as 2 inches in the fall or early spring with a flail chopper to remove residue.

**Seed cleaning:** Cleaning goldenrod seed is difficult and time consuming because the seeds contain pappas, which must be broken up using a brush machine before material will flow through seed cleaning machines. Once brushed, the material can be cleaned using an air-screen machine. Machines that contain trays of balls under the screen are very helpful in cleaning goldenrod. The balls bounce against the screen which helps sift the seeds from the fine pappas. It can be difficult to distinguish between filled versus unfilled seed and to clean this species to high rates of purity.

**Average yields/Stand longevity:** 180–400 pounds per acre. Yield varies depending on harvest method. If fields are established from plugs, plants will produce seed in the first growing season. Plants continue to expand year after year, and thus have steadily increasing yields. Fields at the Corvallis PMC have remained highly productive for over five years.

**Remarks:** Seed of this species will easily spread across nearby fields, but very few volunteer plants become established.





# SOLIDAGO SPATHULATA

*Mt. Albert goldenrod*

**Life form :** Rhizomatous perennial forb

**Pollination:** *Solidago* species are thought to be self-incompatible and must be cross-pollinated by insects to produce viable seed. They are pollinated by various wasps, flies, small bees (especially sweat bees and mason bees), bumble bees, lady beetles, and butterflies.

**Ease of agronomic seed increase:** Moderately difficult. Seed increase fields are best established from plugs, but plants grow relatively fast and are vigorous once established. Harvesting and cleaning seed can be difficult and time consuming and often requires specialized equipment.



**Native distribution/Habitat:** Native range is from Canada south to central California coast, and in mountains to Arizona and New Mexico. Plants grow on coastal sand dunes and open mountain slopes and valleys.

**Ease of wild seed collection:** Moderate. Seeds mature at variable times on each plant and within populations, so collecting a large amount of seed at one time can be challenging. Seed fill is often low and large amounts of material may need to be collected in order to obtain a useable amount of seed. Plants are low-growing, but tend to hold onto their seed once it is ripe unlike many other related aster species.

**Seeds per pound:** 2,000,000



**Establishment:** Seed is not dormant and germinates in warm to hot temperatures in spring. Fields are best established from plugs to avoid competition from weeds and the need for irrigation for establishment in late spring/early summer. Plugs can be grown in a greenhouse over winter and transplanted out in the spring or grown outside over the summer and transplanted in the fall on 2-ft by 1-ft spacing. For direct seeding into a field (not recommended), seeds should be surface sown at a rate of 1 to 2 pounds pure live seed per acre (45 to 90 seeds per square foot) in spring. Seedlings will emerge when soil has warmed sufficiently, but grow very slowly throughout the first growing season.

**Establishment rating:** Medium, when grown from plugs.

**Weed control:** There are no herbicides labeled for use on goldenrod when grown for seed. Therefore, good reduction in the weed seed bank and field preparation is important. Hand hoeing, herbicide spot treatments, and row tillage are options. Cultivation or herbicide treatments between rows can greatly reduce weed pressure. Dune goldenrod will spread via rhizomes in sandy soils and care should be taken to not damage expanding plants when cultivating.

**Fertilization:** Plants may benefit from fertilization every other year with a balanced fertilizer such as 16-16-16 in the spring.



**Pests:** Cucumber beetles are often observed in high numbers feeding on the plants, but they do not appear to significantly damage plants or affect seed yields.

**Harvest:** Seeds of Mt. Albert goldenrod do not ripen until fall. Weather can greatly affect seed maturity as well as harvesting. As seed matures, pappas expands and seeds can fly away from the plants, but this species has better seed retention than other goldenrod or aster species. Plants can flower for many weeks and can continue to flower into late fall. Seed increase fields will contain plants that have mature seed that is blowing away, flowers, and developing flowers. To maximize yields, all the early maturing seedheads are hand harvested multiple times. Once the plants reach peak maturity, they are seed stripped. The seed stripper appears to damage goldenrod flowers so should not be used when many flowers are present. However, it is a great method once the plants are mostly done flowering, but are still forming seeds. The machine does not seem to damage the plants or remove immature or “green” seed.

**Post-harvest residue management:** Mow in spring to 2-inch height with a flail chopper to remove residue.

**Seed cleaning:** Cleaning Mt. Albert goldenrod seed can be difficult and time consuming because the seeds contain pappas, which must be broken up using a brush machine before material will

flow through seed cleaning machines. Once brushed, the material can be cleaned using an air-screen machine. Machines that contain trays of balls under the screen are very helpful in cleaning goldenrod. The balls bounce against the screen which helps sift the seeds from the fine pappas. It can be difficult to clean this species to high rates of purity.

**Average yields/Stand longevity:** 10–150 pounds per acre. Yield varies depending on harvest method and fall weather. This species blooms and sets seed very late. Fall rains and cool temperatures can decrease flowering, pollination, and seed set. When established from plugs, plants will produce seed in the first growing season. Plants continue to expand between years one and three, but typically remain the same size in subsequent years. Plants appear to be moderately long-lived, remaining productive for at least five years.





# SYMPHYOTRICHUM CHILENSE

*Pacific aster*

**Life form:** Rhizomatous perennial forb

**Pollination:** Generally, asters are not self-compatible and require insects to assist in cross pollination. Pollinated by bumblebees, syrphid flies, wasps, various small bees, and long-horned bees, and many butterflies.

**Ease of agronomic seed increase:** Difficult, due to long period of bloom/seed ripening, seeds blowing away when ripe, and difficulty in cleaning fluffy seed.



**Native distribution/  
Habitat:** Open disturbed areas, grasslands, coastal scrub, salt marshes; full to partial sun; elevations below 1600 ft. *S. chilense* is found from Southern British Columbia through

California mostly in coastal areas.

**Ease of wild seed collection:** Moderate. Seeds ripen over a period of weeks to months, depending on fall weather. Seeds fly away when ripe. Plants are usually easy to identify and moderately easy to find.

**Seeds per pound:** 800,000–1,300,000

**Establishment:** Seed production fields are equally successful from direct seeding or plugs transplanted in the fall or spring. Seeds do not exhibit dormancy and require no pretreatment prior to sowing. If direct seeded, the target rate should be approximately 50 seeds per square foot, or 1.7–2.7 pounds per acre, at a depth of



no more than ¼ inch in rows that are 24-36 inches apart. Plugs can be transplanted into 24-inch rows at 12-inch spacing (depending on equipment).

**Establishment rating:** Medium from direct seeding, High from plugs.

**Weed control:** There are no herbicides labeled for use on this crop. Hand hoeing, spot treatments with a nonselective herbicide, and row tillage are other options. Yearly hoeing between the rows also helps maintain space between the plants.

**Fertilization:** This species is adapted to low nutrient environments. Over fertilizing will create large plants, but will not increase seed production. An application of balanced fertilizer at a rate of 50lbs of nitrogen per acre during the active growth phase of the plants is recommended annually, if needed.

**Pests:** None observed.

**Harvest:** Small fields can be harvested with a leaf blower used in reverse as a vacuum. Large fields can be harvested multiple times during a single growing season using a seed stripper to capture seed maturing at different times (from late Aug to late Oct); aster flowers are not damaged by the seed stripping machine. However, tractor tires can damage the plants by running over the same plants multiple times, so seed production fields should be established with “lanes” for the tractor tires. Care should be taken to avoid harvesting



during warm weather when there are a lot of pollinators on the plants, as they do not move out of the way of the seed stripper. If a field has to be harvested when pollinators are present, someone can walk in front of the seed stripper (at a safe distance) and try to herd the bees out of the field.

**Post-harvest residue management:** Plants should be allowed to naturally die back in the fall, then be mowed before spring growth emerges.

**Seed cleaning:** Fluff and seeds harvested with the leaf blower or seed stripper are placed on

tarps to dry, turning often to prevent molding. Run material through a brush machine to break the pappas from the seed, then through a large air screen machine (Crippen) with a lot of rubber balls to sift the seeds from the fuzz. A small air screen machine is then used for fine cleaning.

**Average yields/Stand longevity:** 80–250 pounds per acre. Fields will usually produce a small crop late in the first growing season. Subsequent years will have long bloom times (up to three months) and yields will depend on weather and harvest methods. If fields become crowded, tilling between rows can restore vigor and seed production.

**Remarks:** This species can become an established weed on some farms. Seeds can germinate on bare ground that is undisturbed in the spring. Surrounding the aster fields with grass seed production fields can limit the amount of the “weedy” asters, because these fields usually are sprayed with broadleaf herbicides. The PMC has also worked with *Symphyotrichum subspicatum* and found that seed production techniques are identical.





# SYMPHYOTRICHUM

## HALLII

*Hall's aster*



**Life form:** Rhizomatous perennial forb

**Pollination:** Generally, asters are not self-compatible and require insects to assist in cross pollination. Pollinated by bumblebees, long-horned bees, wasps, various flies, and butterflies.

**Ease of agronomic seed increase:** Seed is difficult to produce due to long period of bloom/seed ripening, fluffy seeds blowing away when ripe, and difficulty in cleaning fluffy seed.

slow growing and will not flower until the second growing season. When direct seeding, target rate should be approximately 50 seeds per square foot, or 2-3 pounds per acre, at a depth of no more than ¼ inch. Rows should be 24-36 inches apart.

**Establishment rating:** Easy to establish from plugs. Medium from directly seeding and may require a lot of hand weeding.

**Weed control:** There are no herbicides labeled for use on this crop. Hand hoeing, spot treatments with a nonselective herbicide, and row tillage are other options. Yearly hoeing between the rows also helps maintain space between the plants.

**Fertilization:** This species benefits from additional fertilization. Two applications of balanced fertilizer at a rate of 50 pounds of nitrogen per acre during the active growth phase (4 weeks apart) of the plants is recommended annually, if needed.

**Pests:** Leaf rusts can be a problem with this species. If plants are stressed by lack of nutrients, or extremely dry conditions, the rust infections can be severe enough to restrict seed production. Spittlebugs (*Clasirptora sp.*) have been noticed in high levels on fields, but do not seem to affect seed production or plant vigor.

**Harvest:** Small fields can be harvested with a leaf blower used in reverse as a vacuum. Large fields can be harvested multiple times during a single growing season using a seed stripper to capture



**Native distribution/  
Habitat:** Wetland prairies in interior valleys and floodplains of the Pacific Northwest; common in ground that is very wet in spring and dry in summer; sometimes in shrub swamps or wooded

wetlands.

**Ease of wild seed collection:** Moderate. Seeds ripen over a period of weeks to months, depending on fall weather. Seeds fly away when ripe. Plants are usually easy to identify and moderately easy to find.

**Seeds per pound:** 1,600,000- 1,800,000

**Establishment:** Seed production fields are best established using plugs transplanted in the fall or spring. Seeds do not exhibit dormancy and require no pretreatment prior to sowing. Plugs can be transplanted into 24-inch rows at 12-inch spacing (depending on equipment). Fields can be established by direct seeding, but plants are



seed maturing at different times (from late Aug to late Oct); aster flowers are not damaged by the seed stripping machine. However, tractor tires can damage the plants by running over the same plants multiple times, so seed production fields should be established with "lanes" for the tractor tires. Care should be taken to avoid harvesting during warm weather when there are a lot of pollinators on the plants, as they do not move out of the way of the seed stripper. If a field has to be harvested when pollinators are present, someone can walk in front of the seed stripper (at a safe distance) and try to herd the bees out of the field.

**Post-harvest residue management:** Plants should be allowed to naturally die back in the fall, then be mowed before spring growth emerges.

**Seed cleaning:** Fluff and seeds harvested with the leaf blower or seed stripper are placed on tarps in the greenhouse to dry, turning often to prevent molding. Run material through a brush machine to break the pappas from the seed, then through a large air screen machine (Crippen) with a lot of rubber balls to break up the fuzz balls. A small air screen machine is then used for fine cleaning.

**Average yields/Stand longevity:** 10-150 pounds per acre. Fields will usually produce a small crop late in the first growing season if grown from plugs. Subsequent years will have long bloom times (up to two months) and yields will depend on weather, plant vigor, and harvest methods. If fields become crowded, tilling between rows can restore vigor and seed production.

**Remarks:** This species is not a high seed producer. Seed production appears greatly tied to plant vigor.





# TRIFOLIUM WORMSKIOLDII

*sand clover*

**Life form:** Rhizomatous perennial legume.

**Ease of agronomic seed increase:** Moderate. Harvesting and cleaning are relatively simple for this species. However, a moderate establishment rating, and a need for weed control increase the difficulty of seed increase.

**Native distribution/Habitat:** This species occurs near streams, in meadows, and on coastal dunes at low to mid elevations from Alaska and western

British Columbia, south to California and Mexico, and from the coast, east to Wyoming, Colorado, and Texas.

**Seeds per pound:**  
348,000

## **Ease of wild seed**

**collection:** Easy. This species typically grows in dense patches in its native habitat. In addition, pods generally mature evenly, seed does not shatter and can be harvested easily by hand picking (gloves are recommended as mature fruit can be prickly).

**Establishment:** Seeds are not dormant but may benefit from scarification. This species is most successfully established from transplanted plugs in the fall or spring. Transplanting plugs creates cleaner fields and results in an established productive field in the first growing season. If direct seeding, sown at a depth of ¼-1/2" in the fall or spring at a rate of 4–6 pounds per acre. Establish fields on 12-18" row spacing. As plants grow together the height of the plants will



increase which will aid in harvesting.

**Establishment rating:** Moderate. Establishing fields from plugs is recommended. Plugs grow moderately and will produce seed their first growing season.

**Weed control:** Pre-emergent herbicides may be labeled for use on this crop. Weed control is performed by hand hoeing, herbicide spot treatments, and row tillage.

**Fertilization:** Fertilizer application coupled with tighter plant spacing can be beneficial with this species. These measures can cause the normally low growing plants to grow upwards rather than outwards, and increase seed yields from the harvest method discussed below.

**Pests:** No significant pests are associated with this species. Seed weevils are found in some clovers but have not been observed on this species.

**Harvest:** This species may require hand harvesting if the plants have not attained sufficient height for use of mechanized equipment. This may be the case in the first season following transplanting, or if the plants are widely spaced. If the plants are of sufficient height (approximately 6 inches), this species can easily be harvested using a flail-vac seed stripper. This species flowers and produces seed throughout the summer. A flail-vac harvester can be used multiple times to collect seed as it matures. Other harvest methods that require a



cleaned with an air-screen machine to separate stems, chaff, weed seeds, and empty seeds.

**Average yields/Stand longevity:** This species does flower and produce seed in the first year, producing approximately 20-40 pounds per acre. A significantly higher yield of 400-1000 pounds per acre can be expected in subsequent years depending on harvest methods and stand density.

**Remarks:** One of the most productive native legumes.

one-time cutting (swathing/combining, swathing/collecting on tarps to dry) will reduce yields, but can be performed if plants are of sufficient height.

**Post-harvest residue management:** None. Residue can be left on the field to decompose over the winter.

**Seed cleaning:** This species is dried on tarps in a covered area following harvest. When dry it is processed through a large brush machine to separate the seed from the heads. Then it can be





# VERONICA PEREGRINA

*neckweed*

**Life form:** Annual forb

**Pollination:** Primarily self-pollinated. Flowers are very small, non-showy, and are present very early in the season when few pollinators are flying.

**Ease of agronomic seed increase:** Difficult. This species is easy to harvest and clean on a small scale, but establishment takes a moderate amount of effort. Large scale seed increase on this species is not practical because of its low

growth habit. Seed ripens unevenly and shatters as it ripens. Seed production without weed fabric would not be feasible.



**Native distribution/  
Habitat:** *Veronica peregrina* is found throughout the United

States. It is usually found in disturbed habitats such as roadsides and fields, as well as moist areas, wet meadows, swamps, and stream banks.

**Ease of wild seed collection:** Difficult. Plants are usually 3-6 inches tall, which makes them challenging to locate. Seeds ripen variably up the stalk and shatter when mature.

**Seeds per pound:** 5,000,000-7,000,000

**Establishment:** Seeds do not have dormancy and germinate in warm temperatures. Start plugs in a greenhouse in late winter. In the spring, transplant into a field covered with weed fabric with holes on 1ft by 1ft spacing. Seeds can also



be sown into holes in the weed fabric in the spring, but this is not recommended because plants may need irrigation to become large enough to produce seed before soils dry out in the summer.

**Establishment rating:** Medium. Plugs are preferred.

**Weed control:** Weed fabric excludes most weeds, but hand weeding may be needed in the holes in the fabric. Borders need to be kept clean using herbicides or tillage. Weed fabric can catch wind-borne seeds, or seeds that are ejected from many feet away. Reducing these types of weeds from the seed production area will prevent weed seeds from contaminating the seed crop.

**Fertilization:** Controlled-release fertilizer added to the media used to grow the plugs usually provides sufficient fertility for the annual crop. An application of balanced fertilizer in the spring may be beneficial depending on soil fertility.

**Pests:** None observed.

**Harvest:** Seeds will shatter onto the weed fabric and can be vacuumed or swept up when all the seed has fallen.



**Post-harvest residue management:** As annuals, residue can be left on the field after harvest or removed in the fall for the subsequent crop.

**Seed cleaning:** The seeds are easily cleaned with a small air-screen machine.

**Average yields/Stand longevity:** 100-400 pounds per acre. When using weed fabric an impressive amount of seed can be harvested from this species. Plots are usually less than 1/10th of an acre and yield between 12 and 45 pounds.





# VIOLA ADUNCA

*early blue violet*

**Life form:** Perennial forb

**Pollination:** Capable of self-pollination as well as outcrossing. Pollinated by a variety of small native bees and flies.

**Ease of agronomic seed increase:** Difficult. Weed control and cleaning are relatively easy for this species. Plants are hardy and long-lived once established. However, seeds ripen unevenly and are expelled from pods as soon as they are mature. Weed fabric



is needed to obtain a worthwhile amount of seed. Once on the weed fabric, seeds attract pests such as birds and mice. Mousetraps, bird netting, and fencing may be necessary to ensure harvest goals are met. In

addition, harvesting this species by vacuuming is very time consuming.

**Native distribution/Habitat:** Found extensively in the western half of the United States to New England northward throughout Canada. *Viola adunca* inhabits varied environments such as dry to moist meadows, open woods, grasslands and open, disturbed ground; from lowlands to near timberline. This species is the main larval host plant for the threatened Oregon silverspot butterfly (*Speyeria zerene hippolyta*).

**Seeds per pound:** 470,000

**Ease of wild seed collection:** Difficult. Seed pods can be handpicked, but plants are often sparse



and very low to the ground. Furthermore, seeds shatter immediately upon ripening, and few seed pods are ready concurrently.

**Establishment:** Seeds are dormant and need up to 120 days of wet, cool conditions to trigger germination in spring. For best establishment, stratify seeds in a cooler for four months, move plugs to a greenhouse in late winter, and transplant out in spring. Transplant into a field covered with weed fabric containing holes on 1 ft by 1 ft spacing. Seeds can also be directly sown into holes in the weed fabric in the fall. Place 10 seeds per hole (1 pound per acre) and cover them lightly with soil or vermiculite. Seedlings will germinate in the spring.

**Establishment rating:** Medium; plugs are preferred.

**Weed control:** Weed fabric excludes most weeds, but hand weeding may be needed where the soil is exposed within the holes in the fabric. Borders need to be kept clean using herbicides or tillage. Weed fabric can catch wind-borne seeds or seeds ejected from many feet away. Reducing these types of weeds from the seed production area will prevent weed seeds from contaminating the seed crop.

**Fertilization:** An application of a balanced fertilizer (16-16-16) in early spring as new growth appears may be beneficial depending on soil nutrient levels. This is especially important in older fields.



**Pests:** This species is covered with many types of insects, but no damage has been observed to established plants. Developing seed is highly predated by both birds and mice. Production fields can be protected with bird netting and mouse traps to avoid loss of large amounts of seed. Slugs overwinter in violet crowns, but usually do not cause enough damage to warrant control measures.

**Harvest:** Seeds ripen and are expelled onto fabric throughout the summer. Plants usually stop flowering in mid-summer, but continue to produce capsules filled with seed. The weed fabric collects all the seed, but seeds can blow off the fabric in windy areas. Erecting a “wind fence” using 5-ft high weed fabric around the plot will keep seeds on the fabric. Vacuuming shattered seed from the surface of weed fabric is the preferred harvest method. If seed predation is controlled, one harvest can be performed at the end of season before fall rain begins. Fields harvested using a shop vacuum powered by a generator. Care must be taken to vacuum seeds from under each plant, and from within the holes in the weed fabric. Harvested material is placed in a tub to dry prior to cleaning.

**Post-harvest residue management:** None.

**Seed cleaning:** This species is easily cleaned because of its heavy seed that shatters readily. If necessary, a brush machine or thresher can be used to break up seed pods that have not fully

opened. An air-screen machine can be used to separate seed from empty seed pods, chaff, and dirt.

**Average yields/Stand longevity:** 180 pounds per acre from mature stands. This species flowers and sets seed in the first year if transplanted from plugs, but first year yields are lower than mature stands, producing around 37.5 lb/acre. Plants typically live upwards of five years and sustain high yields.

**Remarks:** This is one of the most challenging species to grow for seed, although it can be very successful with a high level of input.





# EQUIPMENT OVERVIEW



## Container Production

For species that will be established by transplants, plugs at the Corvallis PMC are usually grown in Ray-Leach “SC7 stubby” cells that are 1.5-inch in diameter and 5.5 inches deep. These plastic cone-tainers are expensive, but can be reused many times. Each rack is 1 by 2 ft and holds 98 cones. Racks can also be stacked for easy transport. Since each cell can be moved, the racks of cones can be consolidated and empty cones can be removed. This is important if greenhouse space is limited. The transplants are easy to remove from the cones and most species thrive in this type of cone-tainer. Tap-rooted plants will usually fill the cone-tainer if they are vigorous. The most important reason the Corvallis PMC uses these cone-tainers is for ease of transplanting.

Racks of cones are filled with moistened ProMix BX w/mycorrhizae and biofungicide. A balanced slow release fertilizer is added to the media for species that germinate rapidly and can fill the cone-tainer with roots within two months. Slower growing species are fertigated as needed using a water soluble fertilizer.

If seeds need stratification, they are sown directly into the cone-tainers, and carefully watered. The racks of cones are placed in plastic bags and stored in a walk in cooler for the duration of their stratification. Some species are placed in an outdoor shadehouse after stratification. These species usually germinate best in fluctuating temperatures or need cooler temperatures than our greenhouse can provide. Most species are placed in the greenhouse after stratification. Our

greenhouse facility is a double-wall polycarbonate greenhouse with fans and a furnace that regulate heating and cooling. Typical settings are 65-70 degree days with 50 degree nights.

## Transplanting

Most of the transplanting that occurs at the Corvallis PMC is performed by hand. “Dibble” tools make transplanting very easy. A hole is made by stepping on the dibble to push it into the ground. Next, the plant is pulled carefully from the cone-tainer and set into the dibble hole. Lastly, soil should be pressed around the crown of the plants to cover up all potting media so it does not act like a wick and dry out the plug. On average, one person can transplant 100 plugs per hour with this method. To achieve maximum weed control before transplanting, consider creating a seed bed, leaving it fallow for a season or two, and removing weeds as they germinate (by broad spectrum herbicide, flamer, very shallow tillage, etc.).

At the Corvallis PMC, seed beds are created in late summer/early fall. Weed control is performed in the fall, winter and very early spring just before transplants are planted in fields in March. Transplanting by hand creates almost no soil disturbance, and therefore keeps new weed germination to a minimum. It also can be completed when the soils are very wet (which is good for the plants), but mechanical transplanting requires much drier conditions.

For establishing large fields by transplants, the Corvallis PMC uses a 2-row, mechanical Holland “rotary-one” transplanter. Two passengers ride on the transplanter and place plants in the cups as they spin around on the rotary table. The cups open when they align with the coulters that create a furrow. The plants fall from the cups and an ejector kicks them out into the furrow. The packer wheels follow and cover the plants with soil. This transplanter is meant to be used in tilled soils, but the PMC staff has had good results using it in soils that have not been tilled recently. It is important that plants have a tight root plug to be used with the transplanter. We typically use the 5.5” cone-tainers or shorter 3-inch plug trays for growing plants that will be used with the

transplanter. It can be difficult to get good results when planting the 5.5-inch cone-tainers in soils that have not been tilled since the furrow often is not deep enough and the plants tip over. The smaller plugs, however, work very well in these soil conditions. This planter claims to be able to plant 60-80 plants per minute. When planting in perfect soil conditions, this may be possible. On average, in non-tilled soils, PMC staff can plant 2000 plants per hour. This requires a tractor driver, two passengers loading plants into the transplanter, and one to two people to assist in covering up plants or uprighting plants that have been kicked over by the ejectors. This results in a planting rate of about 400 plants per hour per person, which is much faster than 100 plants per hour when planting by hand.

## Weed Control

Much of the weed control at the Corvallis PMC is performed by hand. After years of searching for the best weeding tools, there are a few that stand out. There are many types of hula hoes available (also referred to as action hoes or stirrup hoes), but getting one with the best angle is important. Our hoes also endure at least 200 hours of use each year in heavy soils, and are sometimes up against large weeds. After destroying cheap ones from the lawn and garden section of hardware stores, PMC staff researched heavy duty hoes with replaceable heads. The PMC uses 5" stirrup hoes made by Glaser. They withstand two seasons of use and are easily sharpened with a file.

For weeding in close quarters, PMC staff use the Nejiri Gama handheld hoe. These hoes are only about \$12, and usually last a season or two. They are light, sharp, and make quick work of scraping the ground or carefully weeding up close to the base of plants. They are also good tools for weeding around plants that are grown in weed fabric. Flat-head screwdrivers also work well for removing weeds with long tap roots or removing weeds that are growing in the crowns of plants.

For spot application of herbicide, backpack sprayers are a helpful tool. There are many makes and models of backpacks available and some reviews are listed online. Hockey-stick herbicide applicators can be used in windy

conditions because there is no drift. These can be purchased or fabricated. The Red Weeder by Smucker Manufacturing is nice because the transparent handle allows you to see the level of herbicide. They will last a couple seasons, and the sock is also replaceable. When spot treating with herbicide, it is very helpful to add blue dye or "marker" in order to see where the herbicide is actually being applied.

## Weed Fabric

We recommend that many of the species in this manual be planted into weed fabric. Weed fabric is a finely woven black plastic tarp material that aids in weed control and maximizes yields. It prevents weeds from germinating, yet is permeable to water and nutrients. At the Corvallis PMC, fields are completely flat, but it can be very windy. We have found that at our site, it works best to use wide sheets (12-15 ft) of woven weed barrier stapled down over a "stale seedbed" (a field that was harrowed and rolled into a seedbed in fall, but left undisturbed until spring). Using a field that has not been recently tilled seems to be a preferred method to keep the fabric from blowing away. Too much air can get under the fabric after holes are cut if the soil has been recently tilled.

About two to four weeks before planting in the spring, the field is sprayed using a broad spectrum herbicide (glyphosate). After weeds begin to decompose, weed fabric is carefully laid across the field. We lay out weed fabric by hand, though there are tractor implements available that will do this for raised beds. Using large staples (3 by 12 inches), the edges and centers of fabric are pinned to the ground. Two to four inches of dirt is shoveled along the entire edge of the fabric, covering it. This prevents wind from blowing under the fabric and picking it up. At planting time, holes or X's are cut in the fabric using utility knives or box cutters. Holes are cut based on the size of transplants and expected growth for that season. It is best to make the smallest hole needed as weeds will grow where soil is exposed and seeds can be lost in the holes. Using plants grown in cone-tainers make the transplanting process very easy. The diameter of the cones is





less than 2 inches and dibble tools fit easily into a 2 to 3-inch hole in the fabric. Some species are best established directly from seed; for these species, once the holes are cut, seeds can be sprinkled into the holes and covered with vermiculite, soil, or compost. To avoid crawling

while seeding holes, we found that funnels perched on 3-ft tall  $\frac{3}{4}$ -inch PVC pipe work well for stand-up seeding. As plants grow in the holes, they spread out and the majority of the plant cover is above the weed fabric. At harvest time, the standing plant material may need to be removed to collect the seed. For large seeds, sweeping up the seeds usually works well, but seeds may be swept into the holes. We typically vacuum the seeds from the holes after we sweep. For smaller seeds, or plants that are not cut, it is usually easier to vacuum the entire sheet of fabric. We use two shop-vacs powered by a generator.

## Seed Drills

Seed drills consist of a hopper that meters out the seed, places it in the soil, and covers it up. The most common drills have box-type hoppers with an agitator inside above adjustable holes. They are calibrated by adjusting the holes to change the amount of seed flowing out. Other types of hoppers apply a pre-measured amount of seed over a specific distance that the tractor travels. These types use belts or cones to equally distribute the seed. They usually have more accurate and consistent seeding rates than box-type hoppers. The other way that seed drills differ is how the seeds are placed in the soil. Drills usually have a shoe, a chisel, one disk or two disks. Drills with shoes require a prepared seed bed, whereas the others can be used in “no till” situations. Two disks usually provide the most

accurate and consistent seeding depths and are great for seeds that need to be shallowly sown ( $\frac{1}{4}$  in or less). The Corvallis PMC has a six-row seeder tractor attachment as well as a couple of push-type single row Planet Jr planters made by Cole. The seeders have small square boxes with an internal agitator that rotates as the wheel moves. The boxes can be fitted with different sized openings depending on the size of the seed. Most come with three disks with numerous holes, for about 40 different size options. Calibration can take time when seeding many different species. It can be difficult to sow very small seeds or “fluffy” seeds with this type of planter. Mixing seeds with a filler can bulk it up and make it flowable. These planters also need a certain quantity of seed in the planter box to operate effectively. However, these types of planters work well with seed that is large, clean, and highly flowable.

The Corvallis PMC also has a Hege 4-row cone-seeder (Hege 1000). This specialized piece of equipment is perfect for seeding many small



fields of various species. The only calibration required is weighing (or measuring) out the amount of seed that should be placed into the hopper for each “trip”. For the PMC’s seeder, a trip is traveling 24 feet and planting four rows at a time (96 linear feet). Coincidentally, the grams of seed per trip is the same as the target pounds per acre, which makes calibrating the seeder very easy. For example, the hopper should be loaded with 4 grams of seed per trip for a species that should be sown at 4 pounds per acre. The hopper is loaded with the premeasured seed and when the lever is pulled by the passenger the seed is dropped onto a metal cone and the seed falls evenly to the base of the cone. As the seeder is pulled forward, the tires turn a system of gears and chains that turn the belt which rotates the cone. The seeds move around the base of the cone until a flap of metal directs them into a hole that leads to the spinner. The spinner evenly divides the seeds up into four separate tubes. The tubes direct the seeds into a furrow created by two coulter disks at the soil surface. A packer wheel behind each set of disks fills in the furrows after seeds have been dropped in. The depth of the disks can be adjusted to set the furrow depth and the packer wheels can be adjusted to control how much the seeds are covered. The disk openers are versatile and can be used on many types of seeds beds. This also works as a no-till drill, but only for seed that is sown shallowly. A drawback to this implement is that it is expensive and it can be slow when seeding large fields (over an acre).

## Harvest Equipment

### Combines

There are many types of combines available. In the Pacific Northwest, the most common combines are very large machines that are made for picking up swaths in 1000-acre grass seed production fields. Small combines are difficult to locate. We have found that small plot combines, especially ones that are made for grasses or clover are usually great combines for native seeds in our area. Some of the main features to look for in a combine are:

- 1) **Adjustable air.** Air settings that are too low can result in added debris in the seed lot which will multiply the hours spent on the seed cleaning process. If the air settings are too high it will cause great losses of seed, which reduces yields. Having a combine with highly adjustable air settings will be more likely to result in high yields of clean product straight off the combine.
- 2) **Ability to stationary combine.** Combines with conveyor belts on the header are very useful for combining material that has already been cut, removed from the field, and dried on a tarp.
- 3) **Easy to clean out.** Depending on how important seed contamination is to your operation, having a combine that is relatively easy to clean out can save a lot of hours during harvest season. This can often be very difficult to determine when inspecting a combine. It may take many cleanouts before you realize you’re still finding seeds in the combine from a crop you harvested five lots ago.
- 4) **Concave.** The more important feature is changeability. A wire concave with the wire spaced a half inch apart, for example, will not be able to break apart seed capsules, pods or heads that are smaller than a half inch. A wire concave with 1/8<sup>th</sup> inch spacing will do a great job at breaking apart small seed capsules, pods or heads but will quickly become clogged up with larger seeded species resulting in poor performance or broken seeds. A solid concave should only be used to harvest crops where the seed containing material must be completely ground up in order to remove the seed. The operator will have to go very slowly or the combine will bog down and become jammed. Most concaves are changeable but some are designed with changing in mind so a few bolts can be loosened and it can be slid right out the side of the machine. If the combine is not designed to have the concave changed often, it may require the inside of the combine to be gutted so the concave can be lowered onto the belt



then pulled out the back of the machine. This could take a good mechanic a full day to complete versus maybe 10 minutes to switch out a concave in a small plot combine.

- 5) **Dependability.** Combining is almost always a very time-sensitive task. Your combine must start and function properly when your field is ready to harvest or the crop may shatter or get rained on and mold or sprout. It is good practice to start up your combine at least a month before you need it and make sure everything is functioning properly. They can be difficult to troubleshoot and parts take time to obtain when available and in some cases need to be custom fabricated.

The Corvallis PMC has two small, plot harvesting combines. Both work in approximately the same manner, but differ in their adjustments, available components and header style. Both combines are created to be used in two configurations: as a direct combine with a reel attachment and a sickle-bar cutter to harvest standing plant material, or as a pick-up header to pick up plant material that has been swathed into windrows and dried. Either way, the plant material goes up a belt and is forced between the cylinder and concave to break up the plant material and remove seeds from seed heads. This part of the machine is known as the thresher. The speed of the cylinder and the distance between the cylinder and concave can both be adjusted. After the material has passed through the thresher it is divided. Straw and large pieces of plant material are thrown upward to the top of the straw walkers where they are walked out the back of the machine. Small pieces of plant material, seed and chaff fall through the straw walkers and land on a belt that moves the material toward the back of the combine where it passes over the sieve. The sieve is a screen like device that is made of many angled fingers that can be adjusted to allow different sizes of material to pass through. Any material that does not fall through the sieve falls out the back of the combine. Below the sieve there is a screen. This helps to further separate straw and chaff from good seed. Air is blown over the sieve and screen to keep material moving across it. The air can be adjusted and should be high enough that the screen and sieve do not



clog up, but not so high that filled seed blows out the back. The sieve and screen shake to help material flow better. Material that has fallen through the screen and sieve should contain all of the seed and only small pieces of plant material. Material that falls into the collection pan is then blown through an air column and to the cyclone. Dust and very light chaff is blown out the top of the cyclone and good seed falls out the bottom where it can be collected in a bag or barrel. From here the material will need to be dried if it was direct combined or cleaned to the desired purity standard with other seed cleaning machines.

### Hege 180 Combine

#### Pros

- Very powerful and can dislodge hard-to-shatter seed
- Most adjustments are simple and easy to perform quickly (except adjusting the concave)
- Comes with three screen sizes for combining different crops
- Highly adjustable reel for direct combining, minimizes shatter.
- Good for fields 0.1 acre to 5 acres in size
- Works well as a stationary combine

## Cons

- The concave is very difficult to remove or switch out, making cleaning cumbersome.
- Guzzles diesel – can easily use 25 gallons in an 8 hour day
- Seeds can hide in many locations, potentially contaminating following seed crop; with thorough cleaning of all hiding spots, it is possible to have minimal contamination.
- The de-awner bars are very difficult to install and must be removed for cleaning between each crop to avoid contamination.
- Our machine has had its fair share of small mechanical problems which are usually electrical.
- The pick-up belt does not have a way to clean itself out causing material to wrap at times, especially with a thin swath. The delivery from the pick-up belt to the feeder house requires a thick, uniform swath or crop builds-up, entering the feeder house in “clumps”.
- With small-seeded species, the air must be adjusted very low, which allows more plant material to fall through the screen and can cause serious clogs in the collection pan on the underside of the combine.

## Wintersteiger Classic Plot Harvesting Combine (Special Fine Seeds version)

### Pros

- Small combine made for a variety of small-seeded crops. Perfect for native seeds!
- The wire fingers on the pick-up attachment are very gentle and cause little to no shatter when combining swathed material.
- The concave can be adjusted easily and can be removed for cleaning by loosening

a few bolts. Concaves can be purchased that have different wire spacing for crops with different sized seed heads.

- De-awner bars can be easily added or removed from the concave when it is out of the combine.
- Our machine has been very dependable and has had few problems.
- Good for plots 0.1 acre to 5 acres. System is well sealed to minimize seed loss.

### Cons

- Sieve is adjustable, but the screen size is not easily changed. It is necessary to purchase the combine with a screen large enough to accommodate the largest seeds that will be harvested. This causes small-seeded species to come out very dirty, requiring more seed cleaning later.
- Air adjustment is complicated because there are three adjustment locations. Finding the right combination of the three can be time consuming until the operator gets a good feel for the system.
- The air coming out of the cyclone is very strong and blows light chaff and awns all over the operator.
- Conveyor belts are difficult to keep in alignment and need to be inspected and adjusted often.





## Woodward Flail-Vacuum Seed Stripper

The flail-vacuum seed stripper is a valuable harvesting tool used at the Corvallis PMC. It is a 6-foot wide “street sweeper” style brush mounted in an aluminum housing that attaches to the front end loader of a tractor. The hydraulically driven brush spins at high speeds which creates a vacuum effect. The brush pulls the seeds from seedheads and they are sucked into a hopper. Dust and other material lighter than the seeds are blown out the top of the housing. This machine does minimal damage to the plants, allowing multiple harvests over the course of a growing season. This is valuable for species that mature over a long period of time. The air outlet can be fitted with a screen to catch seed with pappus (such as aster) that would otherwise be blown out. After the material is harvested with the seed stripper, it must be spread out on a tarp and dried before it can be cleaned. Large plots will require huge amounts of space for drying. A crop harvested with a seed stripper has much more dirt and plant material in it than a crop harvested with a combine, but has much less plant material in it than if the entire crop was swathed onto a tarp and dried.

### Pros

- Makes multiple harvests of a field possible; good for species with indeterminate bloom and variable ripening
- Highly adjustable
- Effective harvest method for many species
- Can be used to “sweep” seed from weed fabric
- Easy to clean out; little contamination

### Cons

- Works best when seedheads are approximately the same height
- Some grass species tend to wrap around the shaft of the brush, requiring frequent cleaning so the machine won't bog down
- The hopper is relatively small and needs to be dumped often when harvesting large plots; best for fields smaller than an acre



We have the Woodward Flail-Vac Seed stripper. We bought it in 1998 and have used it intensely. Often use it very close to the ground, which has caused some dents in the underside. We also fabricated a screen that we clip onto the air outlet on the top of the hood to keep seeds with pappus from flying out. It has not needed any repairs in the time we have had it.

## Modified Swather

The PMC uses a custom built self-propelled, mini-swather borrowed from an OSU researcher. The front is like a mini-combine with a reel attachment and a sickle-bar cutter to harvest standing plant material. Cut material lands on a conveyor belt where it is fed up to a passenger who then stuffs the material into bags to be hauled to a drying area.

### Pros

- MUCH quicker and less labor-intensive than hand harvesting!
- Catches the seed that shatters when the plants are cut (normally this is lost when hand harvesting).

### Cons

- These machines need to be hand built or fabricated out of an existing machine. This requires someone with good fabrication skills and knowledge of the necessary specifications for efficient collection of plant material.
- Crops harvested with this type of machine require a huge amount of space to dry because there is no separation of seed and plant material in the harvesting process that one would achieve with a seed stripper or more so with a combine.
- This machine has trouble cutting plants that are prostrate.





## Threshers

### Wintersteiger Thresher LD 180

This machine is a small plot thresher that removes seed from plant material. Seed stalks are fed into a chute at the top of the machine. They are grabbed by a rotating cylinder that has plastic flaps bolted onto it. The plant material is forced between the plastic flaps and a metal concave which breaks the seeds free from the seed stalks. The material keeps going around in the chamber until the operator presses a foot pedal which opens a flap at the bottom of the chamber. Once the flap has been opened, the ground up material falls through a column of air where some separation occurs. The dense seeds fall to the bottom where they can be collected in a tub. Light material gets blown to another collection chamber at the back of the machine and dust gets blown out the side.

#### Pros

- Adjustable air flow through the column and cylinder rotation speed.
- This machine can break open hard seed capsules and remove very difficult to thresh seeds.
- There is a metal flap that closes the input chute, eliminating blow-back.
- The operator can control how long the material stays in the threshing chamber.
- Very small seed lots can be threshed without losing any seed.

#### Cons

- The gap between the plastic flaps on the cylinder and the concave is not adjustable.
- The air is often too high even when on the lowest setting.
- The chute where the threshed material comes out is in an inconvenient location making it difficult to place a tub or barrel under it.
- The cylinder must be removed to

thoroughly clean between seed lots.

- Material with thick seed stalks must be fed in very slowly to prevent the motor from bogging down. This machine threshes in many small batches rather than a continuous feed.

### C. S Bell Hammer Mill # 10

The hammer mill is another machine that the PMC uses to detach seeds from seed stalks or to remove seeds from seed heads. The plant material is fed into a chute at the top of the machine. The material falls into a chamber with a rotating cylinder attached to many steel bars or "hammers". The material is tumbled around in the chamber until it is broken up small enough to fall through the perforated concave at the bottom of the chamber.

#### Pros

- This machine can be used with very fragile seeds without damaging them.
- The perforated concaves are easily changed to allow for different sizes of seeds to fall through.
- Cleaning is simple and quick.

#### Cons

- This machine cannot continuously feed material. There is nowhere for the straw or large pieces of plant material to go, so the operator needs to stop often and remove the straw from the chamber. This makes running large amounts of material through the hammer mill very time consuming.
- If material is left in the chamber long enough to be broken into pieces that are small enough to fall through the screen, resulting stem pieces and chaff are the same size as the seeds which makes the cleaning process more difficult.
- Species with hard seed pods or capsules will tumble around indefinitely without breaking open.

## Almaco Thresher

This thresher works by grinding the dried plant material between a spinning cylinder and a concave. This action effectively removes the seeds of most species from plant material. After the material passes between the cylinder and concave it goes over a rotating tumbler which helps to separate seed and other small pieces of plant material from larger pieces of straw. The seeds and small pieces of material are dropped directly into a column of air where dust and chaff can be blown out. Larger pieces of straw are fed onto a shaker table made of long wires about ½" apart. Air blows the straw across the shaker table and anything that is small and dense falls through and ends up in the same air column as the material passing through the tumbler. Straw and light material is blown out the back of the machine where it piles up on the ground. Seed and other heavy material falls through to the bottom of the air column where it can be collected in a bin.

### Pros

- Can efficiently thresh large amounts of dried plant material.
- Able to adjust the distance between the concave and cylinder, the rotating speed of the cylinder, and the amount of air.
- Material can be continuously be fed in without stopping.

### Cons

- Plant material has to be stuffed through a small opening at the top of the machine. There is little separation between the feeding opening and rotating cylinder, making it potentially dangerous for the operator's hands while feeding material.
- There is a significant amount of blow-back when feeding material into the machine, making it difficult for the operator to see and covering them with a thick coating of dust by the end of a big lot.
- This machine was designed to handle large seeds. Even when the air is turned all the way down, seeds from small-seeded

native species get blown out the back of the machine and land up to 10 feet away. A large tarp can be placed under the thresher to catch all of the seed; straw can be forked off and the remaining seed-containing material can be barreled for cleaning.

- The gap between the concave and the cylinder cannot be adjusted small enough to break open small capsules or remove small, flat seeds from seed heads if they are firmly attached.
- Can damage seed if the concave is not adjusted correctly

## Seed Processing Equipment

### Air-Screen Machines

The Corvallis PMC has three air-screen machines that are used to remove impurities (weed seeds, unfilled seeds, stems, chaff, rocks, etc.) from seed lots to reach desired purity standards. Air-screen machines use a combination of sifting and scalping screens and air flow to effectively clean seeds. Dirty seed is fed into the machine by hand or with a hopper. The material runs over an agitating top screen, which is selected to have openings slightly larger than the seed itself (many sizes of perforated metal and wire cloth screens are available). The seed quickly falls through the holes as foreign material that is bigger than the holes runs off the top of the screen and is collected as trash. After the seed falls through the holes in the screen, it falls onto another screen containing holes that are smaller than the seeds. This screen sifts out objects smaller than the seeds and they are fed to a trash bin. Seeds and remaining debris then pass through a column of air. Debris that is lighter than the seeds as well as unfilled seeds blow out the front of the machine as the heavy seeds are collected in a tray at the bottom. Air flow is adjustable. Agitation can be adjusted in some machines by increasing or decreasing the number of rubber balls in trays under the screens. These balls bounce between the tray and the screen to facilitate the flow of material over the screen. Other machines have brushes to aid in seed flow across the screen. These machines are generally not the best choice



for cleaning native seeds because the small seeds tend to get stuck in the brushes and can be difficult to clean out, thus increasing the risk of contaminating subsequent seed lots.

### **Clipper Office Tester**

This small air-screen machine is best used to efficiently clean small lots of seed, from a small handful up to 25 pounds. However, PMC staff sometimes use the Office Clipper to clean lots as large as 100 pounds because the air is very precise and the agitation is gentler than larger models. Screens come in many shapes and sizes for cleaning various species. The air controls are very precise and can be used to clean tiny seeds such as *Juncus* spp., as well as large seeds like lupines or bromes. The machines are made mostly of wood and have very few spaces to trap seed which could contaminate other seed lots.

#### **Pros**

- Easy to clean out between seed lots.
- Precise air controls.
- Very little “lost” seed.
- Easy to learn how to use and adjust.
- Good for small to medium seed lots (1 gram – 50 pounds).
- Long-lasting piece of equipment; replacement parts are easy to find.

#### **Cons**

- Screens can clog since there are no balls or brushes to aid material flow.

### **Crippen “Midget” 2**

This air-screen machine is most efficient for cleaning seed lots weighing 15 to 2,000 pounds. Many different sizes and shapes of screens are available for this machine and air flows are adjustable. Trays of rubber balls assist the flow of material across the screen; the trays and balls are easy to clean and remove to adjust the level of agitation.

#### **Pros**

- Precise air control for a larger machine.
- Easy to use and adjust.
- Long-lasting piece of equipment that needs few repairs.
- Requires no modifications.
- Great machine for cleaning medium to large lots.

#### **Cons**

- Design and wear of the wood and metal parts create places for seeds to hide which require taking apart the machine to remove.
- Material containing large, trashy pieces cannot be fed through this machine because the large trash scalped off the top screen binds up where it must turn and flow through a small vent to a trash bin.
- Weak design on the bolts that hold the door frame.
- Air controls become less precise when set at the lowest levels.
- Can require significant time to clean with some species.

### **Clipper Eclipse**

This machine is built to use three screens. It is complicated to use and when using three screens they can only be arranged with one screen scalping and two screens sifting. Since native seeds are small, a more helpful design would be two screens scalping and one screen sifting. Luckily, this machine can be used as a two screen machine, which is how it is used at the PMC. It is made from wood and metal but has no spaces where seed can become trapped. It is very easy to clean out because the entire front of the machine opens up for easy access. Since this machine can be used in various configurations, it can be difficult to get a good, tight fit, when

all the screens and trays are in place. Adding layers of weather stripping to the door can help create a tighter fit which will prevent leaks. This machine also has a hopper and feeder that agitate with the movement of the machine. If material is slightly flowable, the feeder works very well and the machine can be left unattended for short periods of time. Large trash that is sifted off the top screen slides off the front of the screen into an open trough, where it is directed to a trash bin. If the trash is too large to fall into the trough, it simply falls off the front of the machine, it doesn't clog up the flow of material. The air column on this machine is very short which doesn't create enough space for adequate separation by air. At the PMC this machine cannot be used as the last step in cleaning because the seed lots contain many impurities that should have been blown out. This machine is good for initially cleaning seed lots that are really trashy, especially with large stems. It is impossible to shut the air off, even with modifications to reduce the amount of air in the air column, it is not as low as needed for cleaning small native seeds. Changing sizes of some pulleys or adding a variable speed motor might be possible ways to reduce the air. The entire machine is enclosed by guards making it very difficult to see what is happening while the machine is running. This creates situations where clogs can go unnoticed for quite some time. The good seed falls into a chute under the machine that is 2 inches away from another chute directing trash being blown out of the air column. They are so close together that it is difficult to achieve complete separation between the two catch pans.

### **Pros**

- Functional feeder.
- Handles large, stemmy material.
- Can quickly reduce bulky seed lots.
- Very easy to clean out.

### **Cons**

- Ineffective air settings and short air column creating impure seed lots.

- Complicated set up, lacking a tight fit, creates leaks.
- Not enough space between good seed and trash chutes to achieve perfect separation.



## Brush Machine

A brush machine is a specialized seed conditioning device. It is used for removing awns or hairs from seeds or for seed scarification. It is also very helpful in detaching seed from pieces of stem, pods, and hulls. Brush machines come in varying sizes and styles, but they all perform essentially the same action. Material is systematically fed through a hopper into a cylindrical drum with a set of rotating brushes which push the material up against the selected mantle. Mantles are exchangeable and come in varying screen mesh sizes, or can be solid and lined with sandpaper. The rotating nylon brushes vary in composition and stiffness (wood slats with medium stiffness is recommended). Seeds or chaff are pushed through the screen and fall into a collection pan under the machine, or are funneled through and discharged out the front into a collection pan. The length of time material remains within the chamber is controlled by an adjustable door at the front opening and by the rate at which material is fed into the chamber. Most machines have a vacuum attachment to aid with removing dust and very light particles from the lot. Usually, material from the brush machine is sent to another piece of equipment for further processing.

### Westrup Brush Machine HA-400

This brush machine is efficient for deawning seed lots weighing 15 to 2,000 pounds. The machine needs a certain quantity of seed to make it functional, so smaller lots may have inconsistent results. Brushes can be adjusted to fit against the screen or slightly away from the screen depending on the size of the seed and amount of deawning needed. Different sized screens (drums) are available, but the Corvallis PMC usually only uses two screen sizes. Very small sized screens are available and are very helpful when working with small seeds, but the light gauge wire used on the screens is not durable, tearing quickly under normal use. It is important to choose a screen size that will provide complete separation of seed either falling through the screen or not falling through and coming out the front. Doing this will also help clean the seed while brushing and achieve a first step in reducing bulk material to be cleaned. This step can also be helpful in removing small



weed seeds from a seed lot (if the crop seeds do not fall through the screen). This machine is also good for lightly threshing small amounts of materials that isn't practical for a large thresher or stationary combine. This brush machine is very powerful and can handle bulky material. There are no speed adjustments, air adjustments, or feeders, and these features are not needed. Over many years of heavy use, this machine has only needed replacement brushes and some bearings. This machine came to us in the late 1980's with no stand, hopper or catch pans. We had these fabricated especially for our facilities. This is a practical, simple, tough machine.

#### Pros

- Versatile – good for many uses other than just de-awning seed.
- Works well for medium to large seed lots.
- Our machine has required no repairs.
- Needs no modifications.
- Powerful and simple.

#### Cons

- Needs a minimum amount of material to work properly.
- Cleaning screens can take a long time.

## Westrup LA-H Laboratory Brush Machine

This mini version of the HA-400 works well for lots weighing between a few grams up to 50 lbs. It can be used to clean lots that are larger than 50 lbs, but becomes less efficient for large lots. This machine also has an adjustable feeder, adjustable motor speed, self-contained dust control vacuum system. Westrup's Labs-sized models are very expensive, but arrive with all the necessary equipment: table, dust control, catch pans, feeders, etc. Our feeder broke within the first five years of use. The feeder wasn't an important component for us since we do not put flowable material in this machine. Other than that, this machine has been quite durable and we have put it through heavy use for 15 years. This machine can also be used as a scarifier when using a sandpaper drum.



### Pros

- Versatile- threshes, de-awns, scarifies!
- Works well for small to medium seed lots.
- Durable, except for the feeder.
- All parts included- set it down, plug it in.

### Cons

- Needs a minimum amount of material to work properly.
- Cleaning screens is time consuming.
- Expensive (although it is a high-quality product).



## Specialty Seed Processing Equipment

### Air-Density Separator

Air-density separators use a vacuum to sort material by density, and are used to further separate filled seed from unfilled seed or weed seed. These machines can be effective for separating a wide, flat, round seed from a narrow, thin, long seed that might fall through the same screens, but have different surface areas. Seed is automatically fed from the hopper cabinet by the vibratory feeder into a vacuum-pressurized column of air. The densest material falls into the lower seed container. Air pushes the seed up into a set of containers in a gradient, with the heavier/denser seed closest to the column and lightest material farthest away. The column of air can be more finely tuned and fed more slowly than an air-screen machine, allowing for more precision. These machines are very simple to use, usually only having one adjustment, which controls the amount of suction in the sorting column.

We have the SeedTech STS-MC3 Separator. We

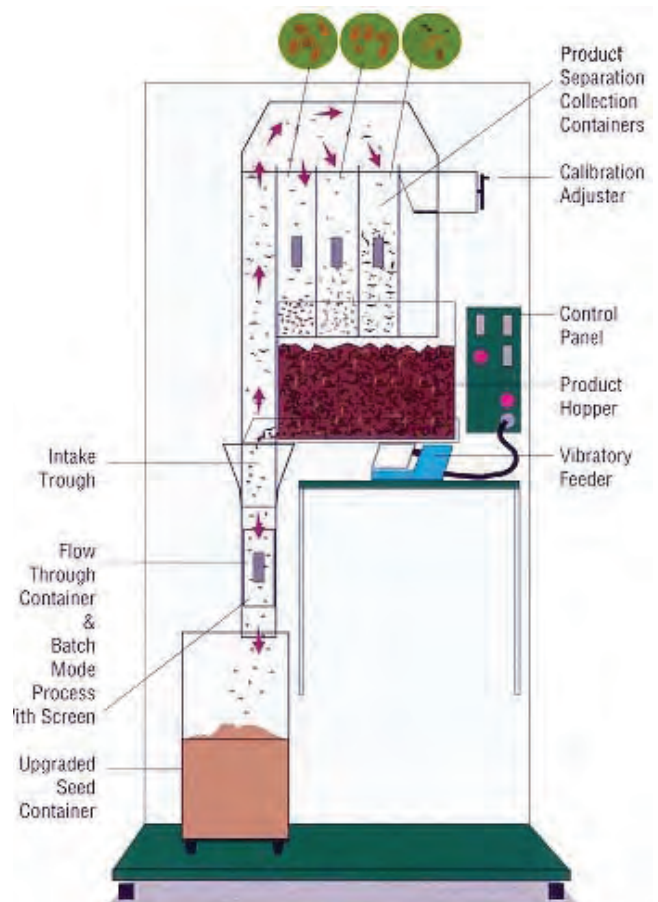


like that everything is clear, because you can see how to best adjust the suction while it is running, but the plastic will chip and crack over time. We have put ten years of use on ours and we've had to reglue many parts, replace the vacuum, and re-wire the feeder. The feeder on this piece of equipment is very effective and we use it on other machines as well.

### Gravity Tables

Gravity tables use a permeable, vibrating table with air blowing up through it to sort seed based on weight and size. These tables can separate seed based on slight differences in weight and density that air-screen machines cannot. These machines are very good for "grading" seed or selecting out the densest seeds (which often have the highest viability). Gravity tables work well with large seeds, and are most often used to achieve very high viability within a seed lot. They are often complicated to set-up and use.

We have the Westrup Laboratory LA-K gravity separator. It was very complicated to use and



the feeder broke within the first 5 hours of use. The feeder is needed for correct operation of the machine, and was a couple hundred dollars to fix.

### **Indent Cylinder**

The indent cylinder separates seeds of similar diameter or weight but different shape or length. It is effective for removing unwanted weed seeds from a seed lot, or separating seeds from sticks or stems of similar diameter that may not be removed using other equipment. An adjustable self-feeding hopper is filled with seed, which flows down into the rotating, adjustable-speed, indented cylinder mantle. Shorter seeds fill the indents and the centrifugal force holds them until inverted and gravity causes them to fall into the trough situated in the center of the cylinder. This trough vibrates and shakes the seeds out into a catch pan. Longer or larger seeds or stems do not remain in the indents and continue to travel through the cylinder and trickle out the front into a separate catch pan. Cylinder mantles are available in several different indent sizes and it is imperative to set the speed of the mantle and feeder at an appropriate level to maximize efficiency.

We have the Westrup Laboratory LA-T indented cylinder. It can handle small or large lots (depending on how much time you have). It has an adjustable automatic feeder, adjustable motor, and adjustable catch trough. It can take some time to learn how to use this machine effectively, but it can be very helpful for removing weed seeds or other debris from seed lots. We've replaced some wearable parts, but overall this is has been a very durable machine for 20 years.



## **Acknowledgements**

*On behalf of NRCS and the Plant Materials Center team, I would like to thank all the people who helped make this document possible. Vanessa East's attention to detail and special plant skills allowed us to have accurate germination trials and fabulous plants to work with. Kevin Robb and Tyler Ross's curiosity, creativity, and enthusiasm regarding new harvest techniques and field management provided us with lots of learning opportunities. Dale Darris offered his knowledge on the grasses that he worked with extensively during his career. Mary Beuthin, Robert Hoffman, Meghan Chuites, and John Knox helped turn my hastily written yearly reports into this comprehensive manual. Lastly, thanks to Annie Young-Mathews, Leanna Van Slambrook, Tracy Robillard and Rita Ramos for their help in editing this document, and to Cat Bailey and Julie DePue for providing the layout and design.*

- Amy Bartow  
Plant Materials Center  
Corvallis, Oregon







USDA is an equal opportunity provider and employer.