CORVALLIS PMC

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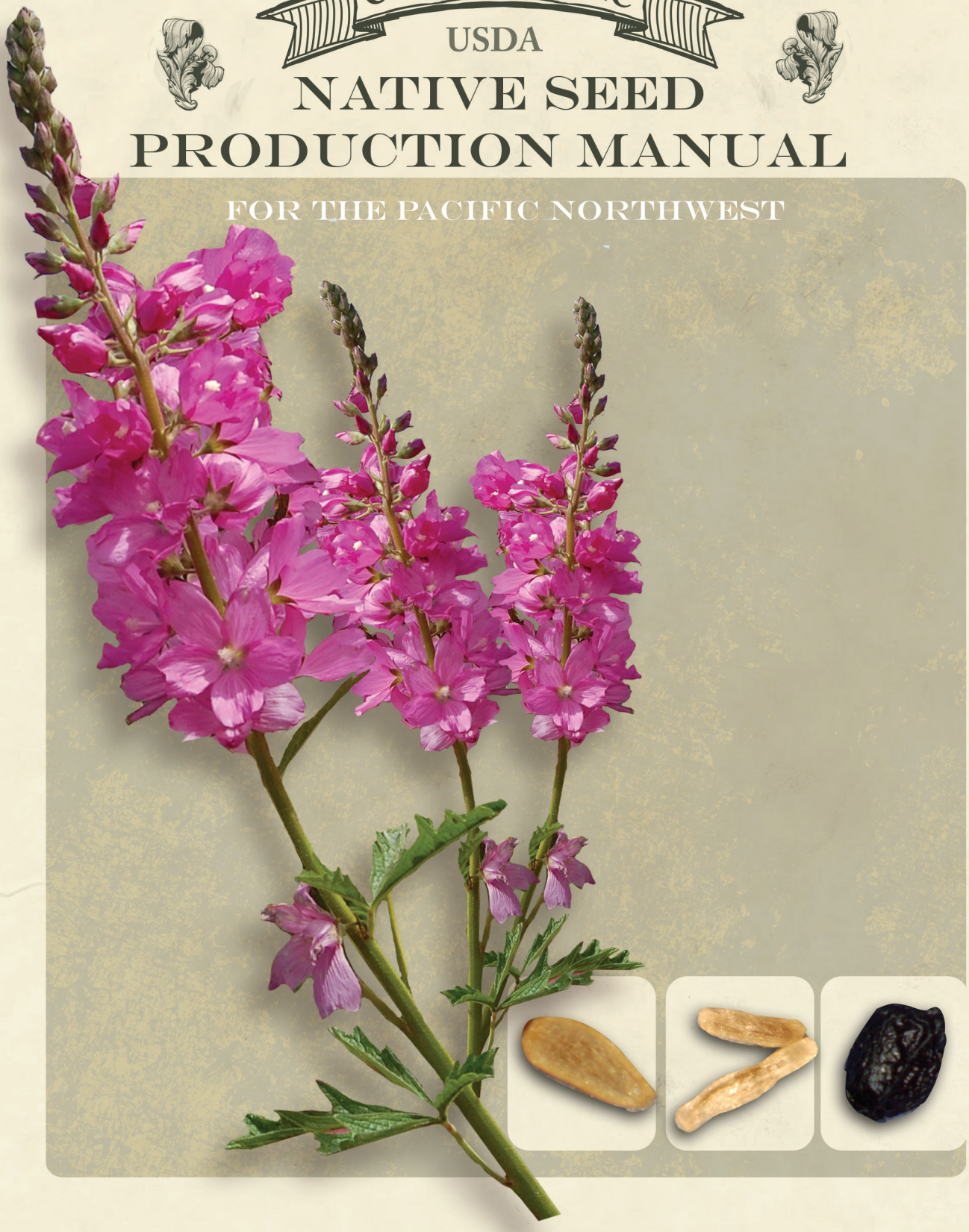
NATIVE SEED PRODUCTION MANUAL

FOR THE PACIFIC NORTHWEST



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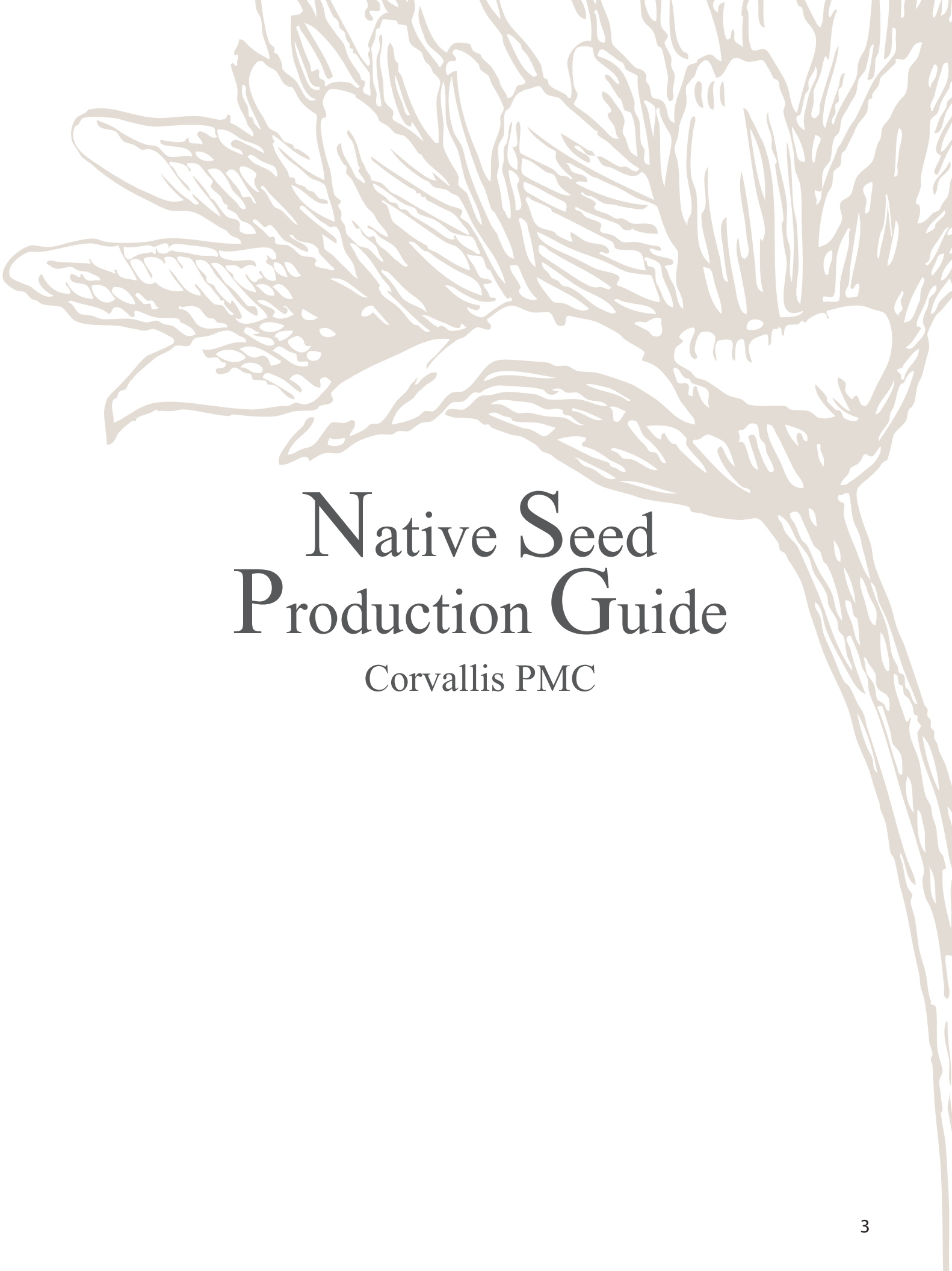

Native Seed Production Guide

Corvallis PMC

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Grasses and Grass-like



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.

Agronomic Seed Crop Traits		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.

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

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

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 growers reliant on other control methods such as cultivation, use of weed fabric, mulching, and hand weeding. Some tools, like flamers 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.

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

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 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.

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.

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 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.

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

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.

ACHNATHERUM LEMMONII

Lemmon's needlegrass

Life form: Perennial bunchgrass

Pollination: Both self-pollination and cross-pollination (by wind) occur on each plant.

Ease of agronomic seed increase: Moderate once established. Some seed is lost from uneven maturation and shattering in the field. Extra conditioning is needed to remove long awns and seed yields are inherently low.

Native distribution/ Habitat: Lemmon's needlegrass is found naturally in northern and western California, including the Sierra Nevada Mountains, north to southern British Columbia and east to Montana, Utah, and Arizona. Usually inhabits south slopes, upland prairies, savannas, and openings in pine woodlands in full sun.

Ease of wild seed collection: Moderately difficult because plants mature seed unevenly, are low yielding, and can be sparse. Seeds can be stripped from the seedhead or the heads cut off and bagged.

Seeds per pound: 95,000 with awns removed.

Establishment: Establishing fields from plugs is recommended. Seed is often dormant and germination improves with 90 to 120 days of cold moist stratification. Seeds naturally germinate sporadically in late January and February. If soils are saturated during germination, massive damping off may occur. Seedlings are slow growing and may not reach maturity until their second or third growing season. Plugs, however, are not as sensitive to standing water or saturated soils, grow fast, and will usually produce seed in their first growing season. Fields established from plugs are also longer-lived and higher yielding. In spring, transplants plugs 1foot apart in rows 2 feet apart. If directly sowing seed, drill in 10 to 14-inch wide rows at 8–10 pounds per acre at a depth of ¼ - ½ inch. This is approximately equal to 18 to 22 seeds per linear foot. If tillage is planned, use wider rows and a lower seeding rate.

Establishment rating: Low if directly sown, high if using plugs.

Weed control: Several broadleaf herbicides can be used on this species for new or established stands. Initial weed control is possible with nonselective herbicide applied to weeds after fall sowing and prior to seedling emergence in late winter or spring. In some states, one or more pre-emergent herbicides may be legal to apply for control of weedy grasses in established stands. Hand hoeing, herbicide spot treatments, and row tillage are other options.

Fertilization: Do not apply fertilizer during spring establishment of new seedings if significant weed competition is anticipated. Optionally, apply 15 to 20 lbs N per acre in spring at or prior to seedling

emergence. Apply 40 to 60 lbs N per acre in early spring (March) to established stands.

Pests: Ergot, a seed fungal disease, may be present but has not been a problem in seed increase fields. In the wild, infected seeds should not be collected. The horn-like shape of the ergot allows most infected seed to be screened out in the seed cleaning process. Seedling mortality in wet soil may be the result of a soil pathogen.

Harvest: Seeds ripen variably and shatter when mature. A flail-vac seed stripper is the most efficient harvest method for large or small fields. Small fields can also be harvested by hand stripping or cutting, drying, and mechanically threshing the seed. Swathing and combining is not recommended due to high seed shatter while drying in the very thin swaths. Direct combining is possible but can be inefficient due to high amounts of seed shatter.

Post-harvest residue management: Crop aftermath is minimal, but it can be removed in summer by mowing (1.5 to 2-inch height).

Seed cleaning: A brush machine or debearder is needed to remove awns. Use an air screen machine to remove chaff, weed seeds, and empty seeds.

Average yields/Stand longevity: 50–150 pounds per acre. If directly sown in fall, this species typically does not flower and set seed until the second full growing season. Peak yields may not occur until the third or fourth growing season, even on ideal soils. Plugs will produce seed the first growing season, but will not reach peak yields until the second season. Anticipated stand longevity is 5 to 10 years when using plugs.

Remarks: High seedling mortality can occur in areas with poor drainage or high winter precipitation during germination period.

AGROSTIS EXARATA

spike bentgrass

Life form: Annual or short-lived perennial grass

Pollination: Wind pollinated; capable of self or cross pollination.

Ease of agronomic seed increase: Moderate. In dry environments, plants sometimes act as annuals, so collection and field establishment have to occur each year. Weed control is difficult on this species due to its slow growth. Weeds can quickly overtake the crop before it is mature enough to tolerate herbicides.

Native distribution/Habitat: Spike bentgrass is native from Alaska to South Dakota and south to California, Texas and Mexico. It occurs in a wide variety of habitats including forest openings, grasslands, meadows, marshes, and stream and lake margins from sea level to alpine zones. It is most commonly found in moist, open, disturbed places, but is also found in dry habitats such as semi-arid grasslands.

Ease of wild seed collection: Moderate. Plants usually do not occur in large patches, and seeds are tiny and shatter easily. Seed heads can be cut with rice knives and placed in poly bags.

Seeds per pound: 5,600,000

Establishment: Seeds are not dormant and will germinate in cool to warm temperatures. Drill seed at 1 to 2 pounds per acre (100 pure live seeds per linear foot) at a very shallow depth (1/8th inch). Seeds will germinate within 2 to 4 weeks after sowing. Germination is best in cool temperatures, so fall or early spring sowing is recommended. Plants established in the fall will produce seed the following summer; spring sown fields will act as biennials and usually will not produce seed until the second growing season.

Establishment rating: Medium. Seedlings are slow growing and only a small percentage of seedlings become established.

Weed control: Several broadleaf herbicides can be used on this species for new or established stands. Hand hoeing, herbicide spot treatments, and row tillage are other options.

Fertilization: Optimal fertilization rates and timing are unknown. However, do not apply fertilizer to new fall or spring seedings if significant weed competition is anticipated. Otherwise, apply 15 to 20 lbs N per acre at the time of fall planting, followed by 30 to 40 lbs N per acre in March or early April. For fall seedings made without a starter fertilizer, a single application of 30–40 lbs N per acre in March or April is suggested. For spring seedings, broadcast 30–40 lbs N per acre after stand emergence and initial weed control.

Pests: None observed.

Harvest: Seeds shatter easily when mature. A flail-vac seed stripper is the most efficient harvest method for this species. It can be used multiple times on a field if maturity is highly variable. Because this species shatters very easily, swathing and combining are not the preferred harvest method. Modified swathers that cut and collect the plant material can also be used. After drying on tarps, plant material can be threshed or stationary combined.

Post-harvest residue management: This species often produces only one seed crop and can be tilled under after harvest.

Seed cleaning: Seed is very small and can be easy to clean using an air screen machine, depending on harvest methods. However, it may be difficult to distinguish between filled versus unfilled seed.

Average yields/ Stand longevity: 100–200 lbs per acre. If spring sown, plants will grow vegetatively all year, flower the following spring, and then die. Yields are much higher for spring sown fields because the plants are larger and older, but fields have to be maintained for 18 months before harvest rather than just 9 months with fall sowing. Most plantings act as annuals and will die after harvest; very few plants make it to the second year.

BECKMANNIA SYZIGACHNE

American sloughgrass

Life form: Annual to short-lived perennial bunchgrass

Pollination: Highly self-fertile; may not depend on much out-crossing for seed production.

Ease of agronomic seed increase: Moderate. Stands are short-lived and regular irrigation is required on uplands, coupled with the need for prolonged weed control measures. However, few pests have been noted and seed is typically easy to harvest and clean.

Native distribution/Habitat: Distribution includes Arctic and temperate regions across much of North America and Eurasia from sea level to 4,800 ft in elevation. In North America it occurs from Greenland to Alaska, across all of Canada, and southward to the central and western United States. It is sporadic in the Midwest and Northeast. American sloughgrass is found on very moist, seasonally flooded, and permanently water-logged sites with full sun to partial shade. This includes wet meadows, vernal pools, marshes, disturbed muddy fields, ditch bottoms, shallow standing water, and the edges of lakes, ponds, and streams.

Ease of wild seed collection: Easy. The mature seed (mid- to hard dough stage) is readily hand-stripped from the stalk or the seedheads can be cut off, placed in paper bags, dried in a warm place, and then threshed.

Seeds per pound: Extremely variable, ranging from 200,000 to 700,000 depending on seed conditioning. What is referred to as a "seed" is actually a flattened hull surrounding one or occasionally two seeds. The number of seeds per pound is approximately 2.5 times higher when the hulls are removed.

Establishment: If irrigation is available, new stands can be planted on well-drained, medium- to fine-textured soils on uplands. Otherwise, grow this grass on seasonally wet soils in low-lying areas or floodplains that are accessible to equipment from late spring through early to mid-fall. Most populations appear to lack seed dormancy, but sources from western Oregon have higher germination when de-hulled. Fall sowing is preferred over spring for over winter development and lower initial irrigation requirements. Seed should be drilled at a rate of 4 to 8 pounds per acre in rows 6–12 inches apart and ¼–½ inch deep. Wider rows (18–36 inches) may be needed if tillage is used for weed control and seeding rates can be proportionately reduced. American sloughgrass is shallow rooted and intolerant of drought, so high soil moisture should be continuously maintained within an inch of the surface. New and established plantings on well-drained uplands require periodic summer irrigation until there is sustained fall rain. Fall sown fields can also be grown as an annual crop. Although presumed to be highly self-pollinated, it is advisable not to sprinkler irrigate during flowering.

Establishment rating: High on well prepared sites. Germination and seedling development are relatively fast.

Weed control: Several broadleaf weed control herbicides can be used on this species for new and established stands. One or more pre-emergent herbicides may be legal to apply for control of weedy annual and volunteer grass seedlings. The stand must have produced at least one seed crop. Summer irrigation will stimulate additional weed germination, so year round control practices are often required. Hand hoeing, spot treatments with a nonselective herbicide, and row tillage are other options.

Fertilization: Do not apply nitrogen fertilizer to new fall or spring seedings if significant weed competition is anticipated. Optionally, apply 15–25 pounds N per acre at planting or after grass seedling emergence and initial weed control. Optimal fertilization rates and timing for established stands have not been determined. Until more is known, it is suggested that 50–75 pounds N per acre be applied in late February or March if fields are accessible. On low-lying ground that is too wet to fertilize or operate equipment on in winter, a split application (one third in early fall and two thirds in late spring) is advised.

Pests: When grown on uplands without adequate irrigation, stressed plants are more prone to pests and diseases. However, few specific diseases have been documented for American sloughgrass under seed production. The Corvallis PMC experienced a significant infestation of crane fly larva feeding on the roots, but insect pests have not been widely reported in the region.

Harvest: Harvesting is typically done by direct combining followed by seed drying. Seed retention is above average. Combine when most seed is in mid- to hard dough stage and minimal shattering has occurred. If maturation is less uniform, it may be necessary to swath the field and allow the windrows to dry in the field for 10 to 14 days before combining.

Post-harvest residue management: Crop aftermath should be promptly removed after seed harvest with a flail chopper (forage harvester) and wagon or baler. The remaining stubble should be left a few inches tall.

Seed cleaning: The seeds require no special conditioning and are usually easy to clean with an air-screen machine. However, seed of some populations have higher germination rates when de-hulled.

Average yield/Stand longevity: 300–500 pounds per acre. This species typically does not flower and set seed until after the stand has gone through one winter if spring or fall sown. Peak yields may not occur until the second growing season. Anticipated stand longevity is 3 to 5 years (2 to 4 seed crops) under optimal conditions.

BROMUS CARINATUS

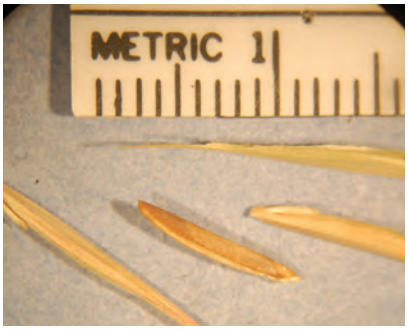
California brome

Life form: Short-lived perennial bunchgrass

Pollination: Wind pollinated.

Ease of agronomic seed increase: Easy. Seeds can be sown with most seed drills, decent stands are easy to establish, fields can be mechanically harvested, and seed is relatively easy to clean. Plants are competitive with weeds and seed yields are dependable and high for a native grass. However, good seed production for some populations may be limited to only a few years.

Native distribution/Habitat: Native from British Columbia and Alberta south to California, Texas, and much of Mexico and eastward to Montana, Wyoming, Colorado, and New Mexico. California brome typically grows in open woods and forests, shrublands, grasslands, meadows, and waste places from sea level to 11,000 ft.



Ease of wild seed collection: Easy. Seeds can easily be hand stripped from the plants, which are usually found in large populations. This species is very similar to two other native brome species, *B. pacificus* and *B. sitchensis*.

Seeds per pound: 60,000

Establishment: Seed dormancy is usually low or nonexistent, so seed can be drilled in the fall or spring at a rate of 6 to 10 pounds per acre (20 pure live seeds per linear foot) and a depth of ¼ to ¾ inch. A row spacing of 12 to 18 inches is suggested unless wider rows (24–36 inches) are needed for tillage. The lower end seeding rate is used for wider rows.

Establishment rating: High. Seedlings are fast growing and have high establishment.

Weed control: Several broadleaf herbicides can be used on this species in both new and established stands. Pre-emergent herbicides can help control weedy grass seedlings. Hand hoeing, spot treatments with a nonselective herbicide, and row tillage are other options.

Fertilization: Do not apply fertilizer to new fall or spring seedings if significant weed competition is anticipated. In milder growing climates such as western Oregon, apply 50–60 lbs N per acre in late winter (late February to early March) to established stands as drainage conditions allow.

Pests: Rust can sometimes be a problem on this species; it can easily be controlled with foliar spray fungicides. This species can be susceptible to ergot and head smut. Most ergot bodies can be removed from the seed lot during seed cleaning. Smut is controlled by using a systemic seed treatment or planting smut-free seed.

Harvest: If seed maturation within the stand is relatively uniform, harvesting is done by direct combining then drying the seed afterwards. The best time to harvest is when most seed is in mid to hard dough stage with minor shattering occurring on some seedheads. Alternatively, more variable maturing stands are swathed (windrowed) first and then combined. Swath the stand when most seed is soft to hard dough stage, generally a few days earlier compared to straight combining. Follow up a week or two later by combining the dry seed stalks and seedheads.

Post-harvest residue management: The remaining straw and standing stubble should be promptly removed by either baling, clipping with a flail chopper (forage harvester) equipped with a collection wagon, or open field burning. If the stubble left after harvest is tall, it should be windrowed or mowed prior to baling. Timely removal of crop aftermath is likely to improve yields the following year. Fields are dormant in summer, but will begin growing when rain begins in the fall.

Seed cleaning: Seeds have small awns that can easily be removed using a brush machine. This will improve flow in seed cleaning and planting equipment. Air screen machines should be used to remove chaff and empty seeds.

Average yields/Stand longevity: 300–400 pounds per acre. This species will flower and set seed in its first growing season, but peak yields are reached in the second and third growing season. Fields should be removed after three or four years, as most plants do not live longer than five years.

Remarks: Very easy species to work with, especially if seed maturation is relatively uniform within a field.

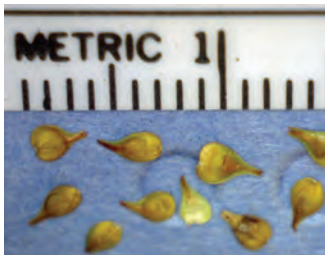
CAREX DENSA

dense sedge

Life form: Perennial sedge

Pollination: Sedges are usually wind pollinated and capable of self-pollination.

Ease of agronomic seed increase: Moderate. Fields should be established using transplants due to the slow growth of the plants and to reduce weed pressure. Seed retention is moderate and maturity is often uniform.



Native distribution/ Habitat: Found on the west side of the Cascade Mountain range from central Washington (rare), throughout western Oregon, to northern California. Grows in dense tufts 1.5–3.5 feet tall in seasonally wet areas, such as in vernal pools, on ditchbanks, or wet meadows and marshes from coastal lowlands to western hillsides.

Ease of wild seed collection: Moderate. *Carex densa* should be fairly easy to identify as it has a specific growth habit and generally has relatively large inflorescences (1 to 2¼ inches long by ½ to 1 inch wide) on tall stems (up to waist-height).

Seeds per pound: 600,000–700,000

Establishment : Seeds are non-dormant and require warm soil temperatures to germinate. Seeds naturally germinate in late spring. Establishing fields from plugs is recommended. Plugs are grown in a greenhouse over winter, and transplanted out into fields in the spring on 1 foot by 1 foot spacing. This method creates cleaner fields and results in an established productive field in the first growing season. For direct seeding, seeds should be sown at a rate of 100 seeds per square foot, or 6–7 pounds per acre. Seeds need light to germinate; sow as close to the surface as possible in rows 10–14 inches apart unless wider spacing is needed for cultivation between rows. Early spring or late winter sowing is preferred, but seeds will not germinate until late spring.

Establishment rating: High from plugs, low to medium if directly sown.

Weed control: Most broadleaf herbicides do not damage sedges when grown for seed, but check labels for what can be legally applied in your state. 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.

Fertilization: Sedges typically don't begin active growth until late spring; apply 16-16-16 fertilizer at 50 lbs/ac as soon as new growth appears in spring to increase plant vigor and seed yield.

Pests: None observed.

Harvest: Seeds shatter moderately when ripe, but fields usually mature uniformly. The most effective harvest method is to cut and collect material with a modified swather, lay material on tarps to dry,

and then feed it into a stationary combine. Direct combining may be a better option depending on the amount of foliage on the plants. Swathing material to dry in the field, then following with a combine two weeks later is generally not recommended due to the amount of seed lost during swathing and drying.

Post-harvest residue management: *Carex densa* will tolerate a light burn or mowing to 3 inches to remove harvest residue and promote the following year's growth.

Seed cleaning: Seeds are easily removed from inflorescences using either a combine (during the harvesting process), a stationary combine, or a thresher. An air-screen machine will further separate seed from remaining plant materials and debris.

Average yields/Stand longevity: 20–250 pounds per acre. Fields established from plugs will produce a seed crop the first year and reach peak production in year two. Fall sown fields will not produce any seed the first year and will most likely have a moderate crop the second year, then peak in year three. Summer irrigation in the first year will boost yields in the second year. Fields can remain productive for 8 to 10 years. Seed also remains viable in good storage conditions for up to ten years.

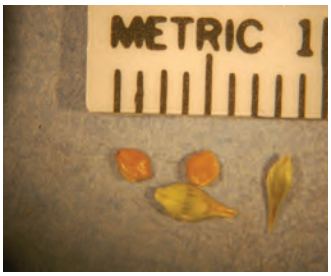
CAREX DEWEYANA

Dewey's sedge

Life form: Perennial sedge

Pollination: Sedges are usually wind pollinated and capable of self-pollination.

Ease of agronomic seed increase: Moderate. Fields should be established using transplants due to the slow growth of the plants and to reduce weed pressure. Seed retention is moderate and maturity is often uniform. This species is not as vigorous as other sedges.



Native distribution/ Habitat: Open, often alluvial forests, stream-banks, and clearings at low to middle elevations. Found in the mountains of northern Washington up to Alaska and as far east as Illinois.

Ease of wild seed collection: Moderate. Plants may be difficult to locate as they are usually intermixed with other species. Seeds retention is moderate, but seed maturity can vary widely depending on how sunny the site is.

Seeds per pound: 760,000

Establishment : Seeds are usually not dormant and naturally germinate in late spring. Establishing fields from plugs is recommended. Seeds prefer warm conditions and light to germinate. Grow in a greenhouse and transplant out into fields in spring on 1 foot by 1 foot spacing. This method creates cleaner fields and results in an established productive field in the first growing season. For direct seeding, seeds should be sown at a rate of 100 seeds per square foot, or 6–8 pounds per acre. Seeds need light to germinate; sow as close to the surface as possible in rows 10–14 inches apart unless wider spacing is needed for cultivation between rows. Spring sowing is preferred over fall sowing, but seeds will not germinate if they are buried too deeply, and they require adequate moisture during warm temperatures. As it can be difficult to create this environment in the field, plugs are the preferred establishment method.

Establishment rating: High when grown from plugs, very low when direct sown.

Weed control: Most broadleaf herbicides do not damage sedges when grown for seed, but check labels for what can be legally applied in your state. 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.

Fertilization: Sedges typically don't begin actively growing until late spring; apply a balanced fertilizer such as 16-16-16, at a rate of 50 lbs/ ac as soon as new growth appears.

Pests: Rust has been observed, but doesn't appear to affect seed production.

Harvest: Seeds shatter moderately when ripe, but fields usually mature uniformly. The most effective

harvest method is to cut and collect material with a modified swather, lay out material to dry, and then feed it into a stationary combine. Direct combining is usually ineffective due to the amount of green material present when seeds are ripe. Swathing material to dry in the field, then following with a combine two weeks later is generally not recommended due to the amount of seed lost during swathing and drying. Also, most fields will not be thick enough to make adequate swaths.

Post harvest residue management: Harvest methods usually remove most of the plant material. Any remaining straw or stubble can be removed by mowing or burning.

Seed cleaning: Use a thresher or stationary combine to shatter seeds from stems. Then run material through an air-screen machine to remove stems, chaff, and unfilled seeds to reach desired purity standards.

Average yields/Stand longevity: 25–100 pounds per acre. Fields established from plugs will produce a seed crop the first year and reach peak production in year two. Directly sown fields will not produce any seed the first year, will most likely have a moderate crop the second year, and then peak in year three. Summer irrigation in the first year will boost yields in the second year. Fields in full sun will only live for about four to five years.

CAREX FETA

green-sheath sedge

Life form: Perennial sedge

Pollination: Sedges are usually wind pollinated and capable of self-pollination.

Ease of agronomic seed increase: Moderate. Fields should be established using transplants due to the slow growth of the plants and to reduce weed pressure. Seed retention is low, but maturity is often uniform within areas of similar hydrology.

Native distribution/Habitat: Wet meadows, prairie, margins of marshes, and road ditches at low to mid elevations west of the Cascade mountains from British Columbia to California.

Ease of wild seed collection: Moderate. Seedheads may be cut just as they turn from green to yellow using rice knives or pruners. Seeds shatter when they are green and may appear immature. Seeds should be checked for maturity by pinching the seed between two thumbnails. If any liquid or thin paste comes out they are not mature and should not be collected. The earliest seed should be collected when the seeds are squeezed and "hard dough" or mashed potatoes comes out.

Seeds per pound: 720,000

Establishment: Seeds are usually not dormant and naturally germinate in late spring.

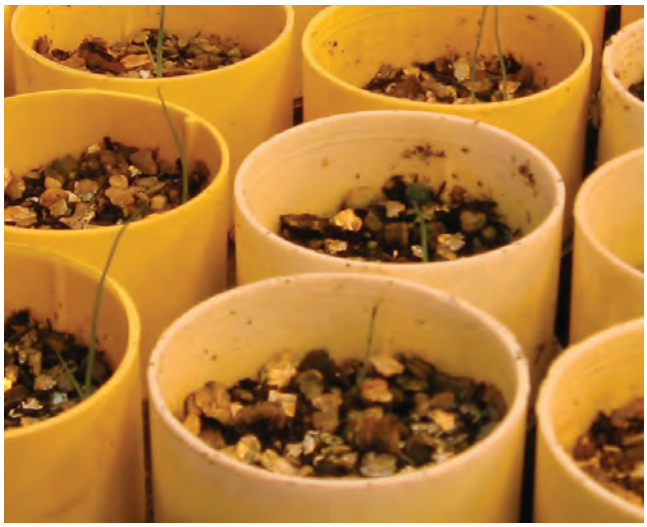
Establishing fields from plugs is recommended. Seeds prefer very warm conditions (75 to 100°F) and light to germinate. Grow in containers in a greenhouse and transplant out into fields in spring on 1 foot by 1 foot spacing. This method creates cleaner fields and results in an established productive field in the first growing season. For direct seeding, seeds should be sown at a rate of 100 seeds per square foot, or 6–8 pounds per acre. Seeds need light to germinate; sow as close to the surface as possible in rows 10–14 inches apart unless wider spacing is needed for cultivation between rows. Spring sowing is preferred over fall sowing, but seeds will not germinate if they are buried and they require high soil moisture during warm temperatures. It can be difficult to create this environment in the field, so plugs are the preferred establishment method. Seedlings will need summer irrigation for establishment the first year.

Establishment rating: High when using plugs, low when direct sown.

Fertilization: Sedges typically don't begin active growth until late spring; apply a balanced fertilizer at a rate of 50 lbs/ac as soon as new growth appears.

Weed control methods: Most broadleaf herbicides do not damage sedges when grown for seed, but check labels for what can be legally applied in your state. 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.

Pests: None observed.



Harvest: Seeds shatter moderately when ripe, but fields usually mature uniformly. The most effective harvest method is to cut and collect material with a modified swather, lay material to dry, and then feed it into a stationary combine. Direct combining is usually ineffective due to the amount of green material present when seeds are ripe. It is generally not recommended to swath material to dry in the field and then follow with a combine two weeks later due to the amount of seed lost during swathing and drying.

Post harvest residue management: Harvest methods usually remove most of the plant material. Any remaining straw or stubble can be removed by mowing.

Seed cleaning : Use a thresher or stationary combine to shatter seeds from stems. Then run material through an air-screen machine to remove stems, chaff, and unfilled seeds to reach desired purity standards.

Average yields/Stand longevity: 40–300 pounds per acre. Fields established from plugs will produce a seed crop the first year and reach peak production in year two. Direct-sown fields will not produce any seed the first year, will most likely have a moderate crop the second year, and then peak in year three. Summer irrigation in the first year will boost yields in the second year. Fields on uplands will only live for about four to five years. Fields planted in seasonally flooded areas will live longer and have higher yields.

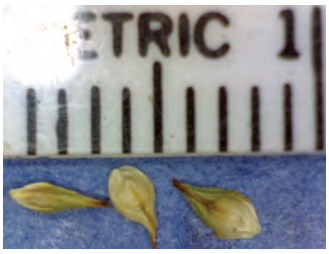
CAREX PACHYSTACHYA

chamisso sedge

Life form: Perennial sedge

Pollination: Sedges are usually wind pollinated and capable of self-pollination.

Ease of agronomic seed increase: Moderate. Fields should be established using transplants due to the slow growth of the plants and to reduce weed pressure. Seed retention is moderate and maturity is often uniform.



Native distribution/ Habitat: Widespread in mesic transition zones between wet and drier habitats, in moist meadows, wet prairie, marsh edges, forest edges, and roadsides; common at low elevations but extending to high elevations. Found from Alaska to California and west to Colorado.

Ease of wild seed collection: Moderate. This species is usually found in large patches, but heads must be collected individually because they grow intermixed with other species. Carex pachystachya resembles other native sedges, but cannot be easily confused with any non-native sedges.

Seeds per pound: 750,000–800,000

Establishment: Seeds are usually dormant and need six or more weeks cold-moist stratification before germinating when temperatures increase in late spring. Establishing fields from plugs is recommended. To overcome seed dormancy, sow seeds in containers and place in a cooler (45°F or lower) for at least six weeks. Alternately, containers can be placed outside in early September through December for six weeks. After a cold period, move containers to a greenhouse set between 70 and 80°F in late December. Seeds should germinate within 2–4 weeks if they receive heat, light, and water. Grow in a greenhouse and transplant out into fields in spring on 1 foot by 1 foot spacing. This method creates cleaner fields than direct sowing, and results in an established productive field in the first growing season. For direct sowing (not recommended), seeds should be sown at a rate of 100 seeds per square foot, or 6–8 pounds per acre.

Seeds need light to germinate; sow as close to the surface as possible in rows 10–14 inches apart unless wider spacing is needed for cultivation between rows. Fall sowing is preferred, but seeds will not germinate until spring. Early spring sowing is not recommended, but can result in an established field if seeds still receive the six weeks of cool temperatures needed to break dormancy.

Establishment rating: High from plugs, low to moderate if directly sown.

Fertilization: Sedges typically don't begin actively growing until late spring; apply a balanced fertilizer at a rate of 50 lbs/ac as soon as new growth appears.

Weed control: Most broadleaf herbicides do not

damage sedges when grown for seed, but check labels for what can be legally applied in your state. 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.

Pests: This species is usually pest-free, but some high elevation ecotypes may experience infections from fungal pathogens if grown in a low, wet area.

Harvest: Seeds shatter moderately when ripe, but fields usually mature uniformly. The most effective harvest method is to cut and collect material with a modified swather, lay material to dry, and then feed it into a stationary combine. Direct combining is usually ineffective due to the amount of green material present when seeds are ripe. Swathing material to dry in the field, then following with a combine two weeks later is generally not recommended due to the amount of seed lost during swathing and drying.

Post-harvest residue management: Harvest methods usually remove most of the plant material. Any remaining straw or stubble can be removed by mowing or burning.

Seed cleaning: Seeds should be dislodged from stems by threshing or stationary combining. Air-screen machines are then used to separate seeds from chaff, weed seeds, and other debris.

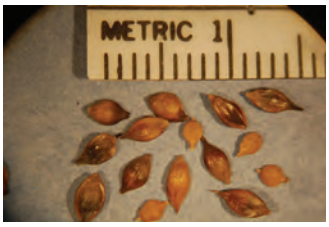
CAREX PANSA

sanddune sedge

Life form: Rhizomatous perennial sedge

Pollination: Wind pollinated and capable of self-pollination, however most plants have either predominantly female or male flowers with a few flowers of the opposite sex mixed in.

Ease of agronomic seed increase: Difficult. Plants are long-lived and hardy, but produce very little seed in cultivated settings.



Native distribution/ Habitat: Coastal sand dunes and sandy meadows from British Columbia to California.

Ease of wild seed collection: Easy. Seeds do not shatter easily and therefore may be collected at one time late in the season. Seeds are often plentiful in the wild, but are usually intermixed with other species.

Seeds per pound: 500,000

Establishment : Seeds should be dehulled for optimum germination. Seeds are usually not dormant and naturally germinate in late spring. Establishing fields from plugs is recommended. Seeds prefer very warm conditions (75–100°F) and light to germinate. Start in containers in a greenhouse and transplant out into fields in spring on 1 foot by 2 foot spacing. This method creates cleaner fields than direct sowing, and results in an established productive field in the first growing season. For direct seeding, seeds should be sown at a rate of 100 seeds per square foot, or 7–9 pounds per acre. Seeds need light to germinate; sow as close to the surface as possible in rows 18–24 inches apart unless wider spacing is needed for cultivation between rows. Spring sowing is preferred over fall sowing, but seeds will not germinate if they are buried and require adequate moisture during warm temperatures. As it can be difficult to create this environment in the field, plugs are the preferred establishment method.

Establishment rating: High when using plugs, low when direct sown.

Weed control: Most broadleaf herbicides do not damage sedges when grown for seed, but check labels for what can be legally applied in your state. 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.

Fertilization: Sedges typically don't begin active growth until late spring; apply a low rate of balanced fertilizer (16-16-16 at 20 pounds per acre) as soon as new growth appears. In trials performed at the Corvallis PMC, fertilization did not appear to increase seed yields in the year it was applied, but the plants produced more biomass, which may increase yields in future years.

Pests: None observed.

Harvest: Seeds do not shatter when ripe, so a late one-time harvest can be performed after all seed is mature. The most effective harvest method is to cut and collect material with a modified swather, lay material to dry, and then feed it into a stationary combine. Direct combining is usually ineffective due to the amount of green material present when seeds are ripe. It is generally not recommended to swath material to dry in the field, then follow with a combine two weeks later because the plants are usually not thick enough to create functional swaths.

Post harvest residue management: Harvest methods usually remove most of the plant material. Any remaining straw or stubble can be removed by mowing or burning.

Seed cleaning: Seeds are very difficult to dislodge from the seedheads. When material is very dry, a stationary combine with high cylinder speed and a "tight" concave will work moderately well. Material may have to run through the combine many times to remove most of the seed. Then run material through an air-screen machine to remove stems, chaff, and unfilled seeds to reach desired purity standards.

Average yields/Stand longevity: 1–25 pounds per acre. Plants grown from plugs will usually produce seed in their second year. Seed production is very low. Plants are very long-lived and extremely hardy.

Remarks: This species is not well suited to agronomic seed increase. Plants are highly vegetative and can be easily divided. Seed is often plentiful in the wild and may be collected in larger quantities than in a seed increase field.

CAREX TUMLICOLA

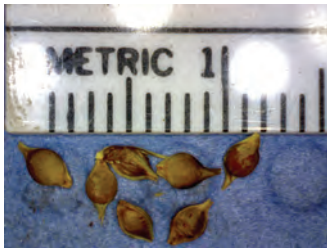
splitawn sedge

Life form: Rhizomatous perennial sedge

Pollination: Sedges are usually wind pollinated and capable of self-pollination.

Ease of agronomic seed increase: Moderate. Plants are long-lived and hardy, but are slow to become established and have low yields.

Native distribution/Habitat: Grasslands, oak savanna, dry slopes, and openings in forests at low elevations on the west side of the Cascade and Sierra Nevada ranges from southern British Columbia to southern California.



Ease of wild seed collection: Medium. Seeds do not shatter easily and therefore may be collected just once late in the season. Plants are usually located in dense patches.

Seeds per pound: 324,000

Establishment: Seeds are usually dormant and naturally germinate in late spring. Establishing fields from plugs is recommended. It is easiest to sow seed in containers in late fall and place outside for 4 to 6 weeks to cold-moist stratify. Then move containers into a greenhouse. Seeds need very warm conditions (75–100°F) and light to germinate.

Transplant out into the field in spring on 1 by 2 foot spacing. This method creates cleaner fields than direct sowing, and results in an established productive field in the first growing season. For direct seeding (not recommended), seeds should be sown at a rate of 100 seeds per square foot, or 5–7 pounds per acre. Seeds need light to germinate; sow as close to the surface as possible in rows 12–16 inches apart unless wider spacing is needed for cultivation between rows. Spring sowing is preferred over fall sowing, but seeds will not germinate if they are buried and they require adequate moisture during warm temperatures. As it can be difficult to create this environment in the field, plugs are the preferred establishment method.

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

Weed control: Most broadleaf herbicides do not damage sedges when grown for seed, but check labels for what can be legally applied in your state. Weed control is performed by spot application of herbicide or cultivation between rows when there is sufficient space. Otherwise, hand weeding is the preferred method for control.

Fertilization: Sedges typically don't begin actively growing until late spring; apply a balanced fertilizer at a rate of 50 lb/ac as soon as new growth appears.

Pests: Rust has been observed, but does not appear to affect seed yields.

Harvest: Seeds do not easily shatter, so a one-time harvest can be performed when the latest seed matures. The most effective harvest method is to cut and collect material with a modified swather, lay material to dry, and then feed it into a stationary combine. Direct combining is usually ineffective due to the sparseness of the stands; there is not enough material to feed through most combines. Swathing material to dry in the field is generally not recommended either because the plants are usually not thick enough to create functional swaths.

Post-harvest residue management: Harvest methods usually remove most of the plant material. Any remaining straw or stubble can be removed by mowing or burning.

Seed cleaning: Use a thresher or stationary combine to dislodge seed from seedheads. Then run material through an air-screen machine to remove stems, chaff, and unfilled seeds to reach desired purity standards.

Average yields/Stand longevity: 50–100 pounds per acre. Plants established from plugs can produce a minimal amount of seed their first year and reach peak production in year two. Directly sown fields will not produce any seed the first year, will most likely have a moderate crop the second year, and then peak in year three. Summer irrigation in the first year will boost yields in the second year. Plants are long-lived and can be expected to produce seed for well beyond five years.

DANTHONIA CALIFORNICA

California oatgrass

Life form: Perennial bunchgrass

Pollination: Both self-pollination and cross-pollination (by wind) occur on each plant.

Ease of agronomic seed increase: Moderately difficult. Stands are long-lived and hardy once established, but plants need a couple years to fully develop. Extracting and cleaning two distinct types of seed (panicle seed and hidden stem seed) may require additional steps depending on harvest equipment or method.

Native distribution/ Habitat: Western Canada and the western United States from British Columbia to Saskatchewan, south to southern California, and west to South Dakota and the Rocky Mountain states from Montana to New Mexico. Varies widely from very dry sites with shallow or serpentine soils including rocky outcrops and steep south and west facing slopes, to oak savanna, pine woodlands, chaparral, moist coastal grasslands, upland prairie, and transitional wetlands with intermittent flooding. Adaptation includes moderately coarse- to fine-textured soils in full sun to light shade.

Ease of wild seed collection: Moderately easy from sites where the species is dominant, but volume can be limited by thin stands or low seed productivity of wild plants. Seeds can be hand stripped or entire stems may be cut, which would also include additional stem seed (enclosed within the leaf sheath).

Seeds per pound: 90,000–165,000 depending on the degree of seed conditioning, genetics, and environment.

Establishment: Establishing fields from plugs is recommended. Seeds are often dormant and germinate in early spring if sown the previous fall. If soils are saturated during germination, some damping off may occur. Seedlings are slow growing and may not reach maturity until their second or third growing season. Plugs, however, grow fast and will usually produce seed in their first growing season. Fields established from plugs are also longer-lived and higher yielding. Seed dormancy is best overcome by cold moist stratifying the seed for at least 90 days. In spring, plugs should be transplanted a foot apart in rows two feet apart. If directly sowing the seed, it must be fall sown for adequate germination in spring. Drill at 8 to 16 pounds per acre at depths of 1/8–1/4 inch in rows 10–16 inches wide. Wider rows may be needed with mechanical cultivation. High seeding rates hedge against potential low or inconsistent germination. Despite the seed size, use shallow seeding depths because seeds of this species require light to germinate.

Establishment rating: From direct seeding, medium, due to risk of low or delayed germination from dormant seed. Seedlings develop slowly, but generally appear disease resistant. Establishment is high from plugs.

Weed control: Several broadleaf herbicides can be used on this species for new or established stands. For highly dormant seed lots, initial weed control is possible with a nonselective herbicide applied to weeds after fall sowing and prior to crop seedling emergence in late winter or early spring. In some states, one or more pre-emergent herbicides may be legal to apply for control of weedy grass seedlings in established stands. Hand hoeing, herbicide spot treatments, and row tillage are other options.

Fertilization: Do not apply fertilizer during spring establishment of new seedings if significant weed competition is anticipated. In milder growing climates, apply 50–60 lbs N per acre in late winter to early spring (March) to established stands.

Pests: Insect problems have not been encountered to date. While this grass is a host for the fungus which causes blind seed, this and other grass diseases such as rust, ergot, or smut have not been significant.

Harvest: Harvesting is best done by swathing (windrowing) followed by combining (threshing) the seed stalks two weeks later after the seed has dried. Combine cylinder selection and settings can be made to simultaneously thresh both seedhead (panicle) seed and hidden stem seed while minimizing damage. To obtain the highest yields, harvest the two types of seeds separately by harvesting panicle seed using a seed stripper then drying the seed on tarps. After seed stripping, stems can be swathed, dried for a week or so, then combined to remove stems seeds and remaining panicle seeds. This double harvest method can result in yields of over 500 lbs per acre on mature fields.

Post-harvest residue management: Crop aftermath, which is moderate in quantity compared to more robust grasses, is removed with a flail chopper (forage harvester) and wagon or by baling then mowing the remaining crowns to a height of 2-3 inches. While the species is known for high tolerance to fire in the wild, the effect on seed production of thermal sanitation methods such as open field burning or propane-flaming is unknown.

Seed cleaning: Seeds usually have small awns that can be removed by running them through a brush machine; this will improve the flow of the material through seed cleaning and planting equipment. The seed can be cleaned with an air-screen machine to separate out stems, chaff, weed seeds, and empty seeds. Care is needed to prevent disposal of narrow stem seeds and dehulled panicle seeds. Panicle and stem seeds can be cleaned separately to reduce losses. Attempts to remove the hull with mechanical devices are not recommended because the embryo is easily damaged in this type of seed conditioning.

Average yields/Stand longevity: Highly variable, 100-500 pounds per acre. This species typically does not flower and set seed until the second summer after fall sowing. Peak yields may not occur until the third or fourth growing season even under optimal conditions. Anticipated stand longevity is 9-12 years, sometimes longer.

Remarks: Can be a challenging crop to produce because of multiple issues with the seed.

DESCHAMPSIA CAESPITOSA

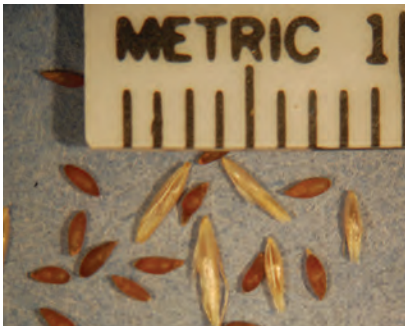
tufted hairgrass

Life form: Perennial bunchgrass

Pollination: Highly cross-pollinated by wind.

Ease of agronomic seed increase: Moderately easy. Stands are typically long-lived, hardy and resilient once established, but seed shatters readily at maturity and supplemental irrigation may be needed in drier situations.

Native distribution/Habitat: Distribution includes most arctic and temperate regions of the world from sea-level to 14,000 feet in the mountains. In North America, it occurs from Greenland to Alaska, across of all of Canada, and southward to include most of the United States except the Central and Southern Plains and Southeast. It grows on moderately moist to seasonally flooded, water logged sites with full sun to partial shade. This includes upper tidal marshes, inland wet prairies, floodplains, streambanks, lakeshores, and moist mountain meadows above timberline.



Ease of wild seed collection: Moderately easy but the tiny seed may not be readily hand stripped. Seed is best collected by cutting off and then drying and threshing the seedheads.

Seeds per pound: 1,100,000 to 2,500,000 depending on population and degree of seed conditioning.

Establishment: Most sources have non-dormant seed which can be spring or fall seeded. However some populations, particularly those of alpine origin, can have dormant seed and therefore benefit substantially from 45 to 90 days of cold moist stratification or fall sowing if not pre-treated. New stands can be planted on well-drained, medium- to fine-textured soils on uplands as well as poorly-drained soils in low lying, seasonally flooded areas with a pH of 5.5 to 7.5. Drill seed at 1 to 2 pounds per acre at a very shallow depth of 1/8 to ¼ inch. Because seed yields of large, robust ecotypes are sensitive to spacing, 24–40 inch wide rows are suggested even if cultivation between rows is not practiced. Narrower rows (10–18 inches) may be acceptable for smaller plants originating from interior and high elevation regions. Spring planted stands should receive periodic summer irrigation the first year. Established stands may also benefit from regular irrigation, especially on lighter upland soils, in lower precipitation zones, or during dry years. Sprinkler irrigation should be avoided during flowering.

Establishment rating: Medium due to slow initial growth and associated risk from early weed competition.

Weed control: Several broadleaf herbicides can be used on this species for new or established stands.

In some states, one or more pre-emergent herbicides may be legal to apply for control of weedy grass seedlings in established stands. Hand hoeing, herbicide spot treatments, and row tillage are other options.

Fertilization: Do not apply fertilizer to new fall or spring seedings if significant weed competition is anticipated. Optionally, apply 20 to 30 lbs N per acre at planting or soon after seedling emergence. In milder growing climates such as western Oregon, apply 80–120 lbs N per acre in late winter to early spring (late February to March) to established stands in a single or split treatment as drainage conditions allow. Lower rates and later spring application dates may be optimal for populations originating from, and grown in, interior regions of the Pacific Northwest. Studies at the Corvallis PMC showed no increase in seed yields from supplemental fall fertilization (25 lbs N per acre).

Pests: Tufted hairgrass can be susceptible to diseases including ergot, several rusts, stripe smut, blind seed, several leaf spots, rapid blight, and the turf disease, take-all patch. Insect pests can include aphids, billbugs, and leafhoppers. However, when locally adapted material is grown, insect and disease pests have been of minor concern in seed production.

Harvest: Harvesting is done either by (1) swathing (windrowing) followed by combining the dry seed stalks a week or two later, (2) direct combining then drying the seed, or (3) direct removal of seed from the seedheads using a flail-vac seed stripper then drying the seed. If windrowed, it is recommended that seed be at soft to mid dough stage (late June to early July in western Oregon) and allowed to cure in the field for 10 to 14 days before combining. Direct combining is done when 5 to 10% of the seed has shattered. When using a swath/combine or direct combine method, leave a stubble height similar to the height of the tuft to reduce the amount of herbage passing through the combine.
Post-harvest residue management: Crop aftermath may be substantial and should be promptly removed after seed harvest with a baler or a flail chopper (forage harvester) equipped with a collection wagon. The remaining stubble should be left at a height of 3 to 4 inches. This may necessitate an additional mowing operation prior to or after baling. Over time, crowns of robust ecotypes become rank and elevated and thus susceptible to damage from chopping or mowing at lower heights. Field burning to remove residue has decreased or failed to increase seed yields in some trials at the Corvallis PMC and is not a recommended practice for this species.

Seed cleaning: Seed that has been delinted (hairs and awns removed from the hulls by a brush machine) will flow more readily and precisely through standard drills and broadcast seeders. Seed can be delinted using a brush machine, then further cleaned using an air-screen machine to remove chaff, weed seeds, and empty seeds.

Average yields/Stand longevity: 250–350 pounds per acre. This species typically does not flower and set seed until after the stand has gone through one winter if spring sown or two winters if fall sown. Peak yields may not occur until the third growing season even under ideal growing conditions. Anticipated stand longevity is 6 to 12 years.

Remarks: This is a highly variable and widespread species, so seed production techniques need to be adjusted to local plant growth traits, development, and stature, as well as soil and climatic conditions for optimal yields.

DESCHAMPSIA DANTHONIOIDES

annual hairgrass

Life form: Annual bunchgrass

Pollination: It is unknown if this species is predominantly cross-pollinated, self-pollinated, or both.

Ease of agronomic seed increase: Moderate. Control of certain weedy annual grasses can be problematic, as can the removal of their seeds during seed cleaning.

Native distribution/Habitat: The primary range of this species extends from British Columbia southward through Washington, Oregon, and Idaho, down to Baja California, and eastward to Montana and Utah. Known occurrences in other regions of North America are probably the result of introductions. Moist to dry, open sites, disturbed ground, coastal and mountain meadows, streambanks, vernal pools, and shallow depressions dominated by annuals. This grass grows on moderately acidic to alkali soil in full sun. Populations tolerate shallow inundation for up to 60 days or more during winter.

Ease of wild seed collection: Moderately easy, but the tiny seed may not be readily hand stripped. Seed is best collected by cutting off the entire seedhead for drying and threshing.

Seeds per pound: 900,000 to 1,100,000 depending on population and degree of seed conditioning.

Establishment: New stands can be planted on well-drained, coarse to fine-textured soils on uplands as well as somewhat poorly-drained soils in depressions or seasonal floodplains. The seed typically has no dormancy, but as a winter annual, the life cycle of this species is best suited to early fall sowing, especially in milder climatic regions of the Pacific Northwest. Seed should be drilled at a rate of 1 to 2 pounds per acre at a shallow depth of 1/8–1/4 inch. Narrow row spacing of 10 to 14 inches is advised unless wider rows are needed for cultivation. In western Oregon, fall seedings do not need irrigation. Spring seeding or any planting made in the interior Northwest may benefit from supplemental water in dry years.

Establishment rating: High. Annual hairgrass germinates and establishes readily on clean ground, but it may be a poor competitor with certain annual weeds.

Weed control: Several broadleaf weed control herbicides can be used on this species. However, annual grass weeds such as annual bluegrass and rattail fescue can be problematic. Hand hoeing, spot treatments with a nonselective herbicide, and row tillage are other options.

Fertilization: Optimal fertilization rates and timing are unknown. Avoid appling fertilizer to new fall or spring seedings until weeds are under control. For fall seedings made without a starter fertilizer, a single application of 30 to 40 pounds N per acre

in March is suggested. For spring seedings, broadcast 30 to 40 pounds N per acre after stand emergence and initial weed control.

Pests: This species can be susceptible to ergot, but it has not been problematic at the Corvallis PMC.

Harvest: This is one of the earlier flowering and maturing grasses in western Oregon. Seed retention is fair and fill is usually good. Harvesting is done either by (1) swathing at mid-dough stage followed by combining the windrow 10 to 14 days later, (2) direct combining then drying the seed if maturation of the stand is uniform, or (3) direct removal of seed from the seedheads using a flail-vac seed stripper then drying the seed. Seed stripping should only be done on clean fields because the head must be held low to the ground, thereby increasing the likelyhood of vacuuming weed seed from the soil surface.

Post-harvest residue management: As an annual, crop aftermath and standing stubble can be left on the field after harvest. Residue is typically incorporated into the soil at a later date.

Seed cleaning: Seed that has been deawned will flow more readily and precisely through standard drills and broadcast seeders. Air-screen machines can be used to remove chaff, weed seeds, and empty seeds.

Average yields/Stand longevity: Highly variable, 50–350 pounds per acre. When fall sown, this species flowers in April or early May and sets seed by early to mid-June. Spring plantings will presumably produce a seed crop the same summer. Stand longevity is a single growing season.

Remarks: This is an adaptable and productive annual that doesn't appear to be a weed threat for perennial seed crops.

DESCHAMPSIA ELONGATA

slender hairgrass

Life form: Annual or biennial grass

Pollination: Self and cross-pollination facilitated by wind.

Ease of agronomic seed increase: Moderate. Plants often act as annuals, so collections and field establishment have to occur each year. Weed control is difficult on this species due to its slow growth. Weeds can quickly overtake the crop before it is large enough to tolerate herbicides.

Native distribution/ Habitat: This species is native to western North America from Alaska to Wyoming through northern Mexico, and South America in Chile. Slender hairgrass occurs in a wide variety of habitats from sea level to 10,000 ft in elevation including forest openings, woodlands, grasslands, meadows, marshes, valley floodplains, and stream and lake margins, although it is most commonly found in moist soil in open habitats.

Ease of wild seed collection: Moderate. Plants are often scattered and do not occur in large patches. Plants in moist areas are often larger and, thus, produce more seed. Seed is best collected by cutting off then drying and threshing the seedheads.

Seeds per pound: 2,700,000

Establishment: Seeds are not dormant and will germinate in cool to warm temperatures. Drill seed at 2 to 4 pounds per acre at a very shallow depth of 1/8 to ¼ inch. Seeds will germinate within 2 to 4 weeks after sowing. Germination is best in cool temperatures so fall or early spring sowing works well. Plants established in the fall will produce seed the following summer; spring sown fields will act as biennials and usually will not produce seed until the second growing season.

Establishment rating: Medium. Seedlings are slow-growing and have moderate establishment rates. Plants are easily outcompeted by weeds.

Weed control: Several broadleaf herbicides can be used on this species for new or established stands. The most difficult weeds to control are weedy annual grasses such as annual bluegrass and rattail fescue. Hand hoeing, herbicide spot treatments, and row tillage are other options.

Fertilization: Optimal fertilization rates and timing are unknown for this species. Avoid appling fertilizer to new seedings until weeds are under control. For fall seedings, a single application of 30 to 40 lbs N per acre in March is suggested. For spring seedings, broadcast 30 to 40 lbs N per acre after stand emergence and initial weed control.

Pests: Rusts can be problematic in seed production fields and cause major stunting and death. Plants are more likely to be damaged by

rust if they are stressed by lack of nutrients or soil moisture.

Harvest: Seeds shatter easily when mature. Harvesting is done either by (1) direct removal of seed from the seedheads using a flail-vac seed stripper then drying the seed, (2) direct combining then drying the seed if maturation of the stand is uniform, or (3) swathing followed by combining the dry seed stalks a week or two later. Using a seed stripper will result in the highest yields. Seeds ripen from the top down and can be harvested multiple times as they mature. Fields can change from green to tan in an afternoon, especially in hot, windy conditions. Maturity needs to be closely monitored.

Post-harvest residue management: This species often produces only one seed crop and can be tilled under post harvest.

Seed cleaning: Seed that has been de-bearded will flow more readily and precisely through standard drills and broadcast seeders. Seed can be de-bearded using a brush machine and then cleaned using an air-screen machine to remove chaff and empty seed.

Average yields/Stand longevity: 200–300 lbs per acre. This species acts as an annual or biennial. Only one harvest should be expected. If spring sown, plants will grow vegetatively the first summer, flower the following spring and then die. Yields are much higher with spring sown fields because the plants are larger and older, but fields have to be maintained for 18 months before harvest rather than just 9 months with fall sowing.

Remarks: This species is associated with disturbance, so it should not be a surprise to find that slender hairgrass can become an established weed on farms. It is not a competitive plant, but can contaminate other seed crops. It remains in the seedbank, which requires careful planning of successional crops to be planted in retired hairgrass fields

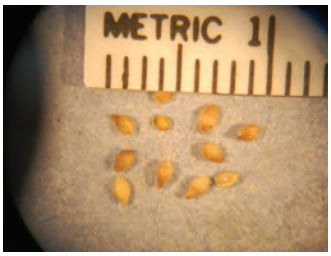
DICHANTHELIUM ACUMINATUM

western panicgrass

Life form: Perennial warm-season grass

Pollination: The earliest flowers mostly self-pollinate, but can also outcross via wind; later flowers do not open (are usually contained in the leaf sheath) and are entirely self-pollinated.

Ease of agronomic seed increase: Difficult. Needs to be established from plugs; harvesting is troublesome due to low, spreading plants, low seed retention, and variable ripening.



Native distribution/ Habitat: Western panicgrass occurs all over North America. This species can be found in a variety of habitats such as wet prairies, marshy woods, roadsides, dunes, and seashores at elevations from sea level to 10,000 feet.

Ease of wild seed collection: Difficult, due to variable ripening and quick shatter when mature.

Seeds per pound: 1,050,000

Establishment: Seeds of this species are usually not dormant and will germinate readily in warm to hot temperatures (75–100°F). If directly sown in spring or fall, seeds will not germinate until late spring to early summer and may need irrigation for establishment. Establishing fields using greenhouse grown plugs is recommended for a robust, productive field in the first year. To aid in harvest, plants should also be planted into a field covered with weed fabric. Plant plugs on 1 foot by 1 foot spacing in the spring. If direct seeding, use a rate of 3 pounds per acre (75 seeds per square foot) and sow as shallowly as possible (surface to 1/8th inch).

Establishment rating: Moderate to high from plugs; low from direct seeding.

Weed control: Several broadleaf and pre-emergent herbicides can be used on this species for new or established stands. Hand hoeing, herbicide spot treatments, and row tillage are other options. 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: Optimal fertilization rates and timing are unknown for this species. New fields established using plugs may not need additional fertilizer their first year. In subsequent years, a single application of 30 to 40 lbs N per acre in April is suggested.

Pests: Mice eat seeds as they accumulate on weed fabric. Leaf rusts can sometimes infect plants, but usually do not decrease vigor or seed yields.

Harvest: Seeds ripen variably and easily fall from the plants when mature. For highest yields, use a

flail-vac seed stripper after all seed has matured to harvest the remaining seed from the plants as well as seed that accumulated on the fabric. This may require more than one pass over the field to collect all the seed. As the plants become bushy they may trap seed under the leaves that can be difficult to collect. In very dense fields, it may be beneficial to swath or cut all leafy plant material, remove it from the field to dry, and then vacuum the weed fabric with the flail-vac seed stripper. This method will require the extra step of threshing or stationary combining the cut material to separate the plant material from the seeds.

Post-harvest residue management: Plants do not need mowing or residue removal unless they are becoming crowded or a heavy amount of thatch still exists after winter.

Seed cleaning: A brush machine should be used to break up larger panicles and remove hairs. An air-screen machine can be employed to remove chaff and empty seeds, but it can be difficult to distinguish filled and empty seeds with this species.

Average yields/Stand longevity: 200–400 pounds per acre. If started from plugs, plants will produce a small seed crop in their first growing season. Second year plants will produce peak yields and should maintain this level of productivity for a couple years. Plants are moderately long-lived, remaining productive for up to 5 years. This species usually is found on low-lying saturated soils, so it may be a longer-lived crop if grown under those conditions.

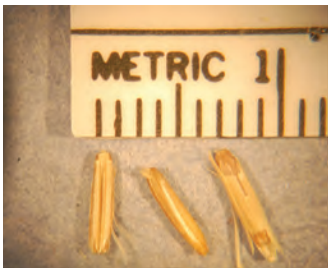
ELYMUS ELYMOIDES

squirreltail

Life form: Short-lived perennial bunchgrass

Pollination: Squirreltail is self-pollinating, but is known to hybridize with other species of *Elymus*, as well as with species of *Hordeum* (barley) and *Pseudoroegneria* (bluebunch wheatgrass).

Ease of agronomic seed increase: Moderate. Fields are easy to establish, but harvesting and seed cleaning can be challenging. Once swathed, the seeds can blow out of the windrows with even the slightest breeze. The long, bent awns on the seeds cause the screen and sieve in the combine to become blocked, resulting in good seed falling off the back of the screen and onto the ground. Some seedheads are not broken apart by the combine, resulting in more seed falling onto the ground.



Native distribution/Habitat: Squirreltail can be found throughout western North America from Canada to Mexico at elevations from 2,000 to 11,500 ft. Mostly found in open, dry, upland habitats with recent disturbance. Often found along roadsides and trails through open areas.

Ease of wild seed collection: Easy. The seeds can either be hand stripped from the stems or the stems can be cut from the plant. Be very careful not to confuse this species with invasive medusahead (*Taeniatherum caput-medusae*), that may look similar to a novice collector or a person not familiar with this species.

Seeds per pound: 93,000–100,000

Establishment: Seed dormancy is usually low or nonexistent. Therefore, seed can be drilled in the fall or spring at a rate of 4 to 8 pounds per acre and a depth ¼–¾ inch. A row spacing of 12 to 18 inches is suggested unless wider rows (24–36 inches) are needed for tillage.

Establishment rating: High with good site preparation. Germination is rapid and dependable, seedling vigor is high, and plant development is rapid.

Weed control: Several broadleaf herbicides can be used on this species in both new and established stands. Pre-emergent herbicides

Pests: Plants are known to be susceptible to rust.

Harvest: Two features of this plant make it very difficult to harvest and clean. As seeds mature along the seedhead, they disarticulate. Seeds also have a very long, bent awn usually between 2 and 4 inches. For a small field, mature seedheads can be harvested by hand with rice knives or mechanically harvested with a swather that has been modified to catch and collect the material once it has been cut. The material can then be dried in a place protected from wind.

can help control weedy grass seedlings. Hand hoeing, spot treatments with a nonselective herbicide, and row tillage are other options.

Fertilization: Do not apply nitrogen fertilizer to new fall or spring seedings if significant weed competition is anticipated. Optimal rates and timing for established stands have not been determined for this region. However, it is suggested that 50 pounds of N per acre be applied each March. Fall fertilization (20–40 lbs N per acre) benefits seed production of this species in other regions of the West and may improve yields locally as well.

Harvest: For large fields, swathing and combining is the most practical harvest method. Swathing early in the morning, when dew is present will help reduce shattering and blowing around. Dense swaths will retain seed better than thin ones as the seeds dry and separate from the stem. When combining, use a solid concave or put de-awner bars in. Set the concave as close as possible to the cylinder without damaging the seeds. These two adjustments will hopefully reduce the awn length enough to allow seeds to fall through the combine screen instead of flowing over the top.

Flail-vac seed harvesters can also be used on this species if properly modified. A framed screen can be clamped into the air outlet on the top of the harvester to block seeds from being ejected out of the hopper. Harvested material will be very fluffy and difficult to handle. This method could be useful on fields that are too sparse to create dense swaths, or where swaths would be disturbed by severe winds.

Post-harvest residue management: The remaining straw and standing stubble should be promptly removed by either baling, mowing with a flail chopper (forage harvester) equipped with a collection wagon, or open field burning. If the stubble left after harvest is tall, it should be windrowed or mowed prior to baling. Timely removal of crop aftermath is likely to improve yields the following year.

Seed cleaning: Use a brush machine to remove the awns. More than one run through the machine may be required to remove all of the awns depending on the machine and the operator. Seed can be deawned easier if material is completely dry. Once the awns are removed, use an air-screen machine to remove chaff, stems, and unfilled seed to reach the desired purity.

Average yields/ Stand longevity: 50–200 pounds per acre. When fall planted this species flowers and produces seed its first year, but does not achieve peak yields until the second or third growing season. Fields should be removed after the fourth year; most plants do not live longer than five years.

Remarks: Use respiratory protection during harvest and cleaning of this seed as particulates from this species are a lung irritant.

ELYMUS GLAUCUS

blue wildrye

Life form: Short-lived perennial bunchgrass

Pollination: Highly self-pollinated, but can hybridize with other *Elymus* and *Hordeum* species.

Ease of agronomic seed increase: Easy. Seeds can be planted with most seed drills, decent stands are easy to establish, fields can be mechanically harvested, and seed is relatively easy to clean. Plants are competitive with weeds and seed yields are dependable and high for a native grass. However, good seed production for some populations may be limited to only a few years.

Native distribution/ Habitat: Blue wildrye is native across North America from Alaska to Mexico, east to New York, throughout the Great Plains (introduced to the northeast and plains states), but not found in the Southeast. It is found in many habitats including prairies, forest edges, open woods, roadsides, chaparral, and sandbars; partial shade to full sun from sea level to 11,000 ft in elevation.

Ease of wild seed collection: Easy. This plant is usually abundant and not easily confused with other species. Seeds can be stripped from the seedhead or heads can be cut, dried, and threshed.

Seeds per pound: 120,000
Establishment: Seed dormancy is usually low or nonexistent. Therefore, seed can be drilled in the fall or spring at a rate of 6 to 10 pounds per acre (20 to 30 pure live seeds per foot) and a depth of ¼–¾ inch. A row spacing of 12 to 18 inches is suggested unless wider rows (24–36 inches) are needed for tillage. The lower seeding rate is used for wider rows.

Establishment rating: High. Seedlings are fast growing and establish easily.

Weed control: Several broadleaf herbicides can be used on this species in both new and established stands. Pre-emergent herbicides can help control weedy grass seedlings. Hand hoeing, spot treatments with a nonselective herbicide, and row tillage are other options.

Fertilization: Do not apply nitrogen fertilizer to new fall or spring seedings if significant weed competition is anticipated. Optimal rates and timing for established stands have not been determined for this region. However, it is suggested that 50 pounds of N per acre be applied early each March. Fall fertilization at 20 to 40 lbs N per acre benefits seed production of this species in other regions of the West and may improve yields locally as well.

Pests: Rust can sometimes be a problem on this species, but can easily be controlled with foliar spray fungicides. This species can be susceptible

to ergot and head smut. Most ergot bodies can be removed from the seed lot by seed cleaning. Smut is controlled by using a systemic seed treatment and planting smut free seed.

Harvest: Seed set is usually good to excellent. The best time to harvest is when most seed is in hard dough stage with minor shattering occurring at the top of some seedheads. If seed maturation within the stand is relatively uniform, harvesting is done by direct combining and then drying the seed afterwards. Alternatively, more variable maturing stands are swathed, left to dry/cure in the field for 10 to 14 days, and then combined. Swath the stand when most seed is between mid and hard dough, generally a few days earlier compared to direct combining. A flail-vac seed stripper can be used on thin stands of uniform height or where high levels of shatter occur during swathing and combining. The seed stripper isn't the best choice for spike-like inflorescences like those found on blue wildrye, but it is a viable harvest option.

Post-harvest residue management: The remaining straw and standing stubble should be promptly removed by either baling, mowing with a flail chopper (forage harvester) equipped with a collection wagon, or open field burning. If the stubble left after harvest is tall, it should be windrowed or mowed prior to baling. Timely removal of crop aftermath is likely to improve yields the following year.

Seed cleaning: Most populations have ½- to 1-inch long awns that can easily be removed using a brush machine. This will improve flow in seed cleaning and planting equipment. Air-screen machines should be used to remove chaff and empty seeds.

Average yields/Stand longevity: 200–500 pounds per acre. When fall planted this species flowers and produces seed its first year, but does not achieve peak yields until the second growing season. Fields should be removed after the fourth year as most plants do not live longer than five years.

Remarks: This is a very easy species to work with, especially if seed maturation is relatively uniform within a field.

ELYMUS TRACHYCAULUS

slender wheatgrass

Life form: Perennial bunchgrass, but occasionally produces short rhizomes

Pollination: Highly self-pollinated, but can hybridize with other *Elymus* and *Hordeum* species.

Ease of agronomic seed increase: Relatively easy. Plants are competitive with weeds and seed yields are dependable and high for a native grass. However, good seed production for some populations may be limited to only a few years.

Native distribution/ Habitat: This variable species is wide spread in North America, occurring naturally throughout most of Canada and the United States, except for the Southeast. Dry to moist well-drained sites with moderately acidic to alkali soil and full sun to light shade. This species is found in grassy meadows and open woods from sea level to 10,000 ft in the mountains.

Ease of wild seed collection: Moderately easy. The relatively large seed can be hand stripped or collected by cutting off then drying and threshing the seedheads.

Seeds per pound: 145,000–165,000

Establishment: In western Oregon, stands should be planted on well-drained, moderately coarse- to fine-textured soils on uplands with a pH of 5.5 to 7.0. Seed dormancy is usually low or nonexistent. Therefore, seed can be drilled in the fall or spring at a rate of 4 to 8 pounds per acre and a depth of ¼–¾ inch. A row spacing of 12 to 18 inches is suggested unless wider rows (24–36 inches) are needed for tillage. The lower end seeding rate is used for wider rows.

Establishment rating: High with good site preparation. Germination is rapid and dependable, seedling vigor is high, and plant development is rapid.

Weed control: Several broadleaf herbicides can be used on this species in both new and established stands. Pre-emergent herbicides can help control weedy grass seedlings. Hand hoeing, spot treatments with a nonselective herbicide, and row tillage are other options.

Fertilization: Do not apply nitrogen fertilizer to new fall or spring seedings if significant weed competition is anticipated. Optimal rates and timing for established stands have not been determined for this region. However, it is suggested that 50 to 75 lbs N per acre be applied each March. Fall fertilization in September or early October (20–40 lbs N per acre) benefits seed production of this species in other regions of the West and may improve yields locally as well. Do not exceed 100 lbs N per acre annually as high rates may promote lodging.

Pests: This species can be susceptible to ergot and head smut in some production areas. Ergot can be reduced by field sanitation and use of ergot-free

seed. Most ergot bodies can be removed from the seed lot by seed cleaning. Smut is controlled by using a systemic seed treatment and planting smut free seed. Others in the West report the occurrence of "silvertop" which is caused by insects puncturing or feeding on the stem in combination with a fungus infecting an area just above the uppermost node. It results in the seedhead turning white and not producing seed. The impact of these and other disease and insect pests has generally been minor at the Corvallis PMC.

Harvest: Seed set is usually good to excellent. If seed maturation within the stand is relatively uniform, harvesting is done by conventional direct combining then drying the seed afterwards. The best time to direct combine is when most seed is in hard dough stage with minor shattering occurring at the top of some seedheads. For stands with variable maturation, swath (windrow) first and then combine a week or two later. Swath the stand when most seed is between mid and hard dough, generally a few days earlier compared to straight combining.

Post-harvest residue management: The remaining straw and standing stubble should be promptly removed by either baling, mowing with a flail chopper (forage harvester) equipped with a collection wagon, or open field burning. If the stubble left after harvest is tall, it should be windrowed or mowed prior to baling. Timely removal of crop aftermath is likely to improve yields the following year.

Seed cleaning: Awn length varies among populations. If awns are longer than ¼ inch, it can be helpful to remove them with a brush machine or debearder to facilitate seed cleaning and improve flow through planting equipment. De-hulling is not recommended. As long as contaminants are not of similar shape and size to the seed, cleaning is readily accomplished with an air-screen machine to remove chaff, weed seeds, and empty seeds.

Average yields/Stand longevity: 300–750 pounds per acre. This species is often short-lived and may only be productive for 3 to 5 years. In western Oregon, seed crops are produced the first growing season after spring or early fall seeding, but the yield advantage from spring seeding has not been determined.

Remarks: This is one of the easiest native grasses to grow for seed in the Pacific Northwest.

FESTUCA AMMOBIA

sand fescue

Life form: Perennial rhizomatous grass

Pollination: The pollination biology of this species has not been studied, but most red fescues are highly out-crossing.

Ease of agronomic seed increase: Easy. Stands establish well, fields can be mechanically harvested, and seed is relatively easy to clean.

Native distribution/Habitat: Sand fescue occurs at lower elevations on moist to moderately dry soils from California to Washington. The native range may extend further north into coastal British Columbia, but not inland. It is found on beaches, rock crevices, meadows, gravelly sites, and streambanks in full sun to partial shade, primarily along the Pacific Coast.

Ease of wild seed collection: Moderate. Plants are usually found in solid stands, but seed fill is often very low, so a large collection may only yield a small amount of pure live seed. Can be confused with native Roemer's fescue, coastal red fescue, and non-native fine fescues.

Seeds per pound: 400,000–500,000

Establishment: Seed is generally not dormant. Fall sowing is recommended as spring sown seedlings need irrigation throughout the summer to become established and will not flower until their third summer. Drill seed at a rate of 4 pounds per acre at a depth of ¼-inch. A row spacing of 12 to 18 inches is suggested unless wider rows (24–36 inches) are needed for tillage.

Establishment rating: Medium. Seedlings emerge 2 to 3 weeks after sowing and grow slowly during the winter or moderately in the spring. Established plants are drought tolerant.

Weed control: Several broadleaf herbicides can be used on this species in both new and established stands. Pre-emergent herbicides can help control weedy grass seedlings. Hand hoeing, spot treatments with a nonselective herbicide, and row tillage are other options. Tillage between rows may be necessary to create space between plants every 2 to 3 years or as they become crowded.

Fertilization: Avoid applying nitrogen fertilizer to new fall or spring seedings until weeds have been controlled and plant development is underway. Optionally, apply 15 to 30 lbs N per acre at the time of planting. For established stands, apply 30 to 70 lbs N per acre between late February and mid-March.

Pests: Fungal leaf and stem rusts are often observed in production fields and can reduce seed yields if not treated. Rodents such as voles, field mice, and pocket gophers can damage stands in some years.

Harvest: Seed retention is generally high for this species. Harvesting is done either by 1) using a flail-vac seed stripper then drying the seed, 2) direct combining, or 3) swathing followed by combining the dry seed stalks 10 to 14 days later. If swathed, seed should be at mid to hard dough stage, and swathing height should be no lower than 4 inches to avoid damaging crowns.

Post-harvest residue management: Crop residue is minimal but should be removed after seed harvest with a flail chopper (forage harvester) and wagon or baler. This species is sensitive to low mowing and crowns can be easily damaged, so remaining stubble should be left at a height of 3 to 4 inches. Field burning is not recommended as plants will require two seasons to recover seed yields.

Seed cleaning: Use a brush machine to remove small awns and break up florets, followed by an air-screen machine to remove unfilled seeds and chaff.

Average yields/Stand longevity: 250–400 pounds per acre. Fall sown fields will produce seed in their second summer. Yields remain relatively stable for many years if adequate space is maintained between rows and crowns are not damaged by mowing or swathing. Some populations produce a high percentage of unfilled seed.

Remarks: Plants are colorful and highly variable.

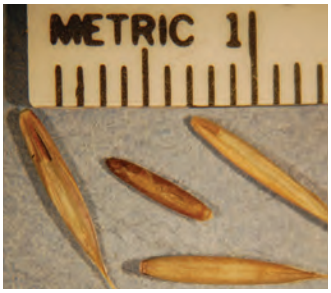
FESTUCA CALIFORNICA

California fescue

Life form: Perennial bunchgrass

Pollination: The pollination biology of this species has not been studied, but most perennial *Festuca* species are highly cross-pollinated.

Ease of agronomic seed increase: Moderate. Compared to other native grasses, California fescue is not as easy to establish. It shatters easily and has low, unpredictable seed yields.



Native distribution/ Habitat: California fescue can be found west of the Cascade and Sierra Nevada Mountains below 6,500 ft from Oregon to Southern California. It grows in oak savannas, the understory of mixed conifer-hardwood forests, chaparrals, and serpentine soils.

Ease of wild seed collection: Moderate. Plants are tall and relatively easy to identify, but do not occur in dense patches. Seed shatters as it matures, but can be easily stripped from the plant by hand. California fescue has wider leaves and is usually taller than other native fescues, but might be confused with tall fescue (*Schedonorus arundinaceus*, synonym *Festuca arundinacea*).

Seeds per pound: 130,000–170,000

Establishment: Seed can have staggered germination; seedlings may emerge over a period of two to eight weeks. Therefore, fall planting when soil temperatures are cooler is highly recommended. Drill seed at 8 to 10 pounds per acre at a depth of ¼ to ½ inch. A row spacing of 12 to 18 inches is suggested unless wider rows (24–36 inches) are needed for tillage.

Establishment rating: Medium. The seeds germinate sporadically during early winter. Seedlings are slow to establish and do poorly in saturated soils. Once established, plants seem relatively hardy.

Weed control: Several broadleaf herbicides can be used on this species in both new and established stands. This species is one of the earliest to flower. It is important to apply broadleaf herbicides prior to boot-stage. In some springs in the rainy Pacific Northwest, it may be difficult to find a dry time to spray. Pre-emergent herbicides can help control weedy grass seedlings. Hand hoeing, spot treatments with a nonselective herbicide, and row tillage are other options.

Fertilization: Avoid applying nitrogen fertilizer to new fall or spring seedings if significant weed competition is anticipated. Optimal rates and timing for established stands have not been determined for this region. However, it is suggested that 50 lbs N per acre be applied in late February. Fall fertilization at 20 to 40 lbs N per acre benefits seed production of this species in other regions of the West and may improve yields locally as well.

Pests: Plants are known to be susceptible to rust.

Harvest: Seed set is usually fair to poor and seeds shatter easily upon ripening. For a small to medium sized field, a flail vacuum seed harvester is recommended. Swathing and combining may be attempted for a large field, but dense swaths are needed to keep seed suspended within. If seed maturation within the stand is relatively uniform, harvesting can be done by direct combining then drying the seed afterwards. The best time to harvest is when most seed is in mid to hard dough stage before shattering occurs.

Post-harvest residue management: The remaining straw and standing stubble should be removed by either baling or mowing with a flail chopper (forage harvester) equipped with a collection wagon. This species is sensitive to low mowing and crowns can be easily damaged so the remaining stubble should be left at a height of 3 to 4 inches.

Seed cleaning: Use a brush machine to remove the small awns, and then use an air-screen machine to remove empty seeds and chaff.

Average yields/ Stand longevity: 50–100 pounds per acre. This species does not produce seed its first growing season. Yields vary, but fields can produce over 100 lbs/acre once mature. In well drained soils, plants can be long-lived.

Remarks: This is one of the most beautiful native grasses, but not a reliable species for seed production.

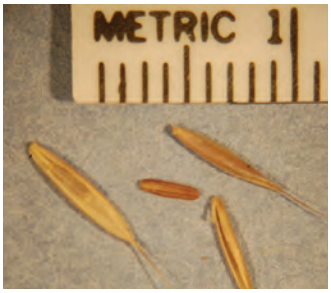
FESTUCA ROEMERII

Roemer's fescue

Life form : Perennial bunchgrass

Pollination: Self-incompatible; highly cross-pollinated by wind. This species intergrades with Idaho fescue and can hybridize with other grasses in the sheep fescue-Idaho fescue-hard fescue complex.

Ease of agronomic seed increase: Moderately easy to grow. However, seed yields are variable and can be low in some years, especially in comparison to improved varieties of fescues.



Native distribution/ Habitat: Roemer's fescue occurs naturally from southwestern British Columbia south to the San Francisco Bay area of California, remaining entirely west of the Cascade Range. The species is found on moderately droughty to moist sites including prairies, savannas, edges of forests, and grassy openings in woods. It grows best on well drained, moderately acid to slightly alkaline soils in full sun to partial shade. Adaptation also includes serpentine and low fertility soils with medium to fine texture.

Ease of wild seed collection: Moderately easy. The seed can be hand stripped just prior to shatter, or entire seedheads can be cut when seed is at mid to hard dough stage, followed by drying and threshing.

Seeds per pound: 420,000–550,000 depending on population and environmental conditions.

Establishment: Seed dormancy is typically low for Roemer's fescue, but some populations can germinate quicker and more uniformly when the seed is cold-moist stratified for 14 days. Drill the seed at a rate of 4 to 6 pounds per acre and a depth of ⅛–¼ inch (½ inch on sandier soils). The lower seeding rate is used for wider rows. Row spacing should be 12 inches for most populations, but more robust ecotypes (e.g., some coastal populations) may yield best in 18-inch rows. Wider rows (30–36 inches) are usually required when tillage is used for weed control. Irrigation is not needed for new fall seedings, but spring plantings may benefit from irrigation during the first summer.

Establishment rating: Medium; seedlings are slow growing the first year.

Weed control: Several broadleaf herbicides can be used on this species for both new and established stands. One or more pre-emergent herbicides that target control of weedy grass seedlings may also be legal in some states. These products are for established perennial grasses that are at least a year old and have produced a seed crop. Caution: certain herbicides listed specifically for fine fescue seed production in the Pacific Northwest may not be legal to apply on Roemer's fescue. Hand hoeing, spot treatments with a nonselective herbicide, and row tillage are other options.

Fertilization: Do not apply nitrogen fertilizer to new fall or spring seedings until weeds have been controlled and plant development is underway.

Optionally, apply 15 to 30 lbs N per acre at the time of planting. For established stands, apply 30 to 70 lbs N per acre between late February and mid-March. Based on research at the Corvallis PMC, additional fall fertilization has not been found to increase yields. If split applications are used, do not exceed 70 lbs N per acre annually as high rates have increased lodging in conjunction with 12 inch row spacing.

Pests: Some populations are very susceptible to stem rust. Treatment is possible using a number of fungicides labeled for control of this and other rusts on grasses grown for seed. Ergot has been detected in some seed lots, but levels of infection have been low. Vole populations and their foraging damage have been high in some fields of Roemer's fescue which may warrant control in some years.

Harvest: Fertile tillering and seed set can flucuate widely from year to year and so will yields. If seed maturation within the stand is relatively uniform, harvesting can be done with a flail-vac seed stripper or by direct combining and then drying the seed afterwards. The best time to harvest is when most seed is in hard dough stage and slight shattering has commenced on some seedheads. For variable maturing stands, swath (windrow) first and then combine. Swath the stand when most seed is between mid and hard dough, generally a few days earlier compared to straight combining.

Post-harvest residue management: The remaining straw and standing stubble should be promptly removed by either baling, mowing with a flail chopper (forage harvester) equipped with a collection wagon, or open field burning. In one study at the Corvallis PMC, the use of a propane flamer increased mortality over baling/mowing, but survivors compensated by producing more seed. In another study, open field burning caused very little mortality and seed yields were higher than all other treatments except for the lowest mowing height. If burning is not used, plants should be mowed to a height of 1½–2½ inches during or after straw removal. Leaving higher amounts of residue has reduced yields the following season and may decrease effectiveness of certain herbicides.

Seed cleaning: Seed should be run through a brush machine to remove the awns and break up floret doubles or spikelet groups. Set the brushes so they barely touch the inside of the mantle (drum). De-awning facilitates cleaning and improves seed flow through planting equipment. Final cleaning is done with an air-screen machine to remove chaff, weed seeds, and empty seeds.

Average yields/Stand longevity: 70–500 pounds per acre. A partial seed crop can be produced the year following a spring planting. Fall seeding will not produce a crop until the second summer. Production typically does not peak until the third summer and can decline thereafter. The lifespan of this species is variable, but many populations remain productive for 6 to 10 years, with some individuals living upwards of 20 years.

Remarks: Roemer's fescue seed fields are often contaminated with red fescues which can be difficult to distinguish for removal. In addition to visual cues for species identification, an ammonia florescence test conducted by a seed lab as part of a seed lot germination test will also alert a grower to red fescue contamination in the field. The roots of red fescue (and species in the red fescue complex) fluoresce yellow while the roots of Roemer's fescue (and species in the sheep fescue complex) fluoresce green when sprayed with a 0.5% solution of ammonium hydroxide. Under seed certification, the allowable amount of red fescue detected by seed test is very low or zero, depending on generation or class.

HORDEUM BRACHYANTHERUM

meadow barley

Life form: Perennial bunchgrass

Pollination: Predominantly self-pollinated but can hybridize with other *Hordeum* and *Elymus* species. Hybrids are sterile.

Ease of agronomic seed increase: Intermediate. Stands are hardy and moderately long-lived, but harvest timing is critical as the seedhead (spike) becomes brittle at maturity resulting in large segments readily breaking off (shattering) along the central axis.

Native distribution/ Habitat: Western North America from Alaska to Mexico and east to Montana and New Mexico, as well as parts of the midwest, northeast and southeast USA and eastern Canada. Moist to wet prairies, salt marshes, coastal beaches, depressions, and streambanks, as well as drier knolls, rocky ridges, and subalpine meadows from sea-level to 12,000 ft elevation. Adaptation includes somewhat dry to seasonally flooded sites, full sun, and moderately acid, alkaline, or saline soils.

Ease of wild seed collection: Moderately difficult due to narrow window for collecting mature seedheads before they fall to the ground and the common presence of head smut disease which should be avoided.

Seeds per pound: 70,000 to 150,000 depending on the degree of seed conditioning.

Establishment: New stands can be planted on well-drained, course- to fine-textured soils on uplands as well as poorly-drained soils in low lying, seasonally flooded areas with a pH of 5.5 to 8.5. Drill seed in 10-14 inch wide rows at 4 to 6 pounds per acre and depths of ¼ to ½ inch. Wider rows may be needed with mechanical cultivation. Most sources have non-dormant seed which can be spring or fall seeded.

Establishment rating: Easy due to rapid germination, high seedling vigor, fast growth, and competitiveness with weeds.

Weed control: Several broadleaf herbicides can be used on this species for new or established stands. In some states, pre-emergent herbicides may be legal to apply for control of weedy grass seedlings in established stands. Hand hoeing, herbicide spot treatments, and row tillage are other options.

Fertilization: Do not apply fertilizer to new fall or spring seedings if significant weed competition is anticipated. Optionally, apply 20-30 lbs N (nitrogen) per acre at planting or soon after seedling emergence. In milder growing climates such as western Oregon, apply 50 lbs N per acre in late winter (late February-early March) to established stands as drainage conditions allow. Higher rates can lead to lodging. A study at Corvallis, Oregon showed no increase in seed yields from supplemental fall fertilization (25 lbs N per acre) when combined with timely spring applications.

Pests: Insect pests are typically not an issue during the production of meadow barley, but diseases including stem or leaf rust, ergot, and head smut can be problematic in some years or stands.

Harvest: Harvesting is done either by (1) swathing followed by combining the dry seed stalks a week or two later, or (2) direct removal of seed from the seedheads using a flail-vac seed stripper then drying the seed for a week or so. Only dense stands should be swathed; otherwise too much shattered seed (segments of spikes) will end up on the ground rather than suspended by crop matter for the combine to gather. Field should be swathed when a high percentage of seedheads have turned from green or purple to tan down to the base. With a seed stripper, harvesting should commence when shattered tips are observed on 10-25% of the spikes. Seed stripping is an advantage on stands with variable maturation because multiple harvests can be done to capture seed from later maturing plants.

Post-harvest residue management: Crop aftermath may be substantial and should be promptly removed after seed harvest with a flail chopper (forage harvester) and wagon, baler, or open field burning. For mechanical removal, the remaining stubble should be left at a height of 2 to 4 inches. While post harvest burning with a full straw load was neutral or beneficial at Corvallis, Oregon, the use of a propane flamer caused injury and reduced yields in one experiment, possibly due to high temperatures. It is not a recommended practice.

Seed cleaning: A two-step process can be used to process the seed: 1) Remove bristly awns from seed and break up spikelet groups using a brush machine and 2) clean with an air-screen machine to separate stems, chaff, weed seeds, and empty seeds.

Average yields/Stand longevity: 20-380 pounds per acre. This species will flower and set seed the first summer if sown in fall or early spring, but higher first year yields will be obtained with fall seeding. Peak yields are likely to occur in the second growing season and be sustained for several years. Anticipated stand longevity is 6 to 10 years, sometimes longer.

Remarks: If soils have enough summer moisture, some secondary flowering will occur after harvest, but two seed crops per year are unlikely. Seedlings volunteer readily in the fall on open ground between rows.

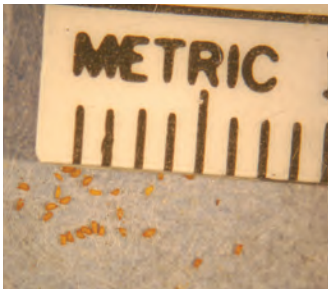
JUNCUS OCCIDENTALIS

western rush

Life form: Clump-forming perennial rush

Pollination: Rushes are usually wind pollinated and capable of self-pollination.

Ease of agronomic seed increase: Moderate. Harvesting this species is easily accomplished by using a machine that both swaths and collects the plant material at the same time. Furthermore, as this species is 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: It is native throughout all fifty states, most of Canada, and parts of northern Europe. Found on freshwater sites with saturated soils during the winter and dry conditions during the summer. This species is common in disturbed areas with seeps and springs such as prairies, meadows, shaded roads, and ditches. Found at low to middle elevations, mainly south of latitude 55˚ N.

Ease of wild seed collection: Medium difficulty. Seed retention is fair and plants mature uniformly. Seed collection locations can be somewhat sparse; however, large amounts of seed can be collected when patches are located.

Seeds per pound: 9,000,000-20,000,000

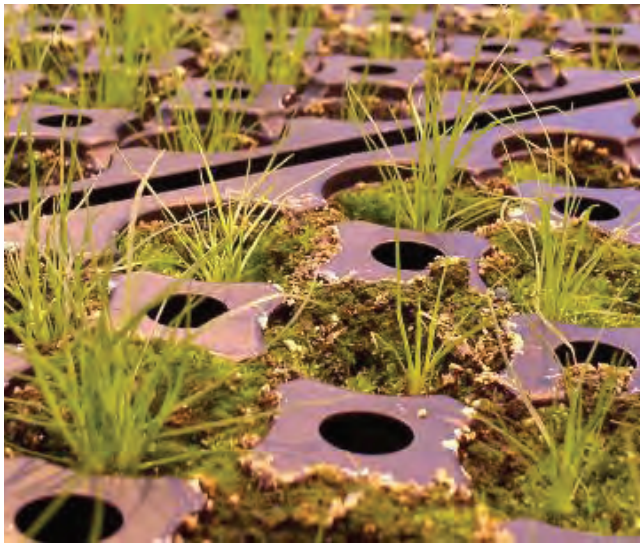
Establishment: Seeds are non dormant and germinate in spring as soils warm. It is recommended to established fields from plugs to avoid competition from weeds and the need for irrigation. Plugs are grown in a greenhouse overwinter, and transplanted out into fields covered with weed fabric on a 1 foot by 1 foot spacing in the spring. Transplanting plugs creates cleaner fields and results in an established productive field in the first growing season. For direct seeding into a field (which is not recommended), seeds should be surface sown at a rate of 460 seeds per square foot, or 1 pound per acre.

Establishment rating: Medium. Seedlings are grown in plugs and transplanted into fields. Transplanted plants grow quickly and face minimal competition due to weed fabric.

Weed control: There are no herbicides labeled for use on this crop. Some Juncus species can be damaged by broadleaf herbicides. Hand weeding is necessary, but is limited due to the use of weed fabric on production fields.

Fertilization: This species typically begins actively growing in late winter; apply a balanced fertilizer at a rate of 50 lbs/ac as soon as new growth appears.

Pests: No significant pests are associated with this species. However, some rust has been observed on plants, which does not seem to affect seed production.



Harvest: After seeds are ripe, capsules begin to open and the tiny seeds are released. Seeds are usually ripe a few days before the capsules split and should be harvested at this time. Fields are often very uniform in maturity, creating an obvious time window for harvesting. Swath plant material and place on tarps to dry. As material dries, capsules will open and much of the seed will accumulate on the tarp.

Post-harvest residue management: Plant material is removed from the field at the time of harvest so no residue management is necessary. If stubble is high, the fields can be mowed in late summer or early fall when plants are semi-dormant.

Seed cleaning: With the appropriate screens for an air screen machine, this species is rather easy to clean. Once harvested, plant material can be left on a tarp or in a tub to dry. Once the seeds have dried and shattered, the plants can be threshed by hand to release large amounts of seed into the tarp/tub. The remaining plant material is run through a brush machine to remove more stubborn seeds from the plants. Following brushing, the material can be combined with the seed from the tarp/tub and an air screen machine can be used to remove any stems, chaff, and other debris. Seeds are very small and can be cleaned to high rates of purity if plant material is not ground up finely in the threshing or brushing process. Be wary of using mechanical threshers or combines with this seed. It is tiny and can easily be blown out or lost in machinery.

Average yields/Stand longevity: This species does produce seed in the first year following transplanting from plugs. Yields in the first year are approximately 5-20 pounds per acre. Subsequent years yield larger amounts of seed averaging 300- 900 pounds per acre. Plants appear to be long-lived, even on upland sites, and should produce for over 5 years. Weed fabric may need to be trimmed back from crowns as they expand in the first few years.

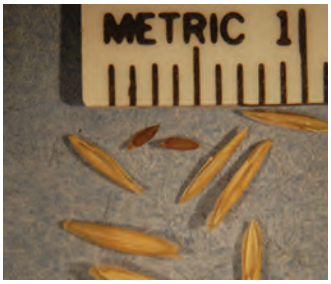
POA SECUNDA

Sandberg bluegrass

Life form: Perennial bunchgrass

Pollination: Wind pollinated by cross or self-fertilization.

Ease of agronomic seed increase: Easy to moderate. Seeds can be used with most seed drills, decent stands are easy to establish, fields can be mechanically harvested but seed is time-consuming to clean.



Native distribution/ Habitat: This species occurs on rocky, dry ridges, flats, and slopes, in the mountains and arid shrub steppe at elevations ranging from 300 to 12,000 feet. This species can be found from British Colombia to California, throughout the mountains and east to the Great Plains.

Ease of wild seed collection: Easy. This species has a wide habitat range, and can be collected easily by hand stripping seed heads, or by cutting seed heads off with a rice knife.

Seeds per pound: 1,200,000

Establishment: Seed dormancy is usually low or nonexistent. Therefore, seed can be drilled in the fall or spring at a rate of 1-2 pounds per acre and a depth 1/4-1/2 inch. A row spacing of 12-18 inches is suggested unless wider rows (24-36 inches) are needed for tillage.

Establishment rating: High. Seedlings germinate quickly and grow rapidly.

Weed control: Several broadleaf weed control herbicides can be used on this species in both new and established stands. Pre-emergent herbicides can help control weedy grass seedlings. Hand hoeing, spot treatments with a nonselective herbicide, and row tillage are other options. Care must be taken to avoid confusing this species with *Poa pratensis* (Kentucky blue grass) when hand weeding.

Fertilization: Do not apply nitrogen (N) fertilizer to new fall or spring seedings if significant weed competition is anticipated. Optimal rates and timing for established stands have not been determined for this region. However, it is suggested that 50-75 pounds of N per acre be applied in late February to early March.

Pests: No significant pests are associated with this species. However, some rust has been observed on plants, which does not seem to affect seed production.

Harvest: Harvesting is done either by (1) direct removal of seed from the seedheads using a flail-vac seed stripper then drying the seed, (2) direct combining then drying the seed if maturation of the stand is uniform, or (3) swathing followed by combining the dry seed stalks a week or two later.

Using a seed stripper will result in the highest yields.

Post-harvest residue management: The remaining straw and standing stubble should be promptly removed by either baling, clipping with a flail chopper (forage harvester) equipped with a collection wagon, or open field burning (where permitted). If the stubble left after harvest is tall, it should be windrowed or mowed prior to baling.

Seed cleaning: Plant material harvested from seed increase fields is first processed in a brush machine to further separate individual seeds from aggregated inflorescences. Following brushing, seeds are cleaned on an air screen machine to remove stems, chaff, and other debris.

Average yields/Stand longevity: 50-500 pounds per acre. This species typically does not flower and set seed until after the stand has gone through one winter if spring sown or two winters if fall sown. Peak yields may not occur until the third growing season even under ideal growing conditions. Stands can be expected to produce for over five years.

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 ¾-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 be shallowly sown (¼ 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 1/8th 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 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 cause 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 pappas 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 petal 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, if 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 to 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

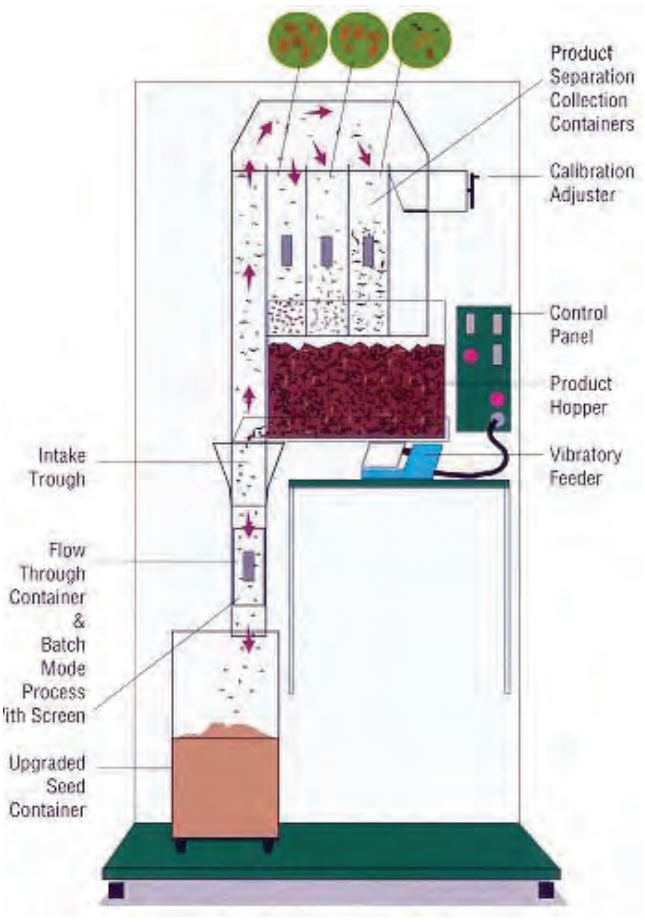
Air-density separators use a vacuum to sort material by density, and are used to further separate filled seed from unfilled seed or weed seed. These machines can be effective for separating a wide, flat, round seed from a narrow, thin, long seed that might fall through the same screens, but have different 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.

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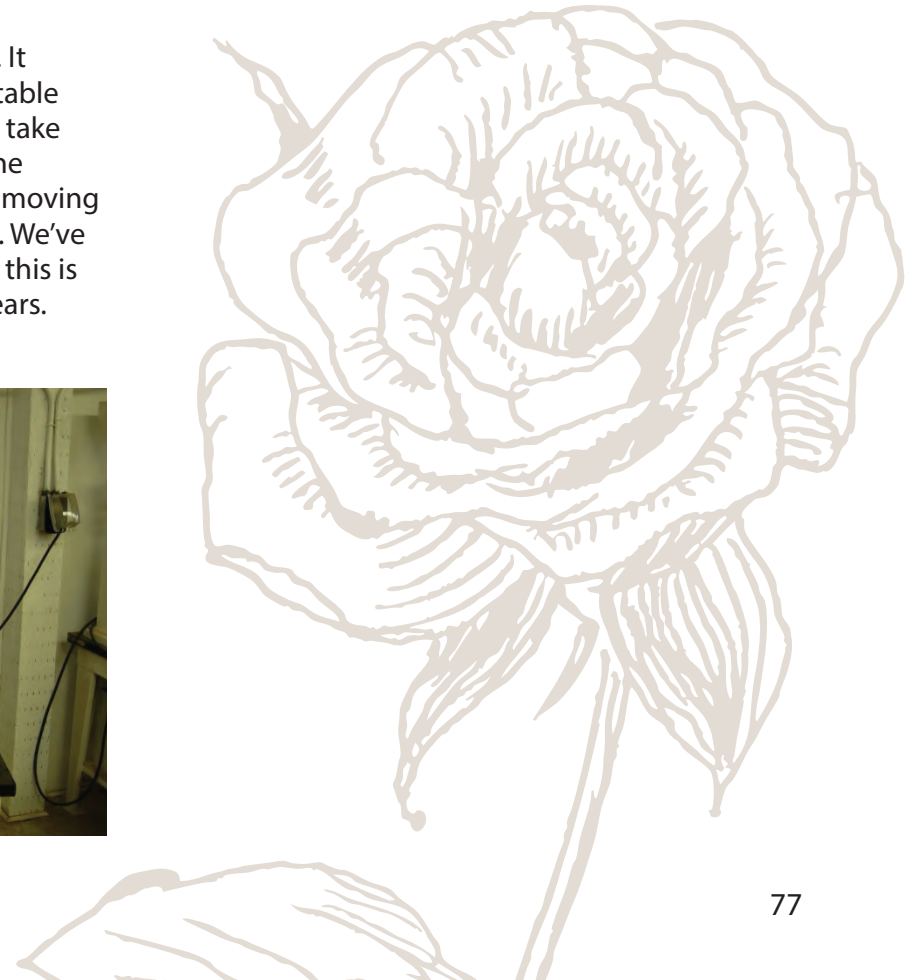

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