Conservation Nursery Manual

4th Edition

Sustainability in Prisons Project

Department of Corrections
WASHINGTON STATE

EVERGREEN
THE EVERGREEN STATE COLLEGE
OLYMPIA, WASHINGTON

Conservation Nursery Manual

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The Evergreen State College

The Sustainability in Prisons Project's mission is to bring science and nature into prisons. We conduct ecological research and conserve biodiversity by forging collaborations with scientists, inmates, prison staff, graduate students, and community partners. Equally important, we help reduce the environmental, economic, and human costs of prisons by inspiring and informing sustainable practices.

Partnership

The SPP is a fruitful partnership with many collaborators. Each partner plays a valuable role in SPP's science and sustainability programs. The founding partners are Washington Department of Corrections (WDOC) and The Evergreen State College. Most SPP programs involve additional partners such as:

- Center for Natural Lands Management
- U.S. Department of Defense, Joint Base Lewis-McChord
- Washington Departments of Fish and Wildlife and Natural Resources
- U.S. Department of Fish and Wildlife
- Oregon Zoo, Point Defiance Zoo and Aquarium, Northwest Trek, and Woodland Park Zoo
- Community colleges, food banks, animal shelters, farms, beekeepers, and other community organizations within a prison's vicinity

SPP Programs

At its beginning we never imagined the vast array of programs that would be started with our DOC partners. Here are a few of the sustainable programs we are thrilled to be a part of:

Native plant production
Food waste composting
Recycling
Sustainable purchasing
Butterfly rearing
Dog training
Firewood processing & distribution
Frog rearing

A Story of Success

You are an integral part of the Sustainability in Prisons Project whether you are a staff member or an inmate technician. Though it may be hard to see sometimes, this is the truth: we could not do what we dream to do without you. With the help of staff members and inmate technicians, an incredible start to a successful restoration of endangered prairie ecosystems has been made possible. The work of SPP has supported the successful reintroduction of endangered Oregon spotted frogs and Taylor's checkerspot butterflies, and the restoration of native habitat with almost one million rare prairie plants produced to date. We are able to grow three times as many plants as we would be able to grow without your help. You are a HUGE part of what we do, and we are thrilled that you're part of the team.

Each of you will have many opportunities to grow and learn throughout your term with SPP and we hope you'll take advantage of them. As an inmate technician you will have a chance every day to learn about botany and how to successfully grow stubborn plant species, and you'll also have a chance to see where you fit in with this whole "sustainability" thing. A sustainable future involves everyone everywhere, and you are an important part of that future. We hope that through your work with SPP you'll not only gain a sense of what sustainability means but also where you can work toward a more sustainable future. This is also true for staff members. We hope that you'll take full advantage of the opportunity for hands-on experiences growing plants and learning about sustainable practices with us.

This manual aims to guide decisions in the cultivation of native prairie plants and assist with the daily nursery work: from filling trays, sowing seeds, and watering, to identifying the seedlings or nursery weeds. In order to improve this manual in the future, please let us know if there is any other information that you'd like to see added. Happy growing!

Seed Treatments

The seeds of many native plant species, some deciduous or evergreen trees and shrubs, and most herbaceous perennials and herbs are incapable of germinating immediately after they are harvested. They will not germinate without pre-treatments such as: stratification, smoke water, and scarification. These treatments simulate the natural conditions that a seed must undergo before germination is possible.

Some seeds need a treatment period because:

- They have an under-developed embryo; they require a further period to complete the development of immature parts.
- They have built-in dormancy mechanisms (like mechanical barrier to water or physiological "block") that prevent them from germinating (sprouting) until conditions signal that their environment is favorable to growth.

Depending on the species, seeds will not break dormancy:

- Under too wet or too dry growing conditions.
- Under imminent winter conditions or high temperatures.

Seeds treatment methods:

- *Dry storage*: For seeds that require time for further development, dry storage will sometimes suffice.
- *Stratification*: First wetting seeds and allowing them to imbibe (absorb) water, then providing a period of cold, warmth, or a combination of the two. This process can remove mechanical moisture barriers or physiological blocks within the seed. Also, complex combinations of cold and warm stratification can complete the maturation of underdeveloped seed embryos.
- *Scarification*: Eliminating or breaking of the seed coat through chemical, thermal, or mechanical methods.
- *Smoke-water treatment*: Soaking seeds in water containing captured chemicals from the incomplete combustion of plant materials. Smoke-water treatment promotes the germination, vigor and establishment of a number of plant species.

These methods are explained in detail further in this section.

Stratification

In most species of wild plants, the mother plant invests the seed with a hormone(s) to delay germination. These hormones make the embryo dormant until environmental conditions and seed enzymes permit the hormone to be broken down inside the embryo. The enzyme required is present in the embryo but it is inactive until activated by temperature and moisture. This temperature and moisture period is called stratification. After stratification, the seed is ready to germinate if the germination temperatures are suitable. In this way plants have evolved a chemical mechanism to germinate at the most opportune time for seedling survival.

Types of Stratification

Depending on what the seeds may normally experience in nature and the form (morphology) and function (physiology) of the seed there are four primary processes to break seed dormancy.

1) *Warm-wet*. Temperatures above 12°C and moist seed. This process is common in desert regions where available water is a limiting factor for plant survival.
2) *Cold-wet*. Temperatures around 3°C and moist seed. The duration is highly variable by species and geography: at least 2 weeks but sometimes as much as 10 weeks. This stratification is common in temperate climates and is the most common stratification technique used in the conservation nursery.
3) *Warm-cold-warm-wet*. A combination of warm and cool treatments ending with a warm treatment to germinate. Where summer temperatures are high and summer moisture is common, this is a method to break dormancy. Frequently encountered in plants from the Eastern and Southern U.S. and wetter climates in Asia.
4) *Warm-cold-warm wet-and dry*. A combination of warm-cold in moist medium followed by a period in which the medium and seeds are allowed to dry for one-to-a-few months, repeating this cycle for the necessary number of treatments and ending with a warm treatment to germinate. This is rarely encountered but sometimes found in plants from tropical high elevations or plants with a complex combination of dormancy mechanisms.

Seeds that respond to one series of treatments have simple physiological dormancy caused by plant hormone processes. Plants that require repeated treatments or combinations of treatments may have a combination of physiological dormancy and a morphological dormancy usually caused by having a naturally underdeveloped embryo in the seed.

Let Nature do the Work

Our default position for stratification is nature's way: we often sow the seed in autumn and leave out in the weather for natural cold-moist stratification. Though we also run tests to measure the actual days in stratification needed by a species, “in pot” cold-moist stratification has proven very effective for many species that germinate over a wide time frame. Planting the seeds in the fall for germination the following spring can often satisfy a seed's requirement for cold-moist stratification. Also, some species will have a natural variation in the duration of cold-moist stratification necessary to break dormancy. Sowing “in place” in the pot and allowing for seasonal variation in temperatures often results in a greater germination rate than stratification in a refrigerator for a set time length. Additionally, we hold some trays of seeds for more than one year to see if combinations of dormancy “breaking” mechanisms may be useful to germinate some species.

Manipulative Stratification

Manipulative stratification is an old and simple practice of stimulating seed to germinate by placing layers of a moist media and seed and then submitting the seed to a period of temperatures that simulate a natural stratification time. The seeds are soaked in mesh bags then wrapped with wet absorbent pads. The seed and pad are stored in sealed containers such as polyethylene bags. The bags are simply stored at room temperature to provide the moist warm treatment. They can be placed in the refrigerator if a moist cold treatment is required at 2-4°C for the required length of time for the species. Each species has a slight variation in stratification time; see the protocol in the individual species descriptions for stratification durations.

Stratification Procedure General

Labeling

It is very important that all labeling is in replicate. The inner mesh bag and the outer plastic bag all get the important information. Label both the outside of the plastic bags and plastic label with a waterproof pen. Include the stratification starting date, when they are due to be removed from stratification, species, lot number, and grams of seed. Do not make large bags of seed even if the lot number is same, break out the seed into amounts a crew can sow in one day (approx.. 80 trays).

Soaking or Imbibing

Cold moist stratification requires the seed to be imbibed or soaked in water. The time in the imbibe process varies for species. In general *Asteraceae* family takes the least amount of time 4-8 hours. Most species seed imbibes approximately 12 hours. *Liliaceae* (bulb seed) and Aquilegia can take up to 36 hours to imbibe.

Some seeds have a phenolic chemical inhibition to germination. These require soaking and regular changing of water during the imbibe process, as a rule change water every two hours or when the water turns brown. Remove in 6 to 36 hours and rinse.

Stratify

Record in the stratification log when you placed the seeds into stratification and when to remove them. Wrap in absorbent pads and place into sealed plastic bags with identifying information from the plant label written on masking tape on the bags. Seeds of different species or lots may go in the same plastic bag if labeled in full on the outside.

Place the sealed containers into the proper cold or warm stratification environment. The seed should be monitored every two weeks to prevent molding. Record all monitoring activities in the stratification log. If seeds start to mold, rinse them with cold water and air out bunched-up seed.

Cold Stratification Protocol Detail

Account and Weigh Seed

1. What you will need:
    a. All seed lots to be stratified that day
    b. A netted poly bag for each lot
    c. Twist ties, 5in labels, hole punch, permanent marker, scissors
2. Remove appropriate species and seed lots(collection) from bin – For each species and seed lot, please keep an accurate accounting of the following on labels and in Record Sheet:
    a. CODON; lot number; year collected, location collected/grown out; weight of seed, date in stratification, date out of stratification
3. Weigh amount of seed as listed on the Production Schedule for each species and individual seed collection. If a large amount of seed from a lot or collection is to be stratified calculate how much seed a facility can sow in a day – use 80 trays as standard even though SCCC can sow more than that.
4. Place each collection or amount of seed to be sown in a day in a netted poly bag (all except seed smaller than 0.5mm); label with plastic 5in label with a (punch hole) and secure twice with twist ties
5. Test secure bags in a tub of water to ensure no leakage of seed
6. Record above information on the Seed Stratification Record Sheet, on the label on the netted poly bag.

Imbibe Seed

1. Set up the bubbler to provide air circulation and moving water if you have a lot of seed, if you have a small amount you can use a plastic tote and change the water every two hours
    a. Materials: water trough, clamps, re-circulating pump, extension cord 10 gal tub filled with water, a saw horse or other 3 ft high prop, misc. stones about fist size
    b. Arrange a trough with the clamps and configure at a~ 4° slope from sawhorse to water filled tub, reduce water loss due to drips by adjusting trough and tub
    c. Install water pump and attaché hose to the top of the trough; plug in
2. Arrange seed bags for full emersion and secure with stones as needed
3. For a small amount of seed skip the bubbler process and use a small tote filled with water and change the water every two hours or so.

Record the following on the stratification log

   a. Seed Treatment if any and time placed in imbibe treatment
   b. Inform Nursery manager, assistant or Plug Production Technician of time the seed was immersed
4. Seed Removal (6 to 24 hours discuss with nursery manager regarding the appropriate amount of time for the species)
   a. Remove seed and set over a tub to drip dry 3-4 hours
   b. Set up for refrigerated cold stratification

Cold Stratification

1. Wrap each sample separately in absorbent cloth, making sure the seed bag is completely covered, this may take 2-4 cloths if the seed lot is large
2. place in plastic bags, keep plastic label and add additional label to the outside of the bag on blue tape
3. Include on the blue tape label: genus, species, CODON, year and location collected, dry weight, and VERY IMPORTANT date put into stratification and target removal date
4. Place in appropriate bin (tracked by target date or facility) in refrigerator
5. Record the following: Date into stratification, days in stratification

Sowing Stratified Seed

From April through July, 99% of the seed you will sow has spent some time in cold-moist stratification prior to sowing. During this time it is kept in mesh bags, wrapped in “chuck rags”, also known as “diapers”, and placed in a refrigerator. The amount of time each set of seed spends in the refrigerator varies by species and year.

While it is in cold stratification make sure to check the seed frequently for sprouts and mold. You don’t want the seed to become over-moist, nor do you want it to dry out. **If the seeds begin to sprout they must become a priority for sowing** to maintain viability. If your seeds should sprout while in the refrigerator **notify your SPP staff member immediately.**

Stratified seed can be moist enough that it is difficult to sow and thus a partial drying can make the process easier. Once you are ready to dry and sow the cold stratified seed, there are some key things to remember:

1) Only bring out the seed needed for that day of sowing.
2) Consider the known work time to bring out the correct amount of seed. Spreading wet seeds on coarse paper towels works best for partial drying.

3) When you are drying the seed, be aware of:
    a. Excessive sunlight
    b. High temperatures
    c. Wind
4) You can dry the seed either indoors or outdoors, but be extremely careful about the above factors; over-drying the seeds will reduce their viability.

Drying Process:

1) Take seeds out of the fridge, lightly shake them up inside of the bag, and then remove the seeds from the bag and set out in a single layer on cookie sheet(s).
2) Pat seeds dry with coarse paper towels.
    a. This does not always work, especially for smaller seeds.
    b. Don't use soft paper towels as they have a higher tendency to stick to the seeds.
3) If patting dry is not effective, leave the seeds on the cookie sheet in a single layer to air dry.
    a. Cover the seed with a towel or paper to slow the drying process.
    B. BE COMPLETELY AWARE OF THE ABOVE-LISTED ENVIRONMENTAL FACTORS (SUNLIGHT EXPOSURE, TEMPERATURE, WIND).
4) **DO NOT** leave seeds out drying for more than 2 hours.
    a. Check on them after 1 hour to observe their progress; do not let them fully dry out!
5) After the day's sowing is complete, any left over seed must be remoistened.
    a. To remoisten and store this seed:
        i. Place back in mesh bag
        ii. Remoisten the chuck rag
        iii. Wrap the mesh bag in the chuck rag and place back in the fridge
        iv. CLEARLY LABEL ANY SEED THAT HAS BEEN PREVIOUSLY DRIED WITH OLD AND NEW INFORMATION.

Seed Scarification

The protective coating that surrounds the seeds of many plants can prevent water and gasses from entering the seed, thus stopping or delaying germination. Species with hard seed coats can last for tens to hundreds of years without germinating; in natural settings, it may take years of extreme temperatures, both high and low, or a rare fire event to weaken seed coats sufficiently to allow germination.

Any process of breaking, scratching, or altering the seed coat through chemical or thermal methods to make it permeable to water and gases is known as *scarification*. Scarification emulates the natural processes that weaken the seed coat, but speeds up and controls the process, removing some of the natural variability in germination rates and leading to the permeability of seed coats. It is a standard technique in horticulture to facilitate the controlled and uniform germination of seed lots. Scarified seeds should be planted as soon as possible after treatment as they do not store well.

The term scarification is most often used to refer to mechanical scarification. In this case the seed coats are filed with a metal rasp, rubbed with sandpaper, nicked with a knife, or cracked gently with a hammer—all action intended to weaken the seed coat. We have found vigorous rubbing with course grit (40 or 50) sandpaper to be effective for scarifying large lots of seeds. When using this technique, examine the seeds with a hand lens before and after applying the abrasion. Rub the seed between the sandpaper for 3 minutes and examine the seed again. Repeat as necessary. Some species take 10 minutes while others may need 30 or more. After the abrasion, the seed coats should be visibly scraped or nicked with the seed coats missing from some areas. You will also see some damaged seeds, an unfortunate byproduct of effective abrasion.

Another scarification method involves the use of hot water for brief periods. Many species' seeds respond to fire scarification to achieve germination. The active element is the fire’s high temperature, shattering the seed coat or making the coat crack along its natural fissures. Sometimes the heat opens up a natural plug (seed lens) at one end of the seed allowing water to enter the seed.

Smoke Water Treatment

Smoke water is a solution containing unstable chemicals which result from low temperature burning of any plant material. Our smoke water was made in a common residential smoker that had a combustion chamber and a second chamber to cool the smoke. The second chamber kept the air temperature less than 130°C most of the time. This created a thick smoke of partially combusted plant material. The smoke was vacuumed through a vessel of water for 1 hour, allowing the water to trap chemicals from the smoke.

Why smoke water?

Certain species of plants have shown to increase germination rates and increased vigor when treated with smoke water prior to sowing. This is particular true for plants in the *Orobanchaceae* family, of which *Castilleja hispida and Castilleja levisecta* are members. These *Castilleja* species are annual or perennial herbs and all are parasitic on the roots of other plants – either holoparasitic or hemiparasitic (fully or partly parasitic). All species in the genus *Castilleja* are hemiparasitic on the roots of another host plant.

Smoke water may increase germination and root vigor in *Castilleja*. *Castilleja*'s roots respond to plant growth regulating chemicals such as strigol, which are regularly produced by the roots of host plants. Strigol and butenolides, the active ingredient in smoke water, have a similar chemical structure to those host root-produced chemicals. Thus, smoke water may act as a root stimulant for plants in the genus *Castilleja*.

Smoke water procedure

1) Place seed to be treated in a plastic 1 L container.
2) Prepare smoke water:
    a. Fill 100 ml container with de-ionized water. DE-IONIZED WATER IS NOT POTABLE, DO NOT DRINK.
    b. Pipette 1ml of smoke water out of container and add to the de-ionized water: this makes a 100:1 water to smoke water solution.
3) Mix smoke water solution with seed, using only enough solution to coat the seed, no more.
4) Let the seed stand for 24 hours.
5) Rinse and proceed to stratification protocol. Or, dry seeds by laying them in a tray, trying to get them evenly distributed in a single layer for quick drying and set up for stratification at a later date. Make sure to put them in a sealed container and clearly label the seed, lot number, and date that they were treated with smoke water.

Sowing Procedure

Soil Mixes

A beneficial potting soil supports a balance of moisture, nutrient retention, and pore (air) spaces within the soil. We use a pre-mixed soil blend for our potting soil that achieves that balance. The primary ingredient (50%) is decomposed Douglas-fir bark. This has large particle size, which encourages drainage. It is combined with small particles, which retain moisture. For additional moisture and nutrient retention, 30% of the soil mix is peat moss. To ensure long-term drainage and increase pore space, 20% volcanic pumice makes up the remaining bulk of the soil mix. Agricultural lime to raise the pH and a slow release fertilizer with micro-nutrients are added for long-term nutrient balance.

Preparing the soil

Fill a 9 cubic foot wheelbarrow nearly full, about 8 cubic feet of soil.
Measure 16 dry oz. of *Apex 22-6-12 NPK Plus* slow-release fertilizer in two scoops of 8 dry oz.; add each scoop to the soil in the wheelbarrow and thoroughly mix the load in between scoops.
Be sure to mix all the way down to the bottom of the wheelbarrow to evenly incorporate the fertilizer.

Filling Trays

Trays can be made in advance of sowing and stockpiled for a week. Check on stockpiled trays to make sure the soil does not dry out excessively.

Materials:

- Plug Containers
- Prepared soil
- Metal tray covers
- Wooden soil tampers
- Film canisters
- Chopsticks, or spoons (optional)

Before filling any trays, check the moisture content of soil: it should feel as wet as a wrung out sponge. Moisten if necessary by mixing or with a watering can or stockpile inside to dry out.

Once soil is ready to go into trays, set up a station at a strong worktable. Locate the appropriate plug container size (c4, c7 or c10), and tray cover. (Appropriate plug container information is located within species information.)

If plug container is a tray with cells, place tray cover firmly over tray and fill with soil.

Lift tray and drop on table repeatedly to settle soil; top off and repeat. Once the soil in the tubes does not compact further when dropped, use the soil tamper to compact soil until the soil is about 0.5 inches below the top of the cells.
If the cones (cells) are uneven heights, tamp down cells that are still too high with an empty film canister.

Make sure to remove any large amounts of dirt that have fallen in between the cells (leaving dirt between the cells increase the presence of weeds). Chopsticks or the thin handle of a spoon work well for this purpose.
Stack and move full trays to greenhouse/sowing area.

Sowing Seed

The sowing protocols will list different techniques specific to each species. Use the protocol to guide you with the following:

- The number of trays to sow
- The number of seeds to sow in each cell
- Cultural methods specific to the species: some seeds are sown on the surface, some are covered with soil and others get soil and gravel (these depend on the seeds' size and density).

Use sowing tray with a bent spoon/scoopula or dial-a-seeder to deliver the appropriate number of seeds per cell. Work slowly and carefully to deliver the appropriate amount of seed per cell; speed up once practice makes perfect.

Cover (if necessary)

Check protocol book for type of soil to use, and how much, to cover the sown seeds: it may be different for each species. As a *general* rule, cover seed twice the thickness of the seed; tiny seed is never covered, medium seed around 2mm cover soil and large seed 4mm of cover soil. These are general rules; consult the section of the manual describing each species and outlining the production protocol.

Place the metal tray cover over the cells, and use the sifter to gently cover the cells with the material. Check the corners and edges of the tray to ensure even coverage—when filling trays the middle cells often fill faster than the corners and edges. For species that require gravel or rock covering, very little gravel or rock is necessary; a light dusting of 1-2mm keeps the seeds from floating away when irrigated.

Check the depth of the cover soil by looking at what has accumulated on the metal tray cover.
When done DO NOT sweep the soil on the metal tray cover into the cells: that will put too much soil on top of the seeds.

Be careful when moving the trays, as you might lose seeds with abrupt movement.

Surface Sown or Sown into Gravel

A few species require surface sowing or sowing into gravel. These seeds need light to germinate or they are very small (> 2000 seeds/gram). Prepare the trays before sowing with a light 1-2mm dusting of grit; you should still be able to see the soil between the particles of grit when done. After sowing, water the seed in lightly so the seeds fall between the grit and the seed is not washed away from excessive water puddling.

Watering & Irrigation

Plant Moisture Check-up

The farmers' shadow is the best manure; this means all plants will do better if you check on them daily, especially to check on the moisture of the potting soil. Most plants in most conditions do not need to be watered every day, but they all need to be checked. When thinking about watering, consider:

- Decide when to water by how the plant looks AND by looking at what is happening in the soil. Before and after watering, pick up the cells and test if they are wet by their weight. Also take a few plants out of their cells and pots to examine the soil visually. These tests should be done before watering to note how dry the soil is and after watering to see how deeply the water entered into the soil.
- Look over the watering pattern and note poor plant growth; no observation is trivial.
- Watering should follow a pattern: active irrigation until the soil is saturated or just over saturation, followed by a rest period of a set number of days when the soil is allowed to dry. Alternating wet and dry allows active root growth; roots need both water and air for vigorous growth and to fight off disease.

Over Watering

Over watering is just as common as under watering. Symptoms of over watering do not happen overnight; they are the result of days or weeks of too much water in the soil. Symptoms of over watering are:

- Decreased plant vigor
- Yellow-brown to opaque/darkened lower leaves
- Wilting from stem rot

All of these symptoms can look just like symptoms of under watering, so care and observation are necessary to know which condition you are dealing with.

Spot Watering

Even the most well designed automatic watering system has areas that do not receive enough water. Also, different sizes of cells and pots dry out at different rates. Varying pot positions can have an effect as well: the corners and edges dry faster than the centers of the beds and tables. These factors create areas in a hoop house that will be dry while the rest of the house is wet. Running irrigation will only make matters worse.

Spot watering by hand is the only way to remedy the situation. Spot watering means FULLY SOAKING those dry the pots or cells. Spot water can only be done by hand and it is one of the most effective ways to achieve uniform growth and increase success rates.

Hand Watering

Applying water should be like a persistent, gentle rain, NOT a West Texas flash-flood. Use a fine water breaker (fine screen watering head) and go over the dry cells two or three times. To hand water, follow these steps:

- Turn on the water away from the trays or pots
- Let any air bleed from the hose
- Always point the watering head up to create an arc of water over the plants
- Never shoot water straight down into a tray or pot; this creates a flood, damaging seeds and plants
- Move smoothly and steadily over the watering area; do not let the water puddle.
- Water the corners and edges more than the centers of beds or tables, and go over the area to be watered two or three times
- Repeated watering is necessary to re-wet dry cells or pots; water follows water and thus dry pots tend to leak water over the top or down the edges, rather than absorbing it. By slowly and repeatedly re-wetting the potting soil, more water will be held in the soil and less will run down and out of the pot.
- Irrigate until water is dripping from the lower drainage holes in the pots AND the pot is heavy
- After irrigation sample a number of pots to see how deeply the water penetrated; re-irrigate if necessary

How Often Do the Plants Need Water?

There are a number of factors that regulate how often the plants need to be watered.

Weather

Obviously dry, hot days are going to dry out the cells or pots faster than wet, cool days. On warm sunny days the cells will need to be checked 2 times a day to see if there are areas that need to be spot watered. Wind can also dry the soil surface and the deeper soil very quickly. Check the soil moisture level frequently during windy periods.

The plants' age

Germinating seeds need more frequent, light watering until their first true leaves come out. Check on germinating seeds 2-3x per day; spot watering is often necessary.

Established plants, after their first 4 leaves or so, can often dry out between watering; check on them every other day or so.

Larger plants with roots that fill the pots need more water and fertilizer; often these older plants can be very hard to re-wet after the soil has dried out. More frequent watering will be necessary.

The plant species

The type of plant or species and its root growth form sometimes dictate the amount of water a plant needs. It is okay for prairie plant cells to dry out a bit between watering when the plants are actively growing and the roots have not yet filled the cells. Once the roots have filed the pots, more water more frequently will be necessary.

Plants with tap roots need less water – some examples are *Armeria maritima*, all *Lomatium* species, and *Balsamorhiza deltoidea*.

Plants with numerous, dense roots need more water – some examples are *Viola adunca* and plants from the daisy family: *Eriophyllum lanatum*, *Solidago* (goldenrod) species, and *Symphyotrichum* (aster) species

Plants that go summer dormant (July and August) often require less water during the summer. However, care must be taken as some species, such as *Castilleja* (paintbrush) species, cannot go bone dry. Other species, such as *Dodecatheon* (shooting-star) species and *Delphinium* (larkspur) species, can go fully dry in summer and we do not water them during this time.

Fertilizer Injector

We will use a fertilizer injector called the Fertigator a couple of times a month in the summer to supply nutrients to larger and actively growing plants. When to apply fertilizer will be communicated in e-mails or visits from SPP.

When using the Fertigator:

- Do not move the setting on the machine.
- Make sure all parts are clean before and after using the machine.
- Wash down all parts and the bucket, then run pure water in the bucket and through the feed line for 5 min, before beginning and after application.
- Use 10 oz of fertilizer per 5 gal bucket of water.

Automatic Watering

See the Netafim guide for general ideas about how the system works. The reality is that the corners, edges and ends of the houses do not get enough water and dry out faster, so spot watering will always be required. Staff and SPP support staff will set the water timer. The setting will be recorded in the watering log. Please do not change the setting without recording it in the watering log.

Why are These Prairie Plants so Picky?

On the prairies the majority of the plants go dormant in the summer; which means that even the small plants lose their leaves, store nutrients in their roots and from all outward appearances look dead. By cultivating them in the nursery, we are asking them to actively grow in the summer; this goes counter their natural seasonal pattern of growth. So we have to be more careful when watering the plants. This means going over all the steps in watering, understanding the irrigation system, knowing the plants and recording all activities in the water log so we can all track any changes. This will allow us to adapt our techniques to ensure the health of all the plants.




A few species that need more irrigation and hand watering, left to right: *Microseris laciniata, Erigeron speciosus*, *Symphyotrichum eatonii* and *Gaillardia aristada* Photos by Rod Gilbert




A few species that have distinct summer dormant periods where watering can be decreased but not eliminated, left to right: *Balsamorhiza deltoidea, Lomatium triternatum, Castilleja hispida, Silene scouleri* and *Castilleja levisecta.* Photos by Rod Gilbert

Record Keeping

Record keeping is essential to documenting progress and accounting for the projected goals of the program. It also allows for the nursery programs to adapt protocols for better results by learning from mistakes and successes; without a record, it is near impossible to learn from trial and error.

Plant Labels and Tray Labels

To keep track of the species and seed lots, note on the label maker the following for each species and seed lot number: species code, the date sown, seed lot number, source of seed and any seed treatment.

Data Sheets

The following pages include samples of data sheets that technicians will complete daily and with the close assistance of SPP coordinators. There is a legend or explanation of all the columns in the sheets included before the sheets. Designate one person on the crew to update them every day.

The data sheets include:

- *Sowing Log* – covers the first activities with each seed lot, from sowing date through germination
- *Growth Tracking* – covers plant establishment, active growth, and final inventory for delivery
- *Germination Data Sheet* – used when the majority of the cells have germinated but before the trays are consolidated; it provides a template to sample 5 replicates of each lot number for germination rate and filled cell rate. It is best to do this two to three times before consolidating the trays—this will give sufficient data to analyze germination rate and filled cell rate for each species.

Nursery Records

Use the nursery daily observation sheets to a record of the work you as a crew have performed. Include the following on the sheet at a minimum but additional information is helpful for the nursery coordinator.

- Sowing methods – alterations from protocols or seed conditions
- Daily activities – watering log, weather, weed observations
- Plant growth observations including plant color and changes, insect and disease observations

Explanation of Data Sheets: Sowing,Tracking and Germination Sheets

	Sowing Sheet
Species	List the CODON for the species. The CODON was developed by the US Forest Service as a unique identifier for native plant species. The CODON is the first two letters of the genus name and the first two letter of the species name; for example, *Armeria maritima* is ARMA. Occasionally, two plants will have the same CODON, as in *Castilleja levisecta* and *Camassia leichtlinii*; if this is the case one plant gets a third letter: CALE for the former and CALEI for the latter.
Lot #	Regional seed collection involves numerous batches of wild-collected and farm-raised seed. We frequently collect a small amount of seed from a number of sites, and each of these gets a unique lot number. Tracking the lot number is very important to ensure we know the generic make up of seed from seed farms and for re-introduction to the wild; the seed produced at a farm gets another unique lot #. LOT NUMBERS ARE THE MOST IMPORTANT INFORMATION ON THE TAG. LOT NUMBERS SHOULD BE KEPT TOGETHER. PLEASE TAKE ALL CARE TO NEVER MIX UP LOT NUMBERS BY GROUPING LOT #s WITH THE SAME COLORED LABEL.
Date Sown	Record at the end of the day all flats sown on that day for each codon and lot number. Tracking daily accomplishments is also a great positive affirmation.
Seed Weight Used (g)	In grams write down the amount of seed used to accomplish the sowing for that lot # for that day
Trays Sown (Projected)	This column will include the actual number of trays, and the projected goal of amount of trays to sow shown in parentheses. At the end of the day, record the number of trays sown of each species and lot number. Record the projected number in (): this is the number of trays calculated by the SPP staff that was the goal for the amount of seed provided. By recording both actual amount of trays sown and projected, SPP staff and nursery technicians can adapt sowing techniques to better meet sowing projections.
Date First Germination	Record the date when the first germinants appear in the trays. The appearance of the first seedlings will vary from species to species. Refer to the plant descriptions in the manual or the plant ID cards for information on when to expect germination. Monitor weekly so that you don't miss the first few.
Seeds per Cell	Each species has a unique number of seeds per cell. The number of seeds sown varies by the difficulty of producing the seed, the number of plants needed, and past germination rate for the species. The number of seeds per cell may change year to year depending upon any of the above factors.
Filled Cells per Tray	After a number of the cells have observable germinants, this count is the number of individual cells that have a living plant in a tray. We sample 5 trays of each sowing lot to estimate a range and average for the whole sowing lot.

Explanation of Data Sheets: Sowing,Tracking and Germination Sheets

Germ. Total per Tray	After a number of the cells have observable germinants, this count is the total of ALL the living plants in a tray (including multiple plants in a single cell). We sample 5 trays of each sowing lot to estimate a range and average for the whole sowing lot.
Date of Last Significant Germination	Many of the species grown in the conservation nursery germinate over a long period--as much as 5 months. By noting the difference between the first and last significant germination, we can adapt the sowing protocols to improve overall germination and plant growth.
Notes	Please record any important information, bad smelling seed, lots of chaff, seed hard to sow etc.
Recording the seeds sown per cell, the number of filled cells per tray, and the total germinates per tray for each sowing lot allows us to track the germination percentage and alter the sowing rate for each species from year to year. This is very important information to make the conservation nursery run more effectively and efficiently.	
	Growth Tracking Sheets
Species	repeat the information from above
Lot #	repeat the information from above
Date Sown	repeat the information from above
July Inventory	Number of trays of established plants from each sowing lot as counted in the second week of July. Do not count plants sown June 1 - July 15.
Sept. Inventory	Number of trays of established plants from each sowing lot as counted in the first week of September. We may need to estimate plants that have not been consolidated, those sown after July 15th.
Establish Date	A seed may germinate but not thrive and grow to be an established plant. The date of establishment tells us how long or what cultural methods it takes for a seed to become a plant. A good measure of plant establishment is counting the number of true leaves: when they have two true leaves or two sets of true leaves, the plants are established and watering can be reduced to promote deep root growth.
# of Plants Established	A month or so after establishment, for most species we consolidate the established plants and dump out or separate those cells that do not have germinants. After consolidation provide a count of the total number of plants for each sowing lot.
Date Filled Cells	Plants will grow at different rates. This date is recorded when a significant number of the plant's roots have reached the bottom of the cell and have filled the cylinder. Often this means the plants have completed most of the active growing they can do in the cell. We can alter the sowing date in future years if we know the plants have been held in the cone-tainers for too long.

Explanation of Data Sheets: Sowing,Tracking and Germination Sheets

Insect and Disease Issues	Record all incidents of disease, insects, and weeds. Record the method of control, and frequency and duration of all measures taken--this is true for all physical, mechanical, and chemical controls. Use multiple lines on the data sheet as necessary.
Notes	Note any unique cultural techniques used to grow the lot, any characteristics that made that lot stand out from others, or any relevant information that was not previously noted. Useful conclusions or recommendations for next year can be abbreviated here.
	Germination Sheet
Why?	This is a means to achieve an estimation of the germination rate and filled cell rate of all seed lots. We usually cannot sample a whole population or all the trays sown from a seed lot. Instead we take a representative sample: usually 3 to 5 trays is enough. ONE VERY IMPORTANT NOTE: WHEN SELECTING THE 3-5 SAMPLE FLATS CHOOSE RANDOMLY. TURN YOUR BACK AND PICK A RANDOM NUMBER, COUNT TO THAT FLAT, AND SAMPLE THERE. DO **NOT** PRE-SELECT THE BEST OR WORST FLATS. Germination sampling is vital because it allows us to adapt the number of seeds per cell and the total number of trays sown for future years.
Date Sown	repeat the information from above
CODON	repeat the information from above
Lot #	repeat the information from above
Seeds per Cell	repeat the information from above
Rep. #	note the number of the replicate 1-5
Total Germinants	Count ALL the seedlings in one tray; this is one replicate. Repeat for 4 more trays
Filled Cells/Tray	Count the total of filled cells: cells that contain a living plant of the species we want (not a weed)
Comments	Note odd observations or problems with the sowing, such as too dense or sparse germination

Demonstration Sowing Log 2013-2014

Species	Lot #	Date Sown (projected)	Seed Weight Used (g)	Trays Sown (proj.)	Date First Germ	Seeds per Cell	Filled Cells per Tray	Indiv. Germ total per Tray	Date last sig. Germ	Notes

Demonstration Growth Tracking 2013-2014

Species	Lot #	Date Sown (projected)	July Inventory (# Trays)	Sept Inventory (# Trays)	Establish Date	# of Trays Established	Date Filled Cell	Insect Disease Issues	Notes

LOCATION:
DATE:
TECHNICIAN:

Germination Data Sheet

Date Sown	CODON	Lot #	Sds per Cell	Rep. #	Total Germinants	Filled Cells/Tray	Comments

WCCW Conservation Nursery Daily Observation Sheet

- Date: *11/30/13*

- Crew Members: *Bri M., Carl E.*

- Weather: *Foggy and cloudy in the morning, the sun came out after lunch. It's cold today but not freezing*

- Tasks Accomplished: *Today we sowed BADE, we sowed 35 trays. We covered the sown trays with floating row once we watered them. We also filled some trays for tomorrow's sowing.*

- Did you water today? *No, the cells were still very moist—except the trays we sowed today, we did water those*

- When did you last water? *We last watered about one and a half weeks ago on 11/18*

- Notes/Questions for SPP Nursery Coordinator

Some examples of questions you may have:
We noticed that there's a lot of stuff besides seed in the seed packets—what is it?
We haven't watered in a long time—is that ok?
Why are we sowing so much of this plant, where does it get planted out?
No question is too small or insignificant—don't be afraid to ask any question here that comes to your mind

Transplanting Protocols

Transplanting, also called picking out or replanting, is the technique of moving plants from one soil-location to another. Our most frequent need for transplanting comes when there are many seedlings competing for water and nutrients in the same cell.

Different species react differently to transplanting. The main goal is to avoid *transplanting shock*: the stress or the damage of being in a new environment, and recovering from any damage to roots or foliage incurred during the transplanting process. After transplant, the plants need a period of acclimatization (adaptation to the new environment). This means that the plants will require more attention and check-in on water and nutrient needs until they have recovered.

Follow these steps to minimize the root disturbance, protect from the weather conditions, and care for the seedlings during and immediately after transplanting.

1) Create a shade house with shade cloth over the hoop house. Set up a mesh table under the shade cloth: use a 2 ‘x 2’ piece of plywood to work on. Have a source of water ready to water-in transplants, and a damp rag or piece of burlap handy to cover exposed roots of plants as needed.

2) Consolidate all the cells into four groups:
   1. Large enough and crowded enough to prick out (i.e., more than 5 plants per cell)
   2. Plants too small to prick out
   3. Plants not crowded enough to prick out
   4. Plants not germinated.

3) Check soil moisture. Cells to transplant should be a little on the dry side; partially dry soil makes it easier to separate the plants.

4) Make a number of racks of cells filled less-than-to-the- top and set by the transplant area.

5) Before beginning, create labels for all the trays you are expecting to transplant into. This will keep track of the different species and lot numbers and make sure you never forget to label.

6) Invert cells with the plants to extract entire plug of soil and roots.

7) Lightly drop plug of soil and plants on the plywood; this will loosen the soil around the roots.

8) Tease the plants apart by handling the cotyledons (first leaves) or the oldest leaves; try not to handle the roots. Repeat lightly dropping the clumps of plants until the roots of the various seedlings separate.

9) Hold a single seedling by cotyledons or oldest leaves and move it to a new cell.

10) Move quickly as ROOTS SHOULD NOT BE ALLOWED TO DRY OUT. Drying out can easily happen in any weather, as roots are not made to be exposed to air. If you interrupt work for any reason, USE A DAMP CLOTH OR RAG TO COVER ALL EXPOSED ROOTS.

11) Use a dibble to make a hole in the new soil. Try not to bunch the roots in the hole; instead, lay them flat out on one side and move soil to them horizontally to cover the roots completely.

12) Bury the seedlings to the same level as in the original cell, or a little higher. Do not bury them too deeply, as this may rot the stem and kill the plant.

13) Re-check to make sure all trays are labeled before moving them to a shaded spot in the hoop house.

14) Water-in as soon as possible and keep in the shade for 24 hours before moving them to their permanent spot.

15) Check frequently on fresh transplants to monitor soil moisture and check for signs of stress. Take action as needed!

Plant Identification

Most everyone thinks they can identify a plant and generally they are correct. We can all pick out the leaves, stems, flowers and seeds; *Voilà tout*, that is a plant. However, that is not all there is to a plant. In the conservation nursery we cultivate over 65 species per year and even more species of weeds can appear in the nursery or flow in from the surrounding landscape. Identifying the qualities and characteristics of plants in more detail can provide you with the skills to discover the diversity in plant life and the similarities among plants that allow humans to have a working knowledge of this biological life.

There can be a lot of information in a scientific plant name. People who classify plants for a living (plant taxonomists) strive to give plants a name that will somehow describe its characteristics. The attributes included in a plant name could be:

1. Plant form and structure (morphology)
2. Evolutionary history/relations to other plants (systematics)
3. Historical name or historical edible and medicinal use
4. Plant life cycle
5. Where is grows in the wild (plant biogeography)
6. Lastly, personal ego: some plants were named to recognize important plant taxonomists or those who coordinated large herbariums

Let us choose a common prairie species and a weed to examine how a plant name is useful to describe the plant. In the plant description section of the manual, there are a number of classifying names for plants provided for prairie plants and weeds. At the end of this section you will find an illustrated glossary that will aid you in identifying the terms used in the following examples.

1. *Castilleja hispida***,** Harsh Indian paintbrush, *Orobanchaceae* Family

The scientific name is *Castilleja hispida*. The first name *Castilleja* is the classification of the genus and all members of *Castilleja* have similar attributes of plant structure and form. Unfortunately, *Castilleja* does not describe an attribute of the genus; it is the last name of Domingo Castilleja, a Spanish botanist that collected extensively in the Americas. The second name, *hispida,* is the species name that separates this plant from other 200 species in the genus. Hispid is the botanical description of the stiff hairs that stand up like bristles on the stems and leaves of the species.

Orobanchaceae is the plant family classification. The family name comes from the most abundant single genera or related plants that can be grouped together in the family. All genera (plural of genus) in the *Orobanchaceae* share some similar attributes. The plants are full or partial parasites on other plants, they have significant storage roots,

and leaves are reduced and often fully absent. The flowers are reduced but often have showy leaf structures (bracts) surrounding the flower. The flowers are five (rarely four) petaled, usually fused together in a tube with four stamens. The carpel holds numerous seeds in a dry capsule that disperses the small seeds by wind.

The common name, harsh Indian paintbrush, is a good descriptor of the species, though hispid is more precise than harsh. Many people drop the first part of the name and call the plant simply Indian paintbrush. Thus by using the common name the unique character of *Castilleja hispida* is often lost.

2. Wild Lettuce • Sow Thistles • *Sonchus oleraceus. Asteraceae* Family

This weed is common throughout cultivated lands in the Mediterranean. The ancient Greek name for this plant was *sonchus*, referring to the hollow stem of the plants from this genus. Botanists are partial to Greek and Roman names for plants and many common weeds retain the names used in antiquity. The species name refers to how the young plant was commonly eaten as a salad. *Oleraceus* means a cultivated edible plant. Thus this particular plant was once not considered a weed at all but was welcome in cultivated areas for its choice young leaves.

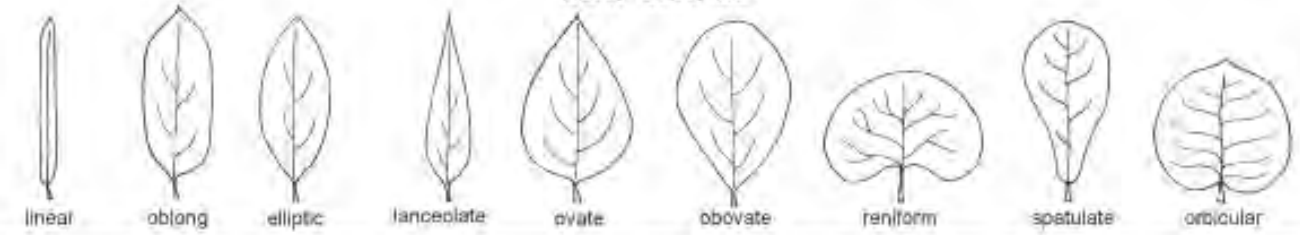
The plant family is *Asteraceae* or aster. Asters are the most abundant genus in this family therefore the family is named for that genus. Once the aster family was called the composite family because the flower heads are a composite of hundreds of small flowers. See *Symphyotrichum chilense* spp*. Hallii* in the plant description section for a good illustrated diagram of an aster flower.

Scientific names can be intimidating at first but by frequent use become like a second language. As with any new language it helps to see through the words and look into what they really mean. SPP has provided a number of illustrated glossaries, plant identification manuals and plant name dictionaries that can introduce you to the specific knowledge involved in the naming and classification of plants

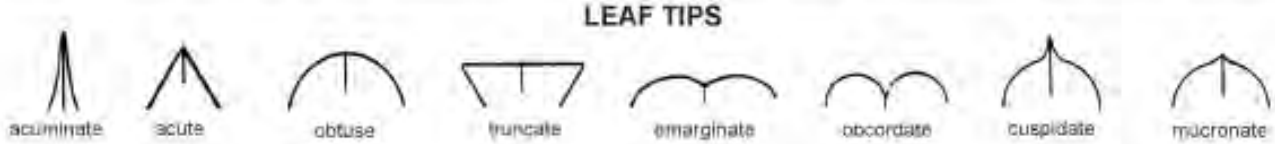
Common names often seem easier to remember than scientific names, but they are not as precise. Not only can a common name refer to very different plants, conversely a single species can have more than one common name. This can lead to confusion, and potentially to serious problems if people confuse weedy or poisonous species with harmless species. Hopefully by becoming familiar with scientific plant names you will begin to recognize their precision and usefulness to broadening your understanding of the plant itself.

ILLUSTRATED GLOSSARY OF LEAF SHAPES

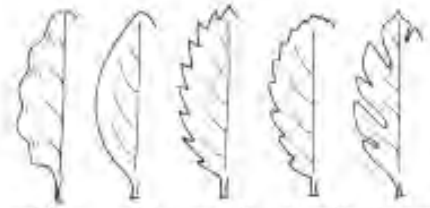
LEAF SHAPES



LEAF TIPS

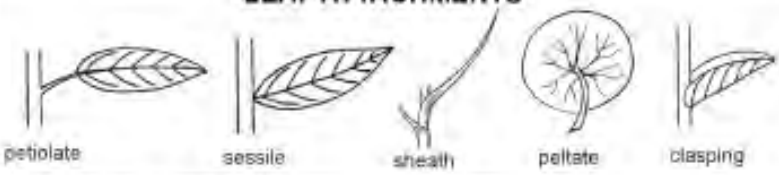


LEAF MARGINS

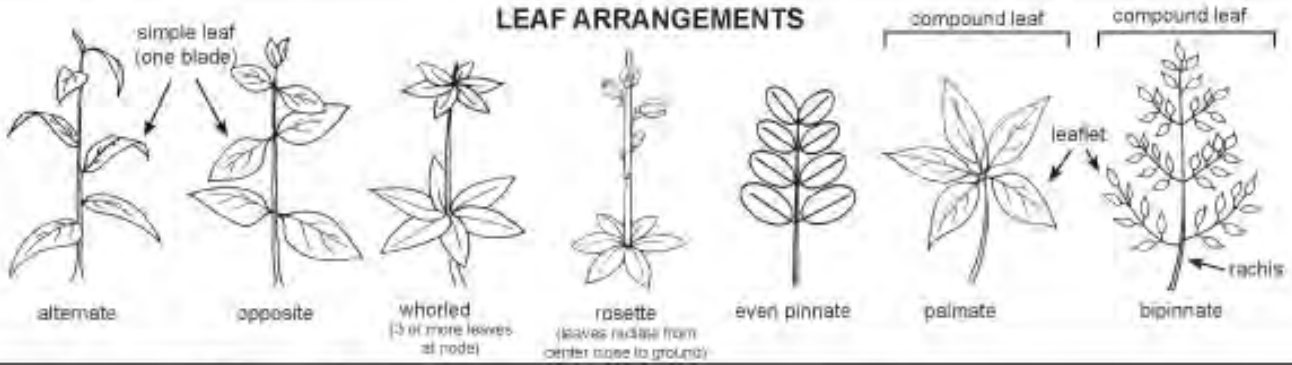


LEAF BASES

LEAF ATTACHMENTS



LEAF ARRANGEMENTS



HABIT

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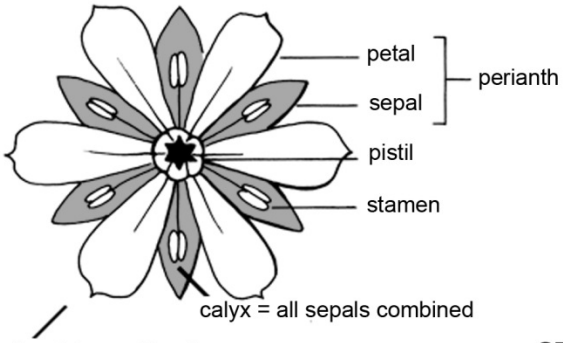
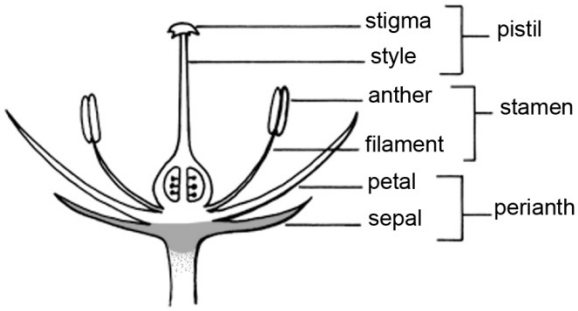
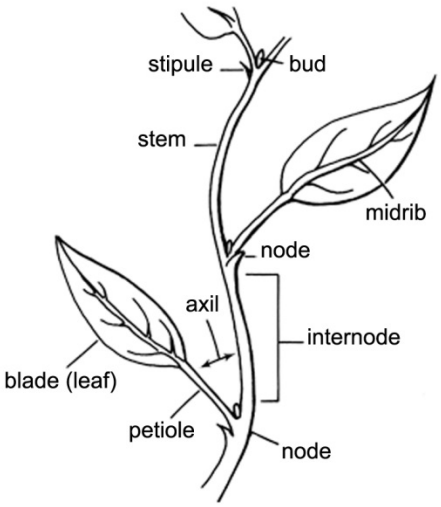
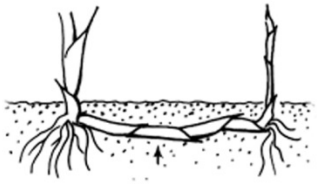
ILLUSTRATED GLOSSARY OF FLOWER PARTS

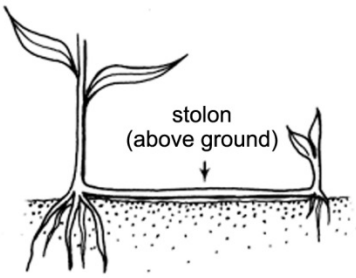


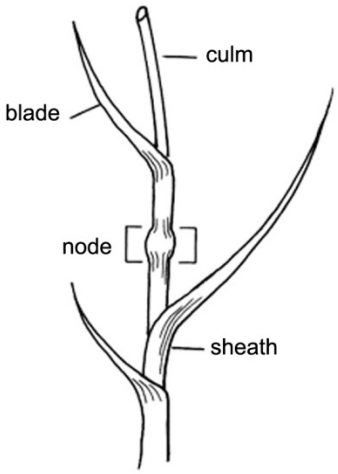


STEMS

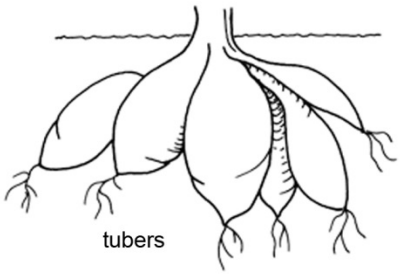


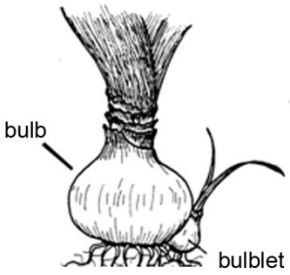


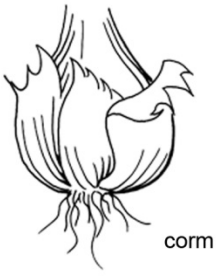


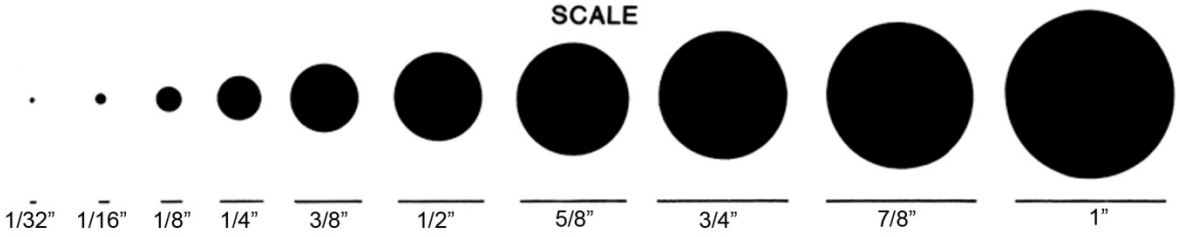


ROOTS









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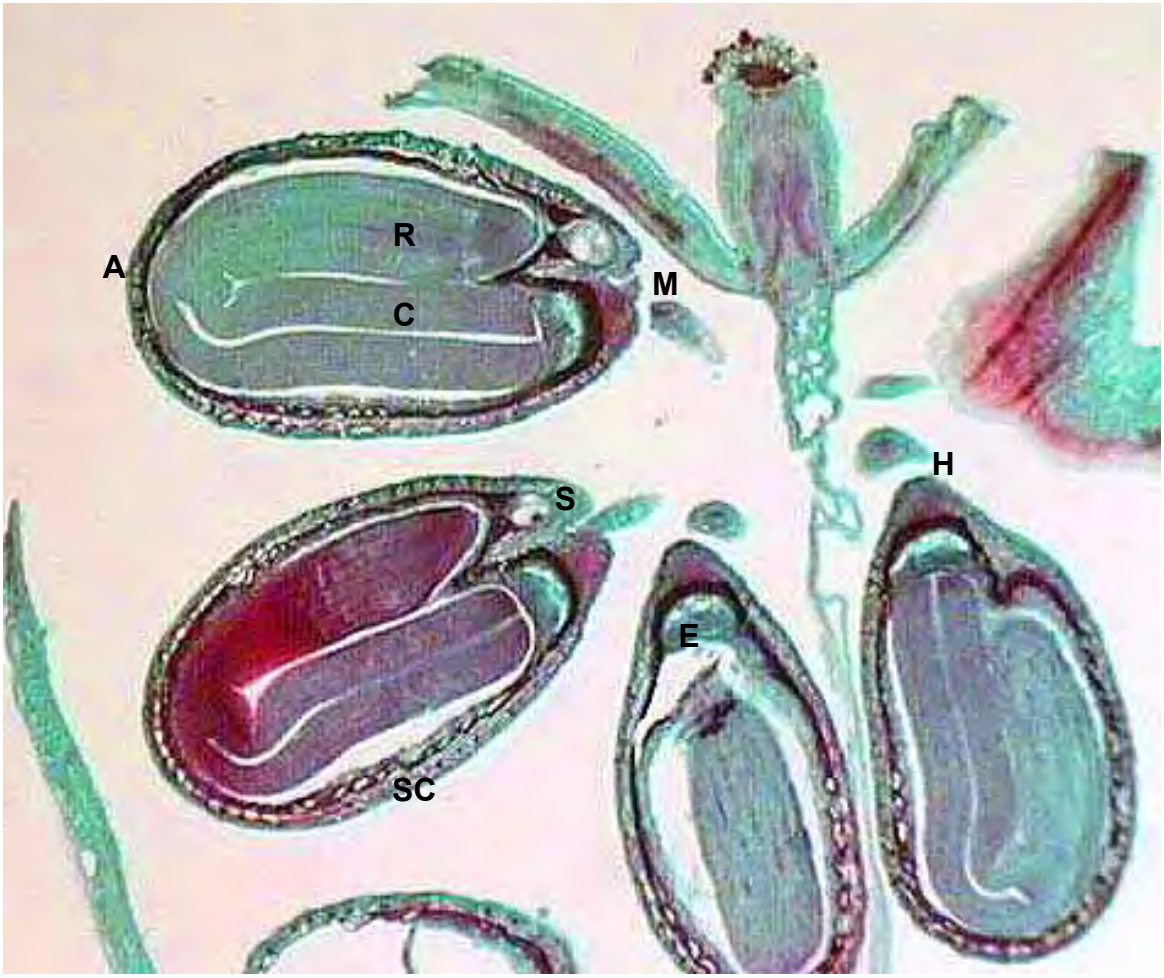

Slide Photo from Ohio State Plant Physiology Lab

Definitions for Dicot Seed Parts

Hilum (H): Specialized cells forming an attachment with the maternal plant.
Apex (A): End of seed opposite the hilum or farthest away for the maternal attachment
Seed Coats (SC): Layers of cells forming the outer edge of the seed. The seed coats also have additional specialized cells surrounding the endosperm where plant growth regulators are concentrated.
Micropyle and/or Lens (M): The folded channel in the seed coat where most of the water enters the seed. An impermeable lens covers the micropyle in species with hard seeds.
Endosperm (E): Cells designed to store starch and provide sugars to the developing embryo.
Radicle (R): The root tip of the developing embryo.
Cotyledons (C): The pair of first leaves on a young shoot.
Suspensor and Basal Cell (S): Specialized cells to hold the developing embryo against the seed coat wall.

General Strategies for Insect and Mite Management

The conservation nursery primarily grows plants to create habitat for rare and threatened butterflies. Eventually some insect will either eat the nectar or leaves of the plants we grow. This potential for our plants as food greatly reduces the choices we have to control insects in the nursery. Many modern insecticides function systemically in the plant and can remain in the plant for over a year. Obviously, these systemic insecticides cannot be used. A number of biological insecticides we have used in the past, we have chosen to discontinue.

The conservation nursery has adopted the precautionary principle when it comes to pesticide application. If there is any possible pathway for an insecticide to affect any butterfly now or if the insecticide effects could persist we choose not to use it. Because of this principle we rely heavily on the first stages of Integrated Pest Management to control pest and diseases. The first step is diligent cultural control. Many of the protocols are detailed for a reason; these methods of nursery cultivation reduce or eliminate the need for further measures. This is particularly true when it comes to the timing of sowing and cultivation and effective yet precise water use to reduce insect and disease problems.

The second step is monitoring plant growth. We provide a number of workshops on insect monitoring and cultural controls through the growing season. Below is an outline of general monitoring techniques. We will extensively use sticky traps and sticky tape as monitoring and mass trapping techniques. These mechanical methods of control, which may include manual removal, will be important to control insect populations.

The third step is the introduction of beneficial insects to the nursery. We plan on trialing beneficial nematodes for the control of fungus gnats and predatory mites to control thrips and two-spotted spider mites. The last step will be the use of insecticides/miticides. We will only use two products in the conservation nurseries. One, horticultural soap and two, horticultural oil will be used to control aphids, whiteflies, mite eggs and powdery mildew. These products have a residual effect of less than 2 weeks and function in a mechanical means by either drying out or smothering the target insect. Thus insects are less apt to develop pesticide resistance to these substances.

Cultural Controls are Essential

Pests are generally brought into the greenhouse on new plant material or come into the hoop houses from the doors and sides. Many are able to survive short periods of time between harvest or plant removal and production of the next crop. Cultural controls are the primary defense against insect infestations.

The following cultural practices will help to prevent pest infestations:

1. Inspect new plants thoroughly to prevent the accidental introduction of pests into the greenhouse.
2. Keep doors, screens and ventilators in good repair.
3. Use clean or sterile soils or ground media. Clean or sterilize tools, flats and other equipment.
4. Maintain a clean, closely mowed area around the greenhouse to reduce invasion by pests that develop in weeds outdoors.
5. Eliminate pools of standing water on floors. Algal and moss growth in these areas can be sources of fungus gnat and shore fly problems.
6. Dispose of trash, boards and old plant debris in the area.
7. Remove all plants and any plant debris; clean the greenhouse thoroughly after each production cycle.
8. If possible, allow the greenhouse to freeze in winter to eliminate tender insects like whiteflies.
9. Avoid overwatering and promote good ventilation to minimize wet areas conducive to fly breeding.
10. Avoid wearing yellow clothing which is attractive to many insect pests.
11. Maintain a weed-free greenhouse at all times.
12. Eliminate infestations by discarding or removing heavily infested plants.

Monitoring

Early detection and diagnosis of pest infestations will allow you to make pest control decisions before the problem gets out of hand. It is good practice to make weekly inspections of plants in all sections of the greenhouse. When monitoring, select plants so that they represent the different species in the greenhouse. Pay particular attention to plants near ventilators, doors and fans. At least 1% of the plants need to be examined on each monitoring visit in the greenhouse.

Insect monitoring devices should be used in the greenhouse. Yellow sticky cards (PT Insect Monitoring & Trapping System, Whitmire, St. Louis, MO) are highly attractive to winged aphids, leafminer adults, whiteflies, leafhoppers, fungus gnats thrips (blue cards can also be used with thrips), various flies and other insects. These can be used to alert

you to the presence of a pest and identify hot spots in the greenhouse. One to three cards per 1000 square feet in the greenhouse is recommended. Cards should be changed weekly. Typically, these sticky cards are suspended vertically just above the tops of the plants. They can be attached to sticks or hung on string. If you cannot identify a trapped insect, contact your county Extension agent for assistance.

Mass trapping products such as sticky tapes are also available for management of thrips, whiteflies, leafminers and fungus gnats. While sticky cards are primarily used just to alert you to insect infestations, mass trapping tools are used to reduce and manage insect infestations. Mass trapping relies on using enough surface area of the attractive sticky tapes to capture and reduce pest numbers. Care should be taken to keep monitoring and trapping products dry and free of debris. This will maintain effectiveness of the traps.

Biological Control Agents

Natural enemies are commercially available for control of some greenhouse pests. Levels of pest control obtained with beneficial organisms will vary greatly depending on a number of factors, including:

- species of pest involved
- species of natural enemy used
- timing of release of natural enemy relative to pest buildup and crop development
- number of beneficial insects released
- greenhouse temperature and range of fluctuation
- time of year
- condition of the beneficial insects at release
- pesticide usage before and after release of beneficial insects

Biological control generally requires more time than pesticides to bring a pest population under control. Natural enemies require time to disperse from release sites and to search for prey or hosts. Appropriate natural enemies should be released as soon as the pest is detected in the greenhouse.

Natural enemies do not provide sufficiently rapid control of pests that are already causing serious losses, and they will not generally eradicate an infestation. In some instances, using an insecticidal soap or other non-residual insecticide is recommended to reduce the infestation before releasing the natural enemies. Knowledge of pest

biology and monitoring of pest populations are critical to determining when to make releases.

Greenhouse managers should avoid unnecessary insecticide/miticide applications before and after release of natural enemies. If insecticide/miticide treatments are required, limit treatments to pest “hot spots” to avoid treating the entire greenhouse. Use a selective, short residual pesticide if possible. For example, *Bacillius thuringiensis* (Bt) products can be used to control caterpillars without harm to natural enemies in the greenhouse.

Beneficial Organisms Commercially Available for Greenhouse Pest Management	
Beneficial organism	**Pest controlled**
Parasitic wasps, *Encarsia formosa*	Whiteflies
Parasitic wasps, *Aphytis melinus*	Scales
Leafminer parasite, *Dacnusca sibiriica* and *Diglyphus isaea*	Serpentine leafminers, fungus gnats
Predatory mites, *Amblyseius californicus*, *Phytoseiulus longipes* and *Phytoseiulus persimilis*	Spider mites
Predatory mites, *Amblyseius cucumeris* and *Amblyseius mckenziei*	Thrips
Lady beetles, *Hippodamia convergens* and *Cryptolaemus montrouzeri*	Various soft-bodied insects and eggs
Green lacewings, *Chrysoperla carnea*	Various soft-bodied insects and eggs

Pesticide Management

Greenhouse operators need to maximize the effectiveness of insecticides and miticides. To provide adequate control, a pesticide must be applied at the proper rate, when the pest is present. Sufficient coverage and pressure are needed to penetrate dense foliage and reach the target pest. This is especially important for sucking insects that infest the lower surface of leaves. Older, lower leaves can be removed to open the canopy of some crops to increase spray coverage. Insecticide or miticide applications must sometimes be repeated frequently to maintain a pest at acceptable levels.

Timing of pesticide applications is important. Some pests are vulnerable to pesticides only at certain stages in their life cycle. For whitefly management, begin control measures early. If control action is delayed until an abundance of adult whiteflies can be seen, then numerous eggs and immature stages, which are more difficult to control, are usually present.

With a limited number of pesticides available for greenhouse use, it is always a concern that pests may develop resistance to pesticides. Managers should rotate among different pesticides for successive applications when controlling specific pests. Rotations must include pesticides belonging to different chemical classes that use different modes of action to control the pests. This will prevent, or at least delay, the development of resistance to a particular pesticide.

To aid pesticide applications, plants that are frequently infested by the same pest and can be legally sprayed with the same material should be grouped together. This will reduce the potential for misapplications to unlabeled crops. Additionally, moving infested material through the greenhouse can spread an infestation to other areas.

Insecticides/Fungicides

Before applying any herbicide, insecticide, or fungicide you must first read the product label. The label will provide very important information such as how much of the chemical should be applied, which plants it can be applied to, protective equipment required for the person applying, what to do in case of a spill or accidental exposure, and other crucial information. The product label is available in several places- it is on file with the Department of Corrections staff, covered by SPP staff during training, and provided in this manual. Please always read the label before using these chemicals. Improper use can be dangerous for your health, the plants, and the environment.

Horticultural Summer Oil

Unlike many gardening products that show promise in laboratory experiments but fail under real-world conditions, horticultural oils have been extensively tested in the lab, greenhouse, nursery, and field on a variety of insect pests found on many species of herbaceous and woody plants. Though not effective on all garden pests, horticultural oils can successfully combat common nuisances including aphids, scale, whiteflies (insects), and mites (arachnids). All are controlled by relatively low concentrations of oil (usually 1-2%) that generally are not toxic to the leaves of plants.

Horticultural oil application immediately creates a physical barrier to respiration by the insect by clogging the spiracles or breathing pores, along the sides of adult and larvae abdomens. Similarly, oils applied to egg masses inhibit oxygen uptake and decrease hatching success. Though contact mortality is considered to be the primary mode of action, horticultural oils also interact with cell membranes, interfering with their function and possibly creating toxins.

Early formulations of horticultural oils tended to contain impurities that caused damage to the foliage of many plant species. Modern formulations are highly purified and bear little resemblance to those first toxic mixtures of kerosene and other volatile chemicals, and professionals who routinely apply oils report little damage to plant material. Horticultural oils are easy to apply and are relatively safe even for new growth, provided mixing and application directions are carefully followed.

It’s worth exploring the circumstances under which plants might be damaged by horticultural oils. While horticultural oils are intended to remain on leaf surfaces to have their pesticidal effects, they often end up inside the leaves as well. Using a variety of imaging techniques, researchers have been able to visualize movement of oils through the stomata and across the cuticle. Once inside, oils are able to move throughout treated leaves and into adjacent, untreated tissues. In some cases, this foliar uptake

can result in phytotoxicity, manifesting itself as chlorotic or yellowing leaves, which might then develop brown stippling, necrotic leaf tips and margins, and/or a water-soaked appearance before eventually dying. Happily, horticultural oils do not cause phytotoxicity to the vast majority of landscape plants. However, very few native perennial plants have been tested for phytotoxicity caused by horticultural oils.

The Conservation Nursery will continue to use horticultural oils on a limited basis for the control of mites, aphids and thrips as well as a secondary method to control powdery mildew.

Horticultural Soap

Horticultural soap is defined as any potassium fatty acid soap used to control plant pests. Insecticidal soap is typically sprayed on plants as a foliar (leaf) application. Insecticidal soap only works when in direct contact with pests. The fatty acids in the soap disrupt the structure and permeability of the insect's cell membranes, allowing the cell contents to leak from the damaged cells, quickly killing the insect.

Insecticidal soap works best on soft-bodied insects such as aphids, mealybugs, spider mites, thrips, and whiteflies and is 40-50% effective against these pests. Many beneficial pollinators and adult forms of predatory insects such as lady beetle adults, bumble bees, and syrphid flies are relatively unaffected, though few studies have been done on soap's effects on larvae.

Soaps have low mammalian toxicity. However, they can be mildly irritating to the skin or eyes. Insecticidal soaps may cause phytotoxicity (toxic to the plant) symptoms, such as yellow or brown spotting on the leaves, burned tips, or leaf scorch on certain plants. In general, some vegetable crops and certain ornamentals are sensitive to burn caused by soaps. Multiple applications in a short time interval and water conditioning agents can aggravate phytotoxicity. When uncertain, spot treat a small portion of the plants, and wait at least 24 hours to see if any symptoms develop before treating an entire group of plants. Plants under drought stress, young transplants, unrooted cuttings, and plants with soft young growth are more likely to develop symptoms and should not be treated with soap.

The concentration of the spray is more important than the amount of soap applied. Usually insecticidal soaps are used as a 2% solution. Soap sprays, alone or in combination with horticultural oils or botanical oils, are also valuable in the management of certain plant diseases, most notably powdery mildew. Repeated applications may be necessary to adequately control high populations of pests or diseases. Always read the label for specific instructions before applying.

Aphids

Almost every plant has one or more aphid species that occasionally feed on it, but low to moderate numbers of aphids usually aren't damaging to gardens or landscape trees. Although aphids can curl leaves and produce sticky honeydew, they rarely kill plants and you usually can wash them off with water. When aphid numbers get high, natural enemies frequently feed on them, eliminating the need for pesticides. When pesticides are necessary, use less toxic products such as insecticidal soaps and oils.

Aphids are common in your garden because:

- **Aphids like lush new growth. Don't over fertilize. Use organic or slow-release products.**
- **Aphids build up on flowering plums, roses, tulip trees, crape myrtles, apples, and many vegetables. Expect aphids when you grow these plants.**
- **Ants protect aphids from beneficial insects. Keep ants off plants to help natural enemies do their job.**

To reduce aphids:

- **Prune out infested leaves and stems.**
- **Knock aphid populations off plants by shaking the plant or spraying it with a strong stream of water.**
- **Protect seedlings with covers or aluminum foil mulches.**
- **Wait for hot weather; most aphids are heat-intolerant and will be gone by mid-June.**

Protect aphids' natural enemies:

- **Lady beetles, both adults and larvae;**
- **Lacewings;**
- **Syrphid fly larvae;**
- **Soldier beetles; and**
- **Parasitic mini-wasps that turn aphids into crusty mummies.**

Beneficial insects such as lady beetles and lacewings will come into your garden naturally when aphids are abundant. Protect these good bugs by avoiding the use of insecticides that can be toxic to a broad variety of insects.

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If insecticides seem necessary, use the safest products.

- **Use nonchemical pest control methods first to manage aphid populations. However, if you feel insecticides are necessary, choose less toxic products.**
- **Insecticidal oils and soaps are the safest products. When properly used, these materials solve most pest problems.**
- **Oils and soaps work by smothering aphids, so apply these products thoroughly. Don't apply them to drought-stressed plants or when it is very hot. A few plants are sensitive to these products.**
- **Apply insecticidal soaps, soap-pyrethrum mixtures, or neem oils on vegetables or small bushes such as roses.**
- **Narrow range horticultural oils—such as supreme or superior oils—are appropriate for larger trees.**
- **Oils and soaps don't kill aphids hidden within curled leaves. Prune these out. Systemic insecticides can kill hidden aphids, but they are much more toxic and might kill honey bees and parasites on flowering plants.**

See *Pest Notes: Aphids* at www.ipm.ucdavis.edu for more details.

Green peach aphid colony.

A healthy aphid is flanked by mummified aphids killed by parasitic wasps.

Minimize the use of pesticides that pollute our waterways. Use nonchemical alternatives or less toxic pesticide products whenever possible. Read product labels carefully and follow instructions on proper use, storage, and disposal.

For more information about managing pests, contact your **University of California Cooperative Extension office** listed under the county government pages of your phone book or visit the UC IPM Web site at **www.ipm.ucdavis.edu**.

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Thrips

When thrips feed, they distort or scar leaves, flowers, or fruit. Healthy woody plants usually tolerate thrips, although damage can become unattractive. Herbaceous ornamentals and developing fruits and vegetables can suffer more serious injuries. Use an integrated program combining good cultural care, pest exclusion, planting thrips-resistant species, and protecting natural enemies by using least-toxic insecticides.

Thrips are tiny, slender insects with hairs on their wing margins.

- **They are less than ½0 inch long, and their color varies depending on the species and life stage.**
- **Thrips hatch from eggs and develop through two feeding larval (nymphal) stages and two nonfeeding stages (prepupa and pupa) before developing into adults.**
- **Certain thrips are beneficial predators of some insects and mites.**
- **Most pest thrips feed while hidden, often in buds and shoot tips or beneath sepals; you'll often observe the damage before seeing the thrips.**
- **Greenhouse thrips and western flower thrips are two common pest species in landscapes.**

Damage often isn't apparent until tissue grows and expands. Look for:

- **Scabby, silvery to dark brown discoloration on fruit, leaves, or petals.**
- **Dark specks of excrement on fruit or leaves.**
- **Distorted, curled, galled, or dead shoot tips and leaves.**

Check for thrips before you treat!

Be certain that pest thrips are present and causing damage before taking control action. Harsh weather, inadequate plant care, pathogens, and other invertebrates can cause similar-looking damage. Shake foliage or flowers over white paper to see if this dislodges any thrips. Hang bright yellow sticky traps to detect flying thrips.

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Thrips are difficult to control. Combine methods in an IPM program:

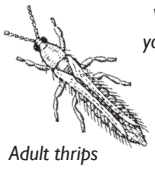
- **Find out what species you have and research the best approach; see *Pest Notes: Thrips* at www.ipm.ucdavis.edu.**
- **Conserve parasites and predators by avoiding persistent pesticides.**
- **Avoid overwatering or applying nitrogen fertilizer, which can increase thrips populations.**
- **Prune off declining, injured, or infested plant parts.**
- **Apply row covers or cages over small plants to exclude thrips.**
- **Cover soil with reflective mulch, which repels flying thrips if foliage covers less than about half of the soil surface.**

Pesticides.

Pesticides won't restore the appearance of injured tissue. Plants remain damaged until injured tissue drops or is pruned off and new growth appears. Thrips are difficult to control with pesticides. Often pesticides won't be effective unless you wait until the next season and spray new growth.

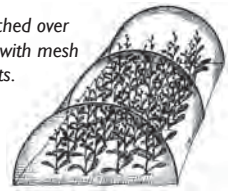
Horticultural oils, insecticidal soaps, and pyrethrins can provide temporary control, especially for greenhouse thrips. Spinosad may be more effective. Pesticides alone rarely provide good control, so combine spraying with other methods.

See *Pest Notes: Thrips* at www.ipm.ucdavis.edu for more details.



Adult thrips

Wire or plastic hoops arched over young plants and covered with mesh can exclude insects.



Minimize the use of pesticides that pollute our waterways. Use nonchemical alternatives or less toxic pesticide products whenever possible. Read product labels carefully and follow instructions on proper use, storage, and disposal.

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Whiteflies

Whiteflies are tiny, sap-sucking insects that damage leaves of many plants. Adults are white and sometimes have darker markings on their wings. Nymphs, which cause most of the damage, are oval, legless, and don't move. Many species occur in California landscapes, and natural enemies keep most under good control. Prevent whitefly problems by using reflective mulches, avoiding dust, choosing less susceptible plants, and eliminating pesticides that kill whitefly natural enemies. When management is required, consider using insecticidal soaps, sticky traps, and removing infested plants.

Signs of a whitefly infestation can include:

- Tiny nymphs on the undersides of leaves.
- Sticky honeydew on leaves, fruit, or beneath plants or a covering of black, sooty mold.
- Yellowing, silvering, or drying leaves that have whitefly nymphs on them.
- Deposits of white wax with some whiteflies.

Protect natural enemies such as lacewings, lady beetles, and mini-wasps.

- Avoid using pesticides such as pyrethroids, organophosphates, carbaryl, or foliar sprays of imidacloprid.
- Prevent dusty conditions.
- Keep ants, which protect whiteflies from natural enemies, out of plants.
- Recognize signs of parasitization such as circular holes in nymphs (see back) or a change in color.

Install a reflective mulch in your vegetable garden to protect young plants.

- Use aluminum-coated construction paper or reflective plastic mulch products.
- Lay the product on bare soil, bury its edges with soil, and insert seedlings or seeds into holes that you make in the mulch.
- Plastic mulches require drip irrigation underneath them; paper mulches can be sprinkle or furrow irrigated.
- Mulches repel whiteflies and other small flying insects such as aphids while plants are small. Remove mulches when plants get large and temperatures get hot.

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Use hand removal and traps to reduce whiteflies.

- Prune out isolated infested leaves when you first detect them.
- Hose adults off or use a hand held vacuum.
- Install ready-to-use, sticky-coated yellow traps or make your own. Use one trap for every medium-size vegetable plant.
- Promptly destroy infested annuals when flowering or fruiting ends.

Pesticides.

Even the most toxic insecticides are only partially effective. If you decide to treat, choose products that are least harmful to natural enemies—such as insecticidal soaps and oils including neem oil—and combine their use with the other practices listed above. Good coverage, including the undersides of leaves, is essential. Repeat applications might be required. Avoid using even these pesticides if many natural enemies are present.

See *Pest Notes: Whiteflies* at www.ipm.ucdavis.edu for more details.

Sweetpotato whitefly and nymphs.

Examine empty nymphal cases for signs of parasitization. The T-shaped hole in the nymph (above) indicates a healthy adult whitefly emerged whereas an adult parasite emerged from the round hole (below).

Minimize the use of pesticides that pollute our waterways. Use nonchemical alternatives or less toxic pesticide products whenever possible. Read product labels carefully and follow instructions on proper use, storage, and disposal.

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Fungus Gnats

Identification

Fungus gnat larvae (*Bradysia* spp.) are white and legless, about 1/4 inch long when mature, and have a shiny black head. The adult is mosquito-like in body shape, about 1/8 inch long, with long legs, a clear pair of wings, and long antennae. Fungus gnats are weak fliers and are frequently observed resting on the media in the pot or running over the foliage or other surfaces.

Damage

Fungus gnats are attracted to damp locations where fungi are apt to flourish. Fungi are a major part of their diet. Studies have shown that fungus gnats develop more rapidly and have greater survival on fungal diets. In the absence of a fungal food source, however, fungus gnats are capable of feeding on healthy plant tissue. They are also general feeders and can injure a number of flower crops grown in the greenhouse.

Fungus gnat larvae are observed feeding on roots, fungi and decaying matter, often injuring bulbs, seedlings and plants with succulent stems and roots. The burrowing of larvae in plant tissue promotes decay. Fungus gnat adults and larvae can spread spores of fungal pathogens, such as *Pythium* species, among plants. Adult flies become a nuisance when present in large numbers. Larvae present in infested plants or soil can lead to prolonged emergence of adults.

Life Cycle of Fungus gnat

The life cycle of fungus gnats is shown in Figure 1. A female fungus gnat may lay up to 300 whitish eggs in clusters of 20 to 30 or more on the surface or in the crevices of moist soil or potting media rich in organic matter. Eggs hatch in about six days. Larvae feed for 12-14 days before changing into a pupa, which is formed inside a silken pupal chamber in the soil. The pupal stage may last 5-6 days and adults live up to 10 days. The life cycle from egg to adult requires approximately 4 weeks depending on temperature; development time decreases as temperatures increase, as is true of most insects.

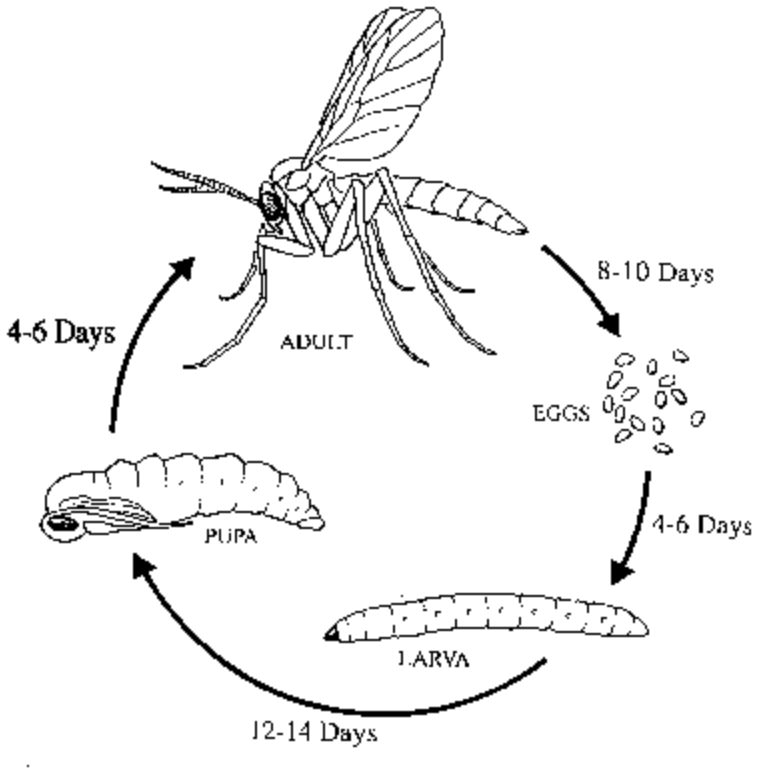


Figure 1. *Life cycle of the fungus gnat*

Management Strategies

1) Fungus gnat populations may be partially suppressed by sanitation practices that reduce breeding areas.
2) Eliminate standing pools of water on solid benches, on walks, and under benches. This may be accomplished by proper grading and drainage in the greenhouse and by improving watering practices to prevent runoff.
3) Potting media should be pasteurized before use if possible.
4) Moist potting soil high in organic matter that has been left outdoors for long periods may contain fungus gnat larvae. Fungus gnats may also be introduced into the greenhouse in the media of infested plants purchased from other greenhouses.
5) Keep areas below benches free of spilled potting mix, weeds and other debris in which fungus gnats and shore flies might breed.
6) Eliminate algae as best you can. Several algicides are currently registered for algae control in the greenhouse. Read and follow directions on these products.
7) Thoroughly inspect all incoming plant material and make early treatments.

Detection and Monitoring

As with any pest, fungus gnat control programs are built on prevention and monitoring. To prevent infestations, establish a weekly scouting/monitoring routine for the duration of the crop.

To monitor for larvae, place raw potato chunks with peel removed on the soil surface. Larvae are attracted to the potato chunks, under which they move and congregate. Check the potato chunks daily for larvae. Potato disks cut one inch in diameter and 1/2 to 1 inch thick work well. In addition, choose plants on each bench and inspect the soil surface and around the base of the plant including the stem just below the soil line. Record the location and the level of infestation. Badly infested containers of plants should be removed as they serve as a source of infestation.

Adult flies can be monitored with yellow sticky cards placed at the base of the plant at soil line. Weekly inspections of yellow sticky cards can detect the onset of an infestation, and continued recording of the number of adults per card per week can aid in evaluating the efficacy of control efforts.

Space 3" x 5" yellow sticky cards 1-4 per 1,000 sq. ft. throughout the greenhouse. Place yellow cards in a horizontal position just above the soil surface, or lay them on the top of the pots. For early detection, position cards near doorways and vents or among new plants being placed in the house. If time permits, check the cards twice weekly particularly when temperatures warm up in the spring. Once fungus gnats begin appearing on sticky cards or larvae are seen under potato chunks then it is time to make treatment decisions.

Biological Control

Several biological control organisms are available for control of fungus gnats, including the microbial insecticide Gnatrol (containing the bacterium *Bacillus thuringiensis israelensis*), a predaceous mite (*Hypoaspis miles*) and parasitic nematodes *Steinernema carpocapsae* and *S. feltiae*. These nematodes have been applied at a wide range of application rates and have produced variable results.

Treatments

Soil treatments (pot drenches and sprenches) at the first sign of insect activity are best used to manage fungus gnats. A drench fully saturates the soil directly without contact to the aboveground plant, while a sprench is sprayed on the stem and base of the plant enough to wet at least the first inch of potting medium. Soil treatments provide direct treatment targeted toward the larval stage. Make sure material is applied to a depth of 1" or more. Materials are most effective when they are retained in the media. Carefully read and follow all label directions.

Fungus gnats are common pests on plants such as geraniums, poinsettia, begonias and bulbs, especially if soilless mixes high in peat moss or immature compost are used. Insecticides may not affect eggs or pupae, and repeated applications may be necessary.

The following is a partial list of options for managing fungus gnats. In the conservation nursery we will be trialing the first two. See label for information on application methods and rates, and plant safety. The asterisk indicates the type of product.

Hypoaspis miles (predatory mite), (*natural enemy)
A soil-dwelling predaceous mite that feeds on larvae. Introduce mites at planting or just after.

Nemasys, Scanmask, (*Steinernema feltiae*, parasitic nematodes), (*natural enemy)
For fungus gnat larvae. Best control is achieved with the first application made at planting or shortly thereafter. Two or three subsequent applications at weekly intervals may keep fungus gnat numbers low throughout a 10 - 12 week crop. . Follow label instructions.

Weed Identification

Annuals—Annual weeds are plants that develop from seeds, mature, produce seeds, and die in one growing season. **Summer annual** plants germinate from seeds in the spring, grow through the summer, produce seeds, and die in the fall. Examples are crabgrass, foxtail, fall panicum, pigweed, and lambsquarters. **Winter annual** plants germinate from seeds in the fall, overwinter, mature, produce seeds, and die in the spring or early summer. Examples are chickweed, henbit, cheat, and shepherd's purse.

The majority of the weeds that are found in our nurseries are winter annuals. These can germinate in fall through early spring. The very successful shotweed or *Cardamine* spp. germinates year-round, especially in cooler areas along the coast.

Biennials—Biennial weeds complete their life cycle over a two-year period (two growing seasons). They frequently develop from seed and form a rosette (a low-growing cluster of leaves) during the first year. During the second growing season, the stems elongate, flowers and seeds develop, and the plant then dies. Biennial weeds include poison hemlock, Queen Anne's lace (wild carrot), common mullein, and musk (or nodding) thistle. Biennial weeds can usually be controlled using the same methods effective on annual weeds, but they are easier to control during the first year of growth.

Perennials—Perennial weeds live for three or more seasons and reproduce by seed and/or vegetative parts. They are often more persistent than annuals or biennials. Johnsongrass, quackgrass, Canada thistle, brush, shrubs, and trees are perennial weeds.

Simple perennial weeds ordinarily reproduce only by seed, but vegetative reproduction can occur if roots or crowns are cut by tillage implements. Cut pieces may send out feeding roots and stems to become new plants. Dandelion, curly dock, and plantain are examples of simple perennials.

Bulbous perennial weeds, such as wild garlic, reproduce by bulbs and bulblets, as well as by seeds. Both aerial bulblets and seeds may be produced in the flower heads. Secondary bulbs may develop below the ground.

Creeping perennial weeds spread by lateral extension of the stems (stolons) along the soil surface, by stems (rhizomes) beneath the soil, by roots, or by seeds. Mouse ear chickweed, knotgrass, and pennywort spread by creeping stems along the soil surface. Quackgrass, johnsongrass, and hedge bindweed spread by rhizomes. Sowthistle and red sorrel spread by creeping roots.

Poa annua **• annual bluegrass** *Poaceae* Grass Family

Grasses are a common weed problem in gardens, especially those near open fields—the same is true with greenhouses. There are a lot of grass species that you'll encounter in the cells, but this is one of the most common.

Poa annua can grow as an annual plant, however in the Pacific Northwest it often acts as a biennial or short lived perennial. It grows in small clumps when in the ground. When it invades greenhouse plant cells its roots can take over the entire cell relatively quickly. Left alone they can grow to be 4-6 inches tall, even within the individual cells.

All photos courtesy of Oregon State University

The flowers are in a wispy inflorescence with white flowers displayed in a terminal (end of the stem) panicle (spiraling) bloom. The leaves are prow-shaped like the ends of canoes. This species, as with most grasses, is a heavy seed producer. They can produce around 100 seeds within 8 weeks. They are also easily spread and hard to rid from the green house. For this reason, grasses should be a top priority for weeding.

Cardamine oligosperma and *Cardamine hirsuta* • bittercress, shotweed

Brassicaceae Broccoli Family

Bittercress is particularly problematic in container nurseries as it favors conditions that are consistently moist. They are easy to miss while weeding because the cotyledon leaves start very small and look very much like many prairie plants.

The seeds readily stick to the walls of cells or to any little bit of gravel on the greenhouse floor, and they germinate quickly. Before they bloom, bittercress plants look like miniature clovers. Many seedlings occur in the same area and can form dense mats, but at an early enough stage they are tiny individual sprouts.

Bittercress Seedlings, photo Oregon State University

Extreme moss and bittercress invasion of a *Lomatium utriculatum* tray, photo by Rod Gilbert

The flowers occur in bunches at the end of the stems and each flower has 4 petals in a cross shape. As if bittercress were not bad enough by itself, it also is a refuge for aphids that proliferate underneath the leaves in late winter and early spring. They grow and germinate year-round in a nursery situation in the Pacific Northwest. Germination is practically abundant in spring and fall. The best way to manage them is to reduce the amount the parent flowers setting seed, keep the greenhouses clean of debris and sanitize the cone-tainers between plantings.

Cirsium arvense • Canada thistle

Asteraceae Aster Family

There are many species of thistle but the most common present in nursery production is the Canada thistle. Canada thistle foliage is covered in small sharp bristles and is a pale, glossy green. The seedlings have rounded spoon-shaped seed leaves (cotyledons) that stand out because of their glossy sheen. They are easy to identify and eradicate as young seedlings.

Photos courtesy of Oregon State University from PNW Weed Management Handbook

The flowers are light pink and about ½ inch long and wide. They reproduce by creating seeds that are spread by the wind. They also have an extensive root system—this means that although they are easy to identify care must be taken to remove all roots when weeding. In addition, seeds can remain viable for a long time. Frequent weeding of surrounding nursery and grounds areas can reduce the amount of seed present in the cells.

Stellaria media • common chickweed

Valerianaceae Valerian Family

This is another common weed in greenhouses that looks similar to Bittercress. It forms small mats and even grows on top of itself. The foliage is glabrous (without hairs) and has ovate leaves alternating down along the stem.

The flowers are terminal (on the end of the stem) and are organized in clusters. The petals are white, 5-merous (5 petals), and each petal is bi-lobed, giving the impression of 10 petals instead of 5.

Chickweed blooms in spring and is easily disguised within the taller plants in the greenhouse. It reproduces with both seeds and new stems rooting at the inter-nodes. One plant can produce several generations of seedlings during one season. Keeping an eye out for it during all weeding is important to avoid a complete takeover.

Senecio vulgaris • common groundsel

Asteraceae Aster Family

The Groundsel is in the *Asteraceae* family along with the weeds ox-eye daisy and dandelion. They grow upright, are branched, and can grow up to 2ft tall—but in the greenhouse you will rarely see them that big. They can compete with seedlings for nutrients and light.

The flower heads, which are tubular, consist of multiple individual disk flowers that create a composite head—common to the Aster family. The species can have multiple generations in one year, sometimes blooming when only a few inches high. It is important to weed them out of the cells early in their life cycle to reduce seed numbers. The plants frequently germinate and grow on the floor at the corners and edges of the greenhouse. Frequent weeding of all nursery areas is essential.

Groundsel is one of the most common weeds of empty lots, clear-cuts and human built environments. The seed needs light to germinate and can blow in from surrounding areas. The source of seed around farms and nurseries is practically limitless.

All photos courtesy of OSU from PNW Weed Management Handbook

Hypochaeris radicata • hairy cat's ear

Asteraceae Aster Family

Hairy cat's ear is the most common weed on Pacific Northwest prairies as well as being common in lawns and gardens. Many people call the plant dandelion as the flowers look similar to that plant. However the flowers of *H. radicata* are atop branched stems primarily blooming in late spring and summer, well after true dandelion. The plant can bloom all through the summer on very little water from rainfall, making it a persistent and adaptable weed.

In a nursery, the plant makes a quick-growing rosette of leaves. This wide and rapid growth blocks out light for the nursery plants. Hairy cat's ear is hard to remove once established in the plant cells, so frequent and thorough weeding is essential. The seed can easily migrate from surrounding lawns and gardens, and good general weed control is necessary to reduce the plant's establishment.

Foliage and branched flower stems of hairy cat's ear, photos from University of Massachusetts Extension

Lactuca spp. • wild lettuce and *Sonchus spp* • sow thistles

Asteraceae Aster Family

These weeds are native to the Mediterranean and can easily be confused as their habit of growth is similar. All are weeds of empty lots and agricultural fields. Believe it or not these spiky invasive plants are in the sunflower family. All grow with a big taproot and have milky sap in the stem. They can grow to be between 1 and 5 feet tall.

Lactuca serriola

Sonchus oleraceus

The newly germinated plants (above) as well as the adult plants (below) resemble dandelions but are frequently prickly with hairs. The flowers are small, yellow and bloom in early spring. Like many resistant weed species, these have long-lived seeds that can blow in from surrounding areas making eradication difficult. Diligent and careful weeding can help keep their numbers under control.

A number of species of *Lactuca* are native to North America and were extensively eaten by First Peoples for their nutritional content. Unfortunately, none of these natives have appeared as weeds in our nurseries.

Lactuca serriola

Sonchus oleraceus, all photos from OSU Extension

Epilobium cilatum • northern willowherb

Onagraceae Evening Primrose Family

Epilobium ciliatum is one of the most difficult weeds to control in container crops, and is among the top five weed species in Pacific Northwest nurseries. *Epilobium ciliatum* gets its name from the Greek word epi which means upon, and lobos, which means pod. This is characteristic of the flower of the plant that surmounts the pod-like ovary. *Ciliatum*, also Greek in origin, means fringed with hairs and is characteristic of the pubescence that lines the stem and inflorescence.

The seeds of northern willowherb develop in long, hairy (pubescent) capsules about 3 cm in length. The seeds are attached to a tuft of hair, which aids in wind dispersal. Seed dissemination occurs from June to September. Wind dispersal mandates excellent sanitation for controlling this weed. Eliminate any plants growing in non-crop areas in and around the nursery.

The container environment provides an ideal site for germination. Seeds can germinate in low light conditions, making them well adapted to germination under the canopy of container crops. Seeds can germinate over a range of temperatures from 40 to 86 F, although germination is more rapid in warmer conditions. This allows germination to occur virtually year round in container nurseries.

E. ciliatum produces a rosette as an over wintering structure. It may also produce turions, a type of hibernation bud in the fall. It is common to see these over-wintering structures in gravel container yards during the winter. As soon as weather warms in the spring, these rosettes bolt quickly into a tall stem with a flush of lush green to purple foliage. Remove these plants during the slow winter months before they bolt and produce more seed.

All photos from Oregon State University PNW Weed Management Handbook

Taraxacum officinale • true dandelion

Asteraceae Aster Family

True dandelions are found in many landscapes, yards and greenhouses. The true dandelion can be identified by the smooth leaves on top and short hairs on the underside of the leaves along the stem.

The stem, which often has a purple hue, is hollow. The leaves are lobed to a degree that they look “toothed like a lion”, and they grow in a rosette from a strong, persistent taproot. The flowers are terminal atop the singular stems, yellow in color, and consist of thousands of ray flowers bunched together. The many seeds produced on the flower heads are spread easily by the wind. Dandelions are sometimes found in the plant containers but more commonly they are around the greenhouse borders, encouraging the seeds to spread into the plant cells.

All photos from Oregon State University PNW Weed Management Handbook

Marchantia polymorpha • **liverwort** • Phylum *Marchantiophyta*

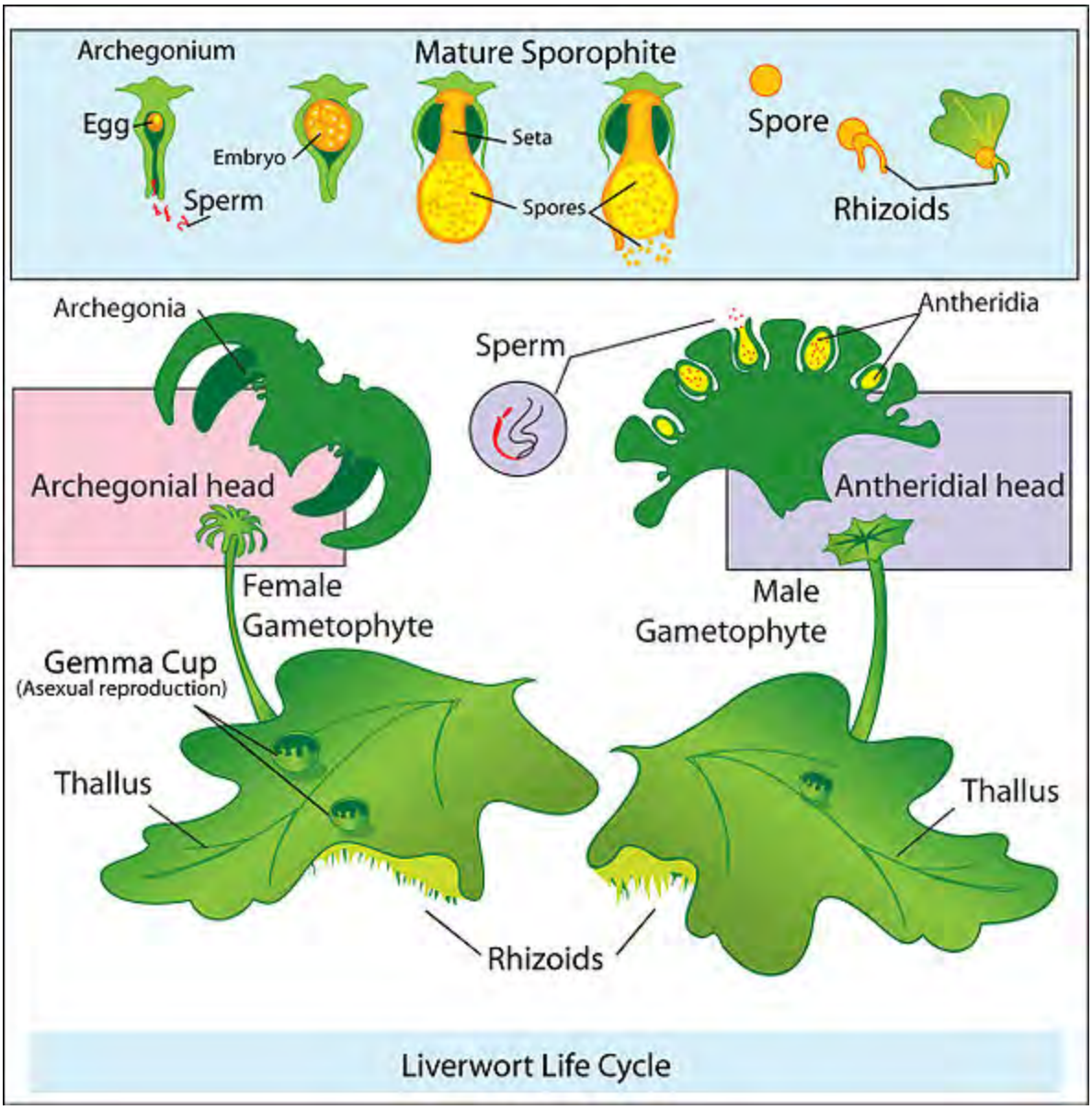
This weed is probably the one you will see most often. It grows fast, spreads easily, and is EVERYWHERE. It is flat and grows in dense, dark green mats that look like octopus tentacles. Liverwort is nearly impossible to keep out of all greenhouse plants, so the weeding needs to be diligent to reduce spreading, and it is relatively easy to weed. Understanding its reproduction will reduce re-establishment.

Each plant has both male (sperm producing) and female (egg producing) reproductive parts. The female (left) tendrils are brush-shaped and the male parts (right) are umbrella-shaped.

Gemma cups

Sexual reproduction occurs in liverworts but it is not the most successful form of reproduction. *Marchantia polymorpha* also produces cups that hold gemmae. These hold enough genetic information to produce another gametophyte. A gametophyte is the most obvious life-cycle stage that is seen in a nursery for all liverworts (non-vascular bryophyte land plants).

Asexual reproduction by gemmae is the most successful form of reproduction for liverworts. The gammae can be disbursed over a meter by splashing water and if kept moist can live in cracks and crevices for over a year. The picture at the left shows parts of a liverwort: the leafy thallus, small gemma cups and in the lover portion of the picture you can see round gemmae that have been disbursed by irrigation. Look around the floor of the nursery and you will find many gemmae in the wet corners and edges.



The Liverwort Lifecycle. Liverworts have a gametophyte-dominant life cycle, with the sporophyte dependent on the gametophyte. Cells in a typical liverwort plant each contain only a single set of genetic information (haploid) for the majority of its life cycle. This contrasts sharply with the pattern exhibited by nearly all animals and by most other plants. In the more familiar seed plants, the haploid generation is represented only by the tiny pollen and the ovule, while the diploid generation is the familiar tree or other plant. The mature sporophyte lives its whole life in the archegonial head and the spores are very short lived, often only a few days. By Mariana Ruiz Villarreal

Control of Liverworts and Mosses in Greenhouses

Summary of research results from Sven Svenson, Oregon State University, North Willamette Research and Extension Center, Aurora, Oregon

1. Do not overwater. If the nursery crop will tolerate the drying, allow the surface of the growing medium to dry between irrigation cycles. If possible, switch to subirrigation systems.

2. Do not apply excess nitrogen or phosphorus fertilizers. Fertilizer concentrations that are above the "required" amount for your crops are often optimal for liverwort growth.

3. Surface applications of slow-release iron sulfate and/or copper sulfate help prevent liverwort infestations. Fertilizers applied to the surface of the growing substrate (as a liquid, granular or slow-release product) support more liverwort growth than if the fertilizer is incorporated into the growing substrate before potting (unless the surface-applied slow-release fertilizer contains adequate amounts of iron, zinc manganese and copper). Zinc sulfate or zinc chloride fertilizers can help control liverworts, but the amount applied to kill the liverwort is often toxic to nursery crops.

4. Liverworts generally die if the crop's canopy will provide sufficient shade to the surface of the growing medium.

5. In the Pacific Northwest, liverwort infestations are more likely to start in early fall through late spring. The heat and dry air of summer will help reduce liverwort growth and establishment. In greenhouses or structures that maintain high humidity, or under production systems with frequent overhead irrigation applications, liverworts are a problem year-round.

6. Surface mulches that dry rapidly will reduce liverwort establishment. The most useful mulches we have tested are: gravel; hazelnut shells (not crushed too small); oyster shells; filter-fabric weed barriers (often treated with copper hydroxide). In commercial nurseries, consumers have stated that they dislike the appearance of the hazelnut shells, oyster shells and weed "discs," and their purchase and application reduces nursery crop profitability.

7. A combination of reduced irrigation frequency, reduced nitrogen and phosphorus application, and a surface-preventative fertilizer (slow-release iron sulfate) has provided nearly 80% control of liverwort infestations. Several nurseries have nearly eliminated their liverwort weeds by changing irrigation practices and "spot-treating" wet areas (walkways, under benches, driveways, etc.) within the production area. Use of subirrigation greatly reduces the establishment of liverworts.

8. Useful pesticides for liverwort control do not currently have a label for this use. These chemicals are usually labeled for use as fungicides, and usually contain the heavy metals manganese and/or zinc. The effective fungicides often have REI's (re-entry intervals) of 48-hours, which restricts their usefulness in any ornamental plant production system.

9. Chemicals that do currently have a "label" for use on mosses (and sometimes liverworts) are usually phytotoxic to crops if applied to the foliage. Examples: DeMoss; GreenShield; Physan. These work with some satisfaction for walkways, under benches, etc., but most growers have not been able to use "over-the-top" foliar sprays without some level of damage to the crops. Similar damage risks have been observed by growers spraying vinegar for liverwort and moss control.

10. Available preemergent herbicides do provide some control of liverwort, but common nursery irrigation and fertilization practices often reduce the effectiveness of the herbicides. Reducing irrigation application frequency, and reducing fertilization, in combination with the use of preemergent herbicides does provide moderate control of liverwort infestations.

A grower in Washington found a fungus growing on his liverworts, effectively "controlling" the liverwort infestation. This potential biocontrol agent has resisted laboratory culture (to date).

Many nurseries and greenhouse growers use recycling irrigation systems, systems that include chlorination, bromine injections, and/or ozonation. We have always been able to grow liverworts from water samples collected after treatment (suggesting that the gemmae, spores or liverwort fragments are resistant to typical commercial-sanitation procedures used by our ornamentals industries). No studies have been done, but the hypothesis has been proposed that air-borne spores can be wind-translocated over very long distances (so growers will "never" be completely rid of the liverwort pressure).

Apocynum androsaemifolium • spreading dogbane • APAN

Apocynaceae Dogbane Family

Plant Description

Spreading dogbane is a perennial herb (blooming every year) that grows up to 1 m tall. The many branched stems have a milky juice when they are broken. The surface of the stems varies from glabrous (smooth) to having white wooly hairs. It has a bushy stature with opposite, oval leaves. The flowers are usually terminal (at the ends of the stems). They are light pink with dark pink towards the center with five petals—they have a bit of a bell shape to them.

Photo by: Ben Legler

Ecological Importance and Distribution

APAN is found widely throughout Washington, preferring dry soil in open areas (like prairies) ranging from low to high elevations. The late blooming time, July and August, makes the plant a valuable nectar source on the prairie. This plant was used by First Peoples medicinally to slow the pulse and practically by making a very strong thread.

Growth and Reproduction

The flowers bloom between June and July. During that time the ovary, situated above the base of the petals, is pollinated and creates slender seed pods. These can be anywhere between 7-20 cm long. The very small seed is borne on the wind through delicate hairs at the end of the seed (pappus). The seed is carefully hand cleaned as no easy mechanical method has been identified. The seed requires cold-

APAN seed with pappus
Photo by JK Marlow

moist stratification for approximately 70 days. To date we have observed that APAN has erratic germination and we hope to gather more information on successful germination in future sowings.

Seed Dimensions

Measurement Range: L: 1.2 – 2.1 mm, W: 0.2 – 0.5 mm, D: 0.1 – 0.3 mm
Shape: Narrow at hilum end and opposite apex. Seed somewhat flattened.
Color: Hilum white against brown seed body.
Surface: Longitudinally ribbed with small glossy globules. Seed shiny (lustrous).

Latitudinal cross section: elliptical 

Longitudinal cross section: elliptical 

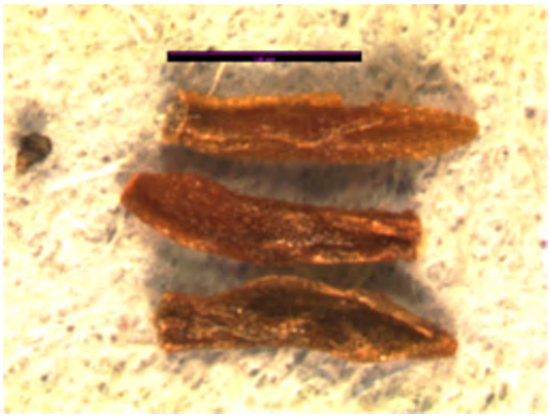


Photo by Lisa Hintz

Sowing Information
- Seeds per gram: 5827
- Seed per cell: 5
- Cover: into gravel
- Stratification: 70 days

Aquilegia formosa • Western columbine • AQFO

Ranunculaceae Buttercup Family

Plant Description

Perennial herb. Flowers are in two parts; the sepals (outer flower parts) are five bright red, long tubes drawn back into red spurs with nectar at the back tip. Inner flower parts or the petals have short yellow lobes sticking out from the outer parts (sepals). Nectar lures and feeds hummingbirds and butterflies. Stamens holding pollen and stigmas, receiving pollen, extend beyond upper lobes of petals in a tight cluster ready to brush against nectar seekers as they feed. The plant blooms from April to June. Leaves are delicate lobed leaflets in groups of 3. Grows up to 3 feet tall.

Sepals red and petals yellow in AQFO; Photo by Rainyside Gardeners

Ecological Importance and Distribution

There are several kinds of columbines in many different colors found across the northern hemisphere. The color of the flower is often an indicator of the primary pollinators. Yellow and pale cream flowers are often visited by moths, blue to white by bumblebees and red to yellow are pollinated by hummingbirds and butterflies. Two species of columbines with different pollinators can grow right near each other with little natural genetic crossing. The western columbine has moderate sized red spurs filled with nectar favored by both hummingbirds and butterflies. The plant is found along stream banks, seeps, moist places, chaparral, oak woodland, and mixed-evergreen or coniferous forest, below 3300 m.

Photo by Marnie Bonesteel

Growth and Reproduction

The western columbine grows slowly and germinates at notoriously low rates, <20% per year; additionally, the seed does not remain viable for a long period of time in storage. This makes the increase of AQFO plant material and seeds for restoration a slow process.

Photo by USDA

Seed Dimensions

Average Measurement: 2.5 x 1.4 x 1.2 mm

Measurement Range: L: 2.5 - 2.75 mm, W: 1.2 - 1.5, D: 1 - 1.5 mm

Shape: Seeds tapering at hilum end, broadening at opposite side.

Color: Hilum is white, seed is black.

Surface: At least one distinct ridge runs from the hilum to the opposite side. End opposite hilum is sometimes puckered or having concave pits. Seed is glossy and lightly textured with very small bumps.

Latitudinal cross section: elliptical 

Longitudinal cross section: obovate 

Sowing Information

- Seeds per gram: 557
- Seeds per cell: 5
- Cover: soil and gravel
- Stratification: >120 days, perhaps

AQFO seedlings four weeks after sowing Photo by Jaal Mann

Armeria maritima • thrift or sea pink • ARMA

Plumbaginaceae Plumbago Family

Plant Description

Armeria maritima is a slow growing evergreen perennial that grows 6-12 inches tall. It has grass-like, dark green leaves and often forms dense mounded tufts. Small, pink to white flowers are found atop stocks in clusters. This species is commonly found in areas along the coast with slightly saline soil. The sub-species most common on South Puget lowland prairies is ssp. *californica.* This variant is found along the West Coast of North America from lower British Columbia to northern California. In the sub-species, flowers are often pale pink to white with extended coverings (inflorescence sheath) giving the whole flower head (inflorescence) a pale papery look.

Armeria maritima Photo by Eric Hunt

Ecological Importance

Thrift is well known for attracting hummingbirds, bees, moths and butterflies. Its ability to grow in salty conditions gives it an advantage over other species that are unable to grow where salt levels are high. The ability of the plant to concentrate salts and heavy metals in the dying (senescing) leaves is genetic and specific to maritime populations of the species. There is some scientific and practical interest in identifying and isolating this genetic characteristic to use in other plants to increase their salt and heavy metal tolerance.

Growth and Reproduction

Thrift maintains a small rosette of leaves throughout the winter. The woody rootstock is long lived and can grow in small rock crevices with little fine soil. The flowers are produced over a long period through spring. Pollination occurs primarily by bumblebees. Seed is held in dense, firm clusters through the summer and dispersed through the winter. The seed is an achene (hard fruit) with a short papery pappus (hairs or coverings attached to the end of the seed), when cleaning the seed removal of the pappus often results in damaged seed. Seed protocols call for retaining the pappus of the seed.

ARMA with brown achene covering the seed. The paper-like wings are the pappus.
Seed Measurement Range:
L 4.3 – 5.5 mm, W 1 – 1.5 mm,
D 1.1 – 1.4 mm

Photo by Lisa Hintz

Cold-stratification duration is variable in the collections from the South Puget lowland prairies. Wild collections often require a brief period of stratification of 15 days; however, some seed from first generation cultivated plants require no cold-stratification.

Sowing Information
- Seeds per gram: 465
- Seeds per cell: 5
- Cover: soil and gravel
- Sowing Advice: Press winged seeds into soil before covering
- Stratification: 0-15 days

Balsamorhiza deltoidea • deltoid balsamroot • *BADE*

Asteraceae Aster Family

Plant Description

This is a perennial (blooming every year) herb with a large taproot—a taproot looks like a carrot as opposed to having many tiny fibrous roots. The leaves grow all from the base, triangular in shape and sparsely hairy. When in bloom the flowers are large and yellow, with sunflower-like heads. This species differs from similar members of the balsamroot genus by having bright green stems as opposed to grey ones and triangular leaves.

Photos by Ben Legler

Ecological and Distribution Importance

This species blooms from March through July and thus is an important early source of nectar for pollinators and the Taylor's checkerspot butterfly in the springtime. The plant is also vital to the prairie ecosystem as its large taproot makes it resistant to drought conditions—even in times with less rain it can survive to support those who depend on it. It is native to the Pacific coast states and frequently found in prairies and other open bluffs and cliffs at low elevations. This species prefers deeper soils on the prairies.

Photo by Rod Gilbert

Distribution of *B. deltoidea* in WA State

Growth and Reproduction

On the prairie, the plants can take up to 5 years to begin producing seed but are extremely long lived, up to 20 or more years. The biggest limitation to increasing populations of deltoid balsamroot is generating enough healthy viable seed. The large seed requires abundant nutrients and water to mature and become viable. Once mature, the large seed is a favorite of seed-eating insects and birds. The seeds are smooth, around 7-8 mm long, 3 mm wide, and without a pappus. They are black, brown or tan and have some longitudinal ribbing. They have a long, slow germination and establishment phase often lasting twelve months or even two years in the nursery. *B. deltoidea* will remain a species we are working to increase for years to come.

Photo by Tim Ennis

Seed Description

Measurement Range: L: 6.5 – 8.2 mm, W: 1.6 – 4.5 mm, D: 1.6 – 2 mm

Shape: Seed shapes have lots of variation. Some squared off, and some three sided. Most seeds narrower at hilum than at opposite apex, but not always. Hilum wrinkled. Seeds have circular, white protrusion at apex opposite hilum.

Color: Seeds black, brown, or tan, with white or tan hilum.

Surface: Seeds have some longitudinal ribbing, and are smooth and matte.

Sowing Information
Seeds per gram: 138
Seeds per cell: 3
Cover: soil and gravel
Stratification: cold-moist 90 days, over winter in pots

Native Prairie Bulb Species

Dichelostemma congestum
Northern Saitas • DICO

Originates from scaly bulb. Leaves 2-3, flattened but keeled on the lower side, 3-10 mm broad, 5-10 cm long, not withering by flowering; stem 20-100 cm tall.
Flowers bluish-purple, the 3-5 bracts 1-2 cm long
Seed per Gram: 672
Soil Cover: soil and gravel
Stratification: cold-moist 120 days

Brodiaea coronaria
Harvest Brodiea • BRCO

Herbaceous perennial to 30 cm high originating from belowground bulb. All base leaves, withering before plants produce flowers.
Flowers: Flowers 5-13 cm long, blue-purple to rose. Fruits: Capsules with black seeds.
Seeds per Gram: 672
Soil Cover: soil and gravel
Stratification: cold-moist 70 days

Triteleia hyacinthina
White Triteleia/Fool's Onion • TRHY

General: Perennial from a scaly, deep-seated bulb. Leaves 1-2, flat but keeled/winged beneath, 3-10 mm broad and up to 40 cm long, not withered by flowering.
Flowers: Clusters of many-flowers, petals slender, 1-4 cm long; white to light blue, with prominent bluish-green mid-vein;
Fruits: Capsule 3-celled, with a slender supporting stalk (stipe) nearly as long.
Seeds per Gram: 637
Soil Cover: soil and gravel
Stratification: cold-moist 70 days

Camassia leichtlinii
Large Camas • CALEI

General: Perennial from a deep-seated bulb, the scape or stalk up to 1 m tall. Leaves several, all at the base, up to 60 cm long and mostly 7-20 mm broad. Flowers: Inflorescence or bloom 10-20 cm long at flowering, longer in fruit; flowers light to deep blue-violet. Fruit: Capsule 3-celled, 15-25 mm long

Seeds per Gram: 104
Soil Cover: soil and gravel
Stratification: cold-moist 60 days

Toxicoscordion venenosum
Meadow Death Camas • TOVE

General: Glabrous or smooth perennial herbs from an onion-like bulb, the simple stem 20-50 cm tall. Leaves mostly from the base, linear, keeled/winged, 10-30 cm long and 3-6 mm broad.
Bloom up to 15 cm long, the flowers all perfect (have both male and female parts); each flower white to cream-colored, bell-shaped; Fruit: Capsule 8-15 mm long.

Seeds per Gram: 354
Soil Cover: soil and gravel
Stratification: N/A

Prairie Bulb Sowing Information
- Seeds per flat: 200
- Cover: soil and gravel
- Stratification: overwinter one to three years in a flat

Native Prairie Bulb Species

Erythronium oregonum

Giant White Fawn Lily • EROR

General: Perennial herb from a deeply planted bulb; flowering stems to 30 cm tall. Leaves from the base, usually paired; lance shaped; strongly mottled with brown.
Flowers: Showy white blooms with 6 petals, up to 5 cm long; 1-3 flowers at stem tips.
Fruits: Erect capsules 3-5 cm long.

Distinguishing Characteristics: The mottled leaves and low-elevation habitat separate this species from *E. montanum*, which also has white flowers; our other *Erythronium* species have pink or yellow flowers.
Seeds per Gram: 189
Soil Cover: soil and gravel
Stratification: N/A

Fritillaria affinis

Chocolate Lily • FRAF

General: Perennial herb from a small, scaly bulb and numerous rice-sized offset bulblets, the unbranched, glabrous/smooth stem 15-100 cm tall.
Leaves: Leaves in 1-2 whorls of 3-5 and scattered upward, lance shaped, 5-15 cm long and 3-25 mm broad.
Flowers: Flowers usually 2-5 in a bunch, broadly bell-shaped, hanging down, strongly mottled, purplish to greenish or yellowish;
Fruits: Capsule 2 cm long, broadly winged.
Seeds per Gram: 454
Soil Cover: soil and gravel
Stratification: N/A

Lilium columbianum

Columbian Lily • LICO

General: Herbaceous perennial from a large, ovoid bulb, the sturdy, unbranched stem 60-120 cm tall.
Leaves: Leaves from whorled to nearly all scattered, smooth and lance shaped 4-10 cm long and up to 3 cm broad.
Flowers: Flowers 2-20 in a leafy branching cluster, with strongly recurved pedals; yellow-orange to reddish-orange, freely spotted with purple or deep red.
Fruits: Capsule cylindric, 3-4 cm long.
Seeds per Gram: N/A
Soil Cover: soil and gravel
Stratification: N/A

Trillium parviflorum

Small-Flowered Trillium • TRPA

General: Oak woodland perennial 17-30 cm tall. Leaves attached to the single stem in a whorl of 3, the blade green with light mottling, oval shaped, 6.5-16 cm long and 5-8 cm wide, not glossy, the tip blunt.
Flowers: Flowers solitary and at the end of the single stem; petals erect, concealing the stamens and ovary, white, linear
Fruits: Capsule sub-globose (not quite spherical), maroon, 4-8 mm long.
Seeds per Gram: N/A
Soil Cover: soil and gravel
Stratification: sow moist, no dry storage, two winter season cold-moist stratification

Prairie Bulb Sowing Information

- Seeds per flat: 200
- Cover: soil and gravel
- Stratification: overwinter one to three years in a flat

Campanula rotundifolia • blue bellflower • CARO
Campanulaceae Bellflower Family

Plant Description

Photo by Ben Legler

A perennial herb with a branched system of horizontal storage roots (rhizomes) arising from a taproot, the stems 10-80 cm tall, usually smooth (glabrous). The leaves at the base make a substantial rosette. The shapes of the leaves are distinctly different from stem leaves and equally variable across the geographic range. The Puget prairie types have egg-shaped (obovate) to round (orbicular) leaves with small teeth at the edges. The stem (cauline) leaves alternate, fairly numerous, broadly linear, 1.5-8 cm long. Flowers in a lax raceme, erect or nodding on long stems (pedicels); petal lobes 5, 4-12 mm long, entire; whole flower (corolla) bell-shaped, blue, 1.5-3 cm long. Fruit is formed in a three-chambered capsule 3-8 mm long.

Ecological Importance and Distribution

Campanula rotundifolia is found across the Northern Hemisphere from high elevations to coastal bluffs. The plant seems very adaptable as long as spring temperatures are moderate. In hotter climates, the plant is found in higher elevations or adapts by storing energy in its taproot and going dormant in the summer months. The plant stores carbohydrate reserves in the roots and rhizomes. This food storage is utilized by fossorial rodents. The roots are both collected and stored or eaten in place. The rhizomes often survive the grazing causing small plants to arise around the original mother plant in future years.

CARO in North America, the plant is common to high elevations and latitudes

Growth and Reproduction

Photo by Rod Gilbert

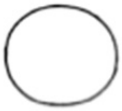
Blooming usually occurs in spring but can also have a second bloom period in September and October. The perennial plant seems to be long lived, even with frequent grazing of roots and shoots by fossorial rodents, such as pocket gophers and voles. This sweet bellflower is a prolific bearer of very small seeds, ~15,000 per gram. From year to year there is rarely a shortage of seeds. We can sow this late in fall for spring germination with “natural” stratification. These plants sometimes get quite root bound in the cells, so an alternate time for sowing could be June after a cold stratification period in the refrigerator.

Seed Description

Photo by Lisa Hintz

Measurement Range: L: 1 - 1.1 mm, W: 0.3 - 0.5 mm, D: 0.2 - 0.3 mm
Shape: seeds tapering slightly at hilum end and opposite apex.
Color: hilum and opposite end are dark brown. The rest of the seed is light brown.
Surface: seeds longitudinally striate and glossy.

Latitudinal cross section: elliptical



Longitudinal cross section: elliptical

Sowing Information
- Seeds per gram: 15,000
- Seeds per cell: 6
- Cover: into gravel
- Stratification: cold-moist 90 days
- Germinates: cool <15°C temperatures

Carex inops • long-stolon sedge • CAIN

Cyperaceae Sedge Family

Plant Description

Long-stolon sedge is a loosely caespitose (growing in bunches) perennial grass. It is a relatively short-growing plant, especially compared to many tall *Carex*. Culms or stems are 10-50 cm long. Leaves are slender, stiff, and wiry. Old, dead leaves are persistent (they don't break off or decompose easily), often forming fibrous tufts or bunches at the stem base. Inflorescences—which are the "flowers" of grasses where reproductive parts are located—are terminal (at the top of the stem/culm) spikes. Male spikes may be located above female spikes. The fruit is a hairy seed ranging from 1.6 to 2.5 mm long. Seed heads bear 5 to 15 fruits each.

Ecological Importance and Distribution

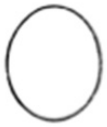
CAIN is found in sporadic pockets across Washington. It prefers relatively flat, dry soil habitats like those of prairies and coastal beach habitats. *Carex inops* is often the first native plant to green up in the winter or after fires. Therefore, many animals, from rodents to deer, depend on CAIN as a grazing resource throughout its long growing season. The species is a defining component of the Puget lowland prairie.

Growth and Reproduction

CAIN is a perennial blooming every year. When it begins growing, it's hard to distinguish from grasses, but once the spikes form they are easier to quickly spot. Male and female reproductive parts are located on different spikes, the male spikes are a little smaller and usually located above the female spikes.

Seed Dimensions

Range**:** L: 2.5 – 4.5 mm, W: 1.2 – 2 mm, D: 1 – 1.9 mm
Shape: Seeds narrow at hilum and opposite apex, rounded in middle. Opposite apex usually sharply pointed. Seed sometimes has bits of husk still attached. Hilum circular.
Color: Tan with some darker brown or black spotting. Hilum usually brown.
Surface: Some concave patches, entire seed covered in fine hair, and matte.

Latitudinal cross section: elliptical 

Longitudinal cross section: elliptical 

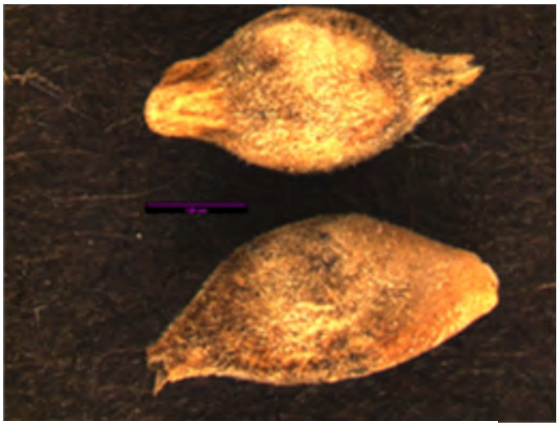


Photo by Lisa Hintz

Sowing Information
- Seeds per gram: 481
- Seeds per cell: 5
- Cover: soil and gravel
- Stratification: N/A

Castilleja hispida • harsh Indian paintbrush • CAHI

Orobanchaceae Broomrape Family

Plant Description

The plant is a perennial herb or forb with upright, un-branched stems to 50 cm. The leaves are covered in rough, coarse hairs (hispid) making it easy to distinguish the foliage from other members of the genus. The upper leaves divide into one or two lateral lobes below the flower clusters. The flowers are alternately arranged at the end of the stems with large showy modified leaves (bracts). These bracts can be orange-red to yellow or numerous shades in between. The flowers themselves are held within the bracts forming a tube 2-4 cm long. The prominent seed capsules are held above plant well after ripening.

Photo by Rod Gilbert

Distribution

Castilleja hispida is the most common Indian paintbrush species on both sides of British Columbia, Washington and Oregon Cascades, its range extends into mountainous areas of Alberta, Idaho, far Northern California and Nevada, and Western Montana. Being intolerant of shade, the plant is found on prairies, meadows, forest clearings and rocky out-crops.

Ecological Importance

All *Castilleja* species are hemi-parasitic; the second-year plants cannot survive without a host plant. The most common host species for CAHI on south Puget prairies are *Festuca roemeri* and *Eriophyllum lanatum*. *Castilleja hispida* is an important larval host for the Taylor's checkerspot (*Euphydryas editha taylori)* butterfly, a federally listed endangered species. An interesting and potentially important relationship between *Castilleja hispida,* Taylor's checkerspot butterflies, and gophers has been witnessed. Some paintbrush specimens at the Artillery Impact Area (AIA) have been found fresh and green well after the

majority of the population has senesced on Joint Base Lewis-McChord (JBLM) prairies. Currently, the only remaining population of Taylor's checkerspot butterflies on JBLM is also found on the AIA. It is hypothesized that these persistent blooming paintbrush specimens may be atop gopher or mole mounds, which create enough of a microclimate to lengthen flowering time. This factor, along with other reasons such as frequent fires from artillery exercises may help to explain the long-term persistence of Taylor's checkerspot butterflies on the JBLM prairies.

Growth and Reproduction

The plant emerges from a woody base in late winter and makes rapid growth in the cool moist spring. Blooming and pollination occurs from late April through July if there is adequate moisture. Brushfoot butterflies, bees, and hummingbirds visit the flowers and contribute to pollination. Seeds are held in capsules and ripen from June to September. The capsules are slow to open and can be easily harvested in summer.

Seed is dispersed in the fall, germination occurs after a 30 to 120 day range of cold moist stratification. The small seed, 9,000 per gram, is sown on the surface of gravel. The germination and establishment process is enhanced by alternating day/night temperatures and cooler temperatures (10°/4°C) as well as butenolide compounds from smoke and incomplete combustion.

CAHI seed coat and hulled seed (middle) Photo by Lisa Hintz

Seed measurement range:
L: 1.1 – 2 mm, W: 0.6 – 1.2 mm, D: 0.6 – 1.1mm

Sowing Information
- Seeds per gram: 9000
- Seeds per cell: 7
- Cover: into gravel
- Stratification: cold-moist 90 days, overwintered in trays

Castilleja levisecta • golden Indian paintbrush • CALE

Orobanchaceae Broomrape Family

Plant Description

Photo by Rod Gilbert

Each stalk has several unbranched stems 10-50 cm tall. Leaves: sticky and softly hairy (viscid-villous), the lower ones smooth-edged, lance-shaped, the upper ones more oval-shaped, with 1-3 pairs of short, lateral lobes on the upper 1/3 of the blade.

Flowers: blooms are straight and upright, the flowers are hidden by the overlapping leaf bracts; bracts about the width of the upper leaves, oblong, with 1-3 pairs of short, lateral lobes near the top. The petals are golden yellow tubes set inside the golden leaf bracts, thus hidden; it has 4 stamens and bears capsule-like fruit/seeds.

Ecological Importance and Distribution

Historically, golden paintbrush was found as far north as the Puget Trough of Washington and British Columbia, and as far south as the Willamette Valley of Oregon. Many populations have been destroyed by the conversion of its native prairie habitat to agricultural, residential, and commercial uses. The decline of golden paintbrush is also correlated with fire suppression. Fire disturbance is an integral component of the prairie ecosystem, maintaining grassland by preventing the successional encroachment of dense grass layers, woody shrubs and trees. As a direct consequence of these land-use changes, golden paintbrush has not been seen in Oregon for over 40 years and is now federally listed as endangered across its whole range. Most populations are found on the islands in the north Puget Sound – Georgia Strait archipelago.

WA counties with historical populations of CALE

Both federal and private players are vital in the conservation of the nine remaining populations in Washington and two remaining populations in British Columbia. These efforts are essential for the continued survival of golden paintbrush. In the absence of active management, fairly vigorous populations of *Castilleja levisecta* have rapidly

declined to extinction within a few decades. Alarmingly, these declines did not result from overt habitat destruction, but from the 'invisible' threats associated with low population numbers, fire-suppression and weed invasion. Presently, no site contains enough golden paintbrush individuals to be immune to drastic, irreversible declines. Therefore, steps to increase population sizes and establish new populations are necessary to ensure long-term survival of golden paintbrush.

CALE has been found to play a vital role as a food source for a threatened butterfly species throughout its range. In 2010, a collaborative effort among US Fish and Wildlife, Joint Base Lewis-McChord, and the Washington Department of Corrections lead to the building of a Taylor's checkerspot butterfly (TCB) rearing facility at Mission Creek Corrections Center for Women. Graduate students and inmate technicians conducted a series of experiments to test the plant preference for adult egg-laying (oviposition) and larval feeding. *Castilleja levisecta* was the preferred host plant for egg laying and to rear the larva of the TCB. This amazing result provides a unique opportunity to coordinate the recovery of an endangered butterfly with the recovery of an endangered plant.

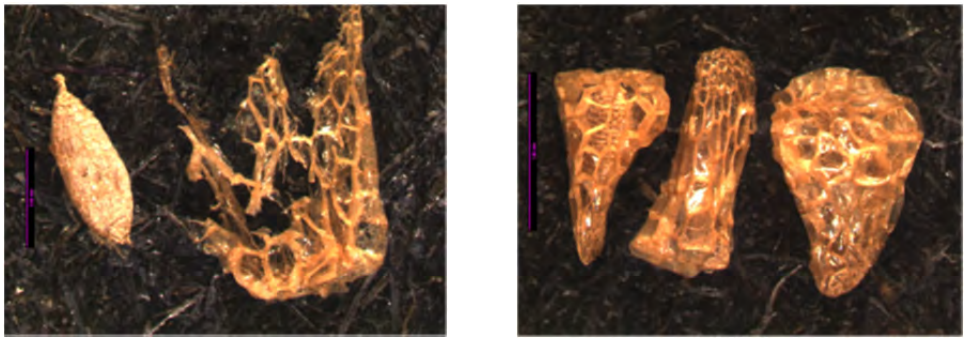
TCB laying eggs on a CALE plant, yellow eggs can be seen at the base of the calyx tube. Photo by an inmate technician at MCCCW.

Growth and Reproduction

CALE, like all *Castilleja* species, is a hemi-parasitic plant that has specialized roots (haustoria) that attach to a suitable host. Though CALE can actively photosynthesize, after the second year of growth it receives most of its primary nutrients for growth from the host. The most common host plants are Roemer's fescue (*Festuca roemeri*) and Oregon sunshine (*Eriophyllum lanatum*). The aboveground growth of CALE commences in late winter, though root and haustoria growth have been active through the rainy season (beginning in October). The plant sends up blooms May through June; the length of bloom period is very dependent upon available soil moisture. *C. levisecta* persists longer and is more abundant on deeper and more moisture retentive soils on WA prairies. The seed is set on the mother plant through July and can persist on the plant for over a season unless harvested.

Castilleja seed is enclosed in a netted capsule that has an equal mass as the seed. Some seed cleaning techniques remove a number of seeds from the surrounding capsule but not always. Thus seed counts per gram can vary significantly depending on the seed cleaning process: ~9,000 seeds per gram for seeds in the capsule to ~17,000

seeds per gram for seeds out of the capsule. Both of these numbers translate into very small seed. This seed is sown into gravel with no covering; watering in the seed settles it into the gravel. *Castilleja levisecta* seed requires 60 days cold-moist stratification. This is achieved by sowing the seed in early winter to stratify in the pots and germinate from March through May. This is a long germination period, up to 120 days after stratification is complete.



CALE seed removed from capsule, left photo and capsuled CALE seed, right photo. Photos by Lisa Hintz

Seed Dimensions

Measurement range: L: 1.1 – 1.5 mm, W: 0.5 - 0.9 mm, D: 0.4 - 0.9 mm
Shape: Seed is narrow at the hilum, widening at opposite end to create a cone-like shape.
Color: Embryo surrounded by distinct honeycombed seed coat that is light tan and transparent. Inside, a golden-brown, rice-shaped embryo is visible.
Surface: Seed is shiny and deeply honeycombed in texture.

Sowing Information
Seeds per gram: 9000
Seeds per cell: 5
Cover: into gravel
Stratification: 60 days (~over winter)

Cerastium arvense • field chickweed • CEAR

Caryophyllaceae Pink Family

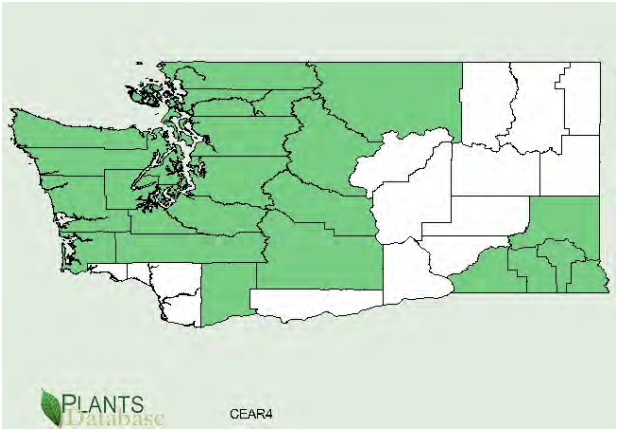
Plant Description

Field chickweed is a clumped, tap-rooted perennial that can form large mats with short-creeping rhizomes. Flowering shoots can reach 25-30 cm above narrow, rounded (oblong) leaves, with small white flowers that contain both male and female parts. Flowers can be singular, or in a small cluster. They have 5 petals, which are notched, so appear to be 10 petals.

Notched white petals and coarse hairs on the leaves of CEAR
Photo by Ben Legler

Ecological Importance

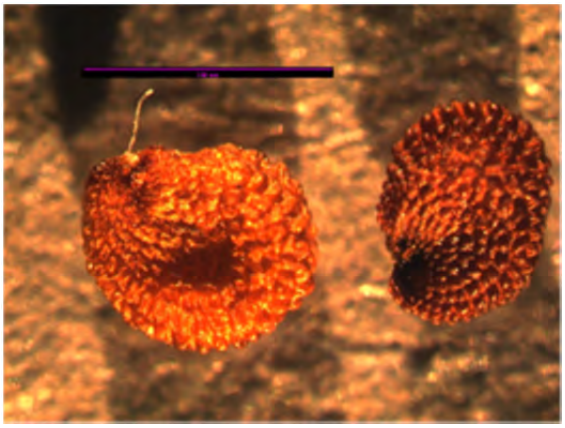
This species, like many others that grow in the prairies, is extremely drought tolerant. However, it cannot tolerate growing in the shade, and requires an open area to flourish. The early-flowering nature of this species makes it an important nectar source for some species. The plant is found throughout the Northern Hemisphere in meadows and rocky prairies.



Distribution of CEAR in WA State

Growth and Reproduction

The sub-species of field chickweed found in Washington State is ssp. *strictum.* This plant has a deep tap root with short root stems (rhizomes). The leaves are thin, greater than 3 times longer than wide with coarse long hairs (hirsute). The common garden field chickweed sold at nurseries is a different sub-species with softer, grey leaves and a strong running habit. In the native plant, dry seeds are held in capsules well above the foliage in summer and are easily harvested and cleaned.
The seed of CEAR is quite small, with almost 6000 seeds per gram.



Cute little knobby seed of CEAR;
Seed Measurement Range: L: 0.75 – 1 mm, W: 0.8 – 1 mm, D: 0.4 – 0.6 mm
Photo by Lisa Hintz

Fun Facts

Field Chickweed is well known within the Iroquois tribe for treatment of injuries resulting from miscarriage. The name chickweed is thought to come from the chickens and small birds that eat the seeds of the species. Young plant growth can be eaten raw or as cooked greens.

Sowing Information
- Seeds per gram: 6000
- Seeds per cell: 4
- Cover: into gravel
- Stratification: none

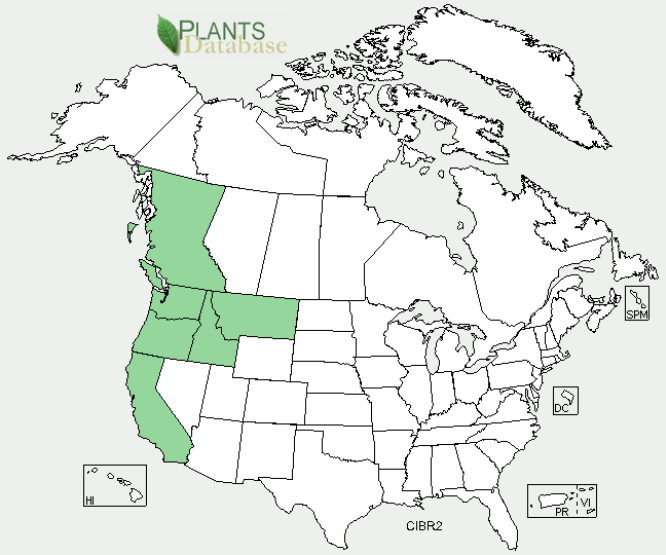
Cirsium brevistylum • clustered thistle • CIBR
Asteraceae Aster Family

Plant Description

Photo by Ben Legler

Clustered thistle is a robust, tap-rooted perennial, one to three meters tall, the stem succulent, thick below and tapering towards the top. Leaves are green and only lightly loose-white-woolly below, weakly spiny, coarsely toothed along the margins. Heads clustered at the ends of branches and the main stem, often surpassed by the leaves; flower head (involucre) 2-4 cm. high, strongly spider-webby, its bracts (dangerous barbs below the flower head) slender and tapering, all but the inner with short spines; flowers all tubular, the tube very slender, dull purplish-red, 12-18 mm. long, the flower lobes 2-4 mm. long; the many flowers are held in a dense, bristly receptacle.

Ecological Importance and Distribution



Distribution of CIBR endemic to Western North America

Crisium brevistylum is a thistle endemic to the Northwestern United States and British Columbia. Along with two other native *Cirsium* species, *C. remotifolium and C. edule,* CIBR plants are becoming rare and often replaced by Eurpean weed thistles such as scotch or bull thistle. Typically, the plant is found in moist areas, along creeks, slow moving water and coastal marshes from low elevations to about 1500 m. The mid-summer blooms provide a good bridge nectar source between the abundant spring flowers and the later asters in summer.

Growth and Reproduction

CIBR achene, pappus and flower tubes, photo by Ben Legler

CIBR behaves like many other thistles in reproduction. Lots of seed is produced and it germinates readily with no stratification. The seed is large, ~400 per gram, so soil and cover to twice the thickness of the seed is necessary to maintain adequate moisture for germination.

Ecologists have numerous hypotheses as to how these thistles have not spread and become weedy like the European thistles. The methods of reproduction and increase are similar and their ecological habitats on prairies are alike. There are a number of possible causes as to the demise of the native thistles; 1) herbivory by insects may be more common; 2) native thistles may not adapt well to grazing by cows or sheep; 3) native thistles may also have been more abundant in the presence of prescribed fire and have reduced with the spread of Douglas-fir forest.

Photo by Ben Legler

Sowing Information
- Seeds per gram: 581
- Seeds per cell: 3
- Cover: soil and gravel
- Stratification: none

Danthonia spicata • poverty grass • DASP

Poaceae Grass Family

Plant Description

Poverty grass is found on shallow prairie soils throughout North America. The grass is a crowded tuft of leaves at ground level. The leaves often become curly and persist as they dry out. Plants in shady and moist areas may not have curly leaves. The flower head (inflorescence) is a narrow panicle of up to 18 spikelets. The spikelets have twisted, hairy awns. There are also some unopening, self-fertile (cleistogamous) florets next to the leaves, and in the panicles. There is a long-lasting soil seed bank, with the seeds persisting for decades before being stimulated to germinate by the removal of competing vegetation by disturbance.

Neat hairy nodes of DASP, photos by missouriplants.org

Ecological Importance

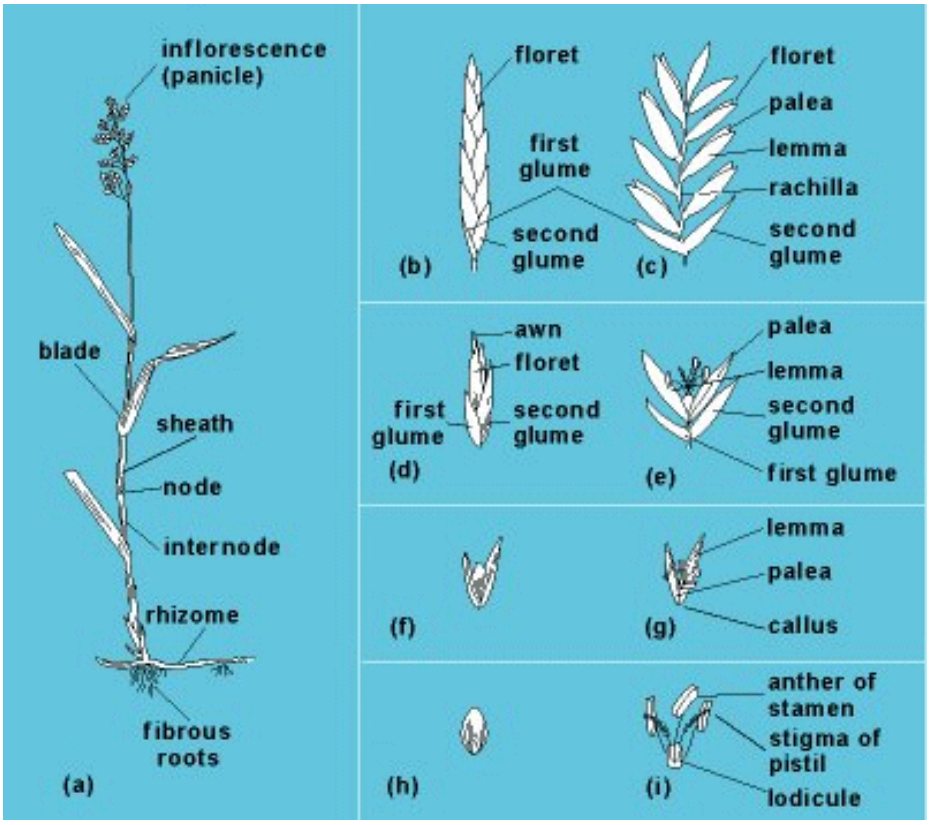
Being a common component of Western Washington prairie sites where the soil is shallow or excessively drained, *Danthonia* can provide important habitat where other grasses perform poorly. The winter growth habit coupled with abundant and persistent foliage through the year allows the plant to provide shelter to larval and diapause stages of insects. This is important in both summers to protect insects from heat as well as in winter to protect them from frost. The early vegetative growth in winter provides food sources to birds and small mammals. Though not overly showy, grasses perform these vital and often overlooked ecological services for habitat enhancement.

Growth and Reproduction

Photo by Carl Elliott

DASP is a cool season grass, putting on most of its growth November through April. *Danthonia* produce seed early on the prairies, often blooming in May and ripening seed by the end of June. Seed is easily gathered by hand or by farm implement. Care must be taken when sowing to ensure full seeds are sown, not just empty lemmas. This is a common problem when sowing all grasses. Take time to look at the seed and parts of a grass flower under a hand lens, so for each species of grass you are capable of identifying and sowing the actual seed. DASP germinates well after a 30 day cold stratification period, no special consideration, cover with soil and gravel and keep moist.

Sowing Information
- Seeds per gram: 971
- Seeds per cell; 4
- Cover: soil and gravel
- Stratification: 30 days



Parts of a typical grass plant. (*a*) Complete plant. (*b*) Many-flowered spikelet. (*c*) Generalized spikelet. (*d*) One-flowered spikelet. (*e*) Spikelet at flowering. (*f*) Floret in fruit. (*g*) Floret in flower. (*h*) A fruit. (*i*) A flower. (*After P. D. Strausbaugh and E. L. Core*, *Flora of West Virginia*, *West Va. Univ. Bull.*, *ser. 52*, *no. 12–2*, *pt. 1*, *p. 67*, *1952*)

Delphinium nuttallii and D. menziesii • Nuttall's and Menzie's larkspurs • DENU and DEME

Ranunculaceae Buttercup Family

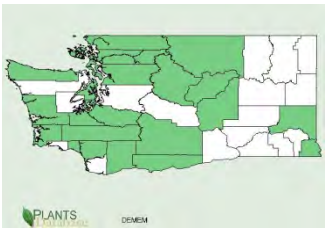
Plant Description

DENU above two images, DEME below two images; note smaller height of DEMU with slightly larger individual flowers with petals that curve back. Photos by Rod Gilbert

These Delphiniums grow single stems 30-60 cm tall for DENU and rarely up to 30 cm for DEME. The leaves of each plant are also slightly differentiated. DENU are long, evenly distributed up the stems, the blades usually >5 cm broad, 3 lobes each dissected into narrowly lance-like or linear segments. DEME leaves are divided into five distinct lobes rarely >5 cm broad. One would think from the previous description the flowers of DENU would be larger than DEME, like the stems and leaves. However the opposite is true. DENU flowers are <12 mm, DEME >12 mm, DENU spurs (the hook on the back of the flowers) <12 mm and DEME spurs often >12 mm. With these distinctions made however I will let C. Leo Hitchcock have the last say from 'Vascular Plants of the Pacific Northwest Vol. 2': "the species are little more than geographic segments of a series of taxa that are linked by near continuous variation". This is botanist speak for 'kinda look all the same to me'.

Ecological Importance and Distribution

Of these two native perennials, DENU is currently on the endangered species watch list for Washington State. They occur chiefly on the west side of the Cascades in gravelly outwash prairies, along the Columbia Gorge, and basaltic cliffs at low elevations. DEME has a broader



DENU range left and DEME range right

range that extends into high elevations and in the pine woodlands of eastern Washington. DENU is found on top of mounded prairie and DEME is found more often on Garry oak edges. Both species bloom from May to June and are an important source of nectar for pollinators.

Growth and Reproduction

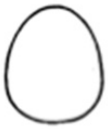
Both species have a number of reproductive and growth habits in common. The seeds require a long cold-moist stratification period, over 120 to 180 days. Often the plants do not germinate in the tubes until the second year because they have not had a long enough natural stratification time. If the seeds germinate in the spring, the plants grow only cotyledons (seed leaves). The leaves die back in June leaving a small 2-5mm globe (a caudex) in the ground. The next year results in a slightly larger plant, 2-5 true leaves and a doubling in size of the caudex but again the plant goes dormant in June. After the two growing seasons the small clusters of globes that make up the caudex are planted out in the field in summer or fall. This is a pattern of cultivation the conservation nursery uses for all bulb production also.

Seed Dimensions (similar for both species)

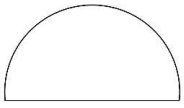
Measurement Range: L: 1.25 – 2.1 mm, W: 1 – 2 mm, D: 0.5 – 1.2 mm

Shape: Usually broader at hilum end, bud seeds variable. Seeds in baggy seed coat that sometimes makes seeds appear winged around the edges.
Color: Inner seed dark brown to black, seed coat white and transparent.
Surface: Seed coat finely longitudinally striate and glossy.

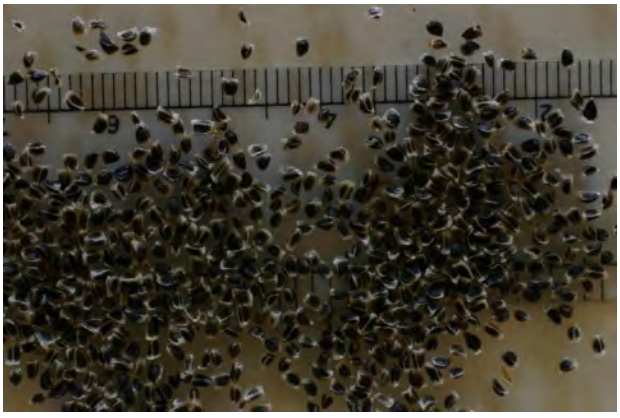
Latitudinal cross section: obovate



Longitudinal cross section: semi circular



Sowing Information
- Seeds per gram: 1200-1300
- Seeds per cell: 5
- Cover: soil and gravel
- Stratification: cold-moist, 120 to 180 days



DENU seeds. Photo by Lisa Hintz

Dodecatheon pulchellum and D. hendersonii • shooting stars • DOPU and DOHE

Primulaceae Primrose Family

Plant Description

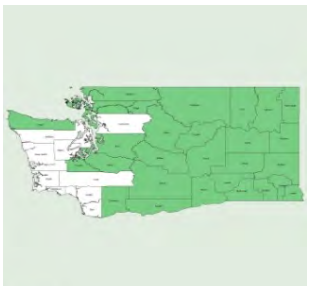
Dodecatheon hendersonii has a basal rosette of leaves, each leaf being broadly egg-shaped to nearly round and plump, 25-50 mm long, tapering rapidly to petiole (leaf attachment to the stem). Leaves lay prostrate to spreading slightly upward at the tips. *Dodecatheon pulchellum* has a greater number of upright spreading leaves. Leaves oval to egg-shaped, often with some fine teeth, 5-25 cm long, narrowing gradually to petiole.

DOHE left, DOPU right. Photos by Rod Gilbert

The flowers of both species cluster atop the stem, DOHE usually with the greater number of flowers per stem. Flower color and hue can be highly variable within either species; DOPU has a larger white band at the base of the petals and DOHE has a white band edged with purple-black. The tube or point of the flower is yellow with purple edges with DOPU and almost all purple-black with DOHE. DOHE may go summer dormant a month or so earlier than DOPU in most habitats.

Ecological Importance and Distribution

These two species may look outwardly similar in flower form but they seem to separate themselves across slightly different habitats in the prairies.
Dodecatheon hendersonii is the most common shooting star on prairies on the cooler, western coastal areas of North America from California to British Columbia. The species grows between mounds on mima prairies and in other areas of poor soil that are frequently very moist in winter and bone dry in summer. Oddly, the plant goes dormant in late spring and no rootstock is persistent. The plant survives the summer from tightly clustered bulblets underground.



DOPU Distribution

DOHE Distribution

Dodecatheon pulchellum is a highly variable species across a wide distribution, primarily in the inter-mountain West. It prefers rocky soil also but proliferates in seeps, springs and along slow moving water courses. In the prairies, DOPU prefers moister soils than DOHE and is found along the slow moving seasonal streams or deeper soil. DOPU goes summer dormant later and persists from very short rootstocks.

Growth and Reproduction

Due to the ephemeral nature of both these species, they are quite challenging to propagate in a nursery. When cultivating them allow the plants to go fully summer dormant. DOHE may completely dry out in summer, even quite small plants that have not developed true leaves form bulblets that emerge the next early spring. For DOPU keeping the plant slightly moist and not allowing it to fully dry out seems to be a more effective method of cultivation. However, with both of these species caring for the young seedlings requires patience and we have not fully developed protocols for either. They both germinate well from a fall sowing with DOHE requiring less time in cold-moist stratification before germinating.

Seed Dimensions

Length: 1 – 1.3 mm, Width: 0.5 – 1 mm, Depth: 0.4 -1 mm
Seeds generally cubic in shape, but very irregularly angular and sometimes pitted. Hilum is very difficult to identify. It may be a small scratch-like scar appearing white in color. Seeds brown, somewhat glossy, and has a net-veined pattern of ridges.

DOPU Seeds. Photo by Lisa Hintz

Sowing Information

- Seeds per gram: 1053
- Seeds per cell: 3
- Cover: soil and gravel
- Stratification: cold-moist stratification, DOPU 30 to 60 days, DOHE 15 to 30 days

DOPU

Lot: 1636

Sown:
12/11/12

Germinated:
4/4/13

DOHE

Lot: 1874

Sown:
11/30/12

Germinated:
3/15/13

Drymocallis glandulosa • Greene's drymocallis • DYGL
Rosaceae Rose Family

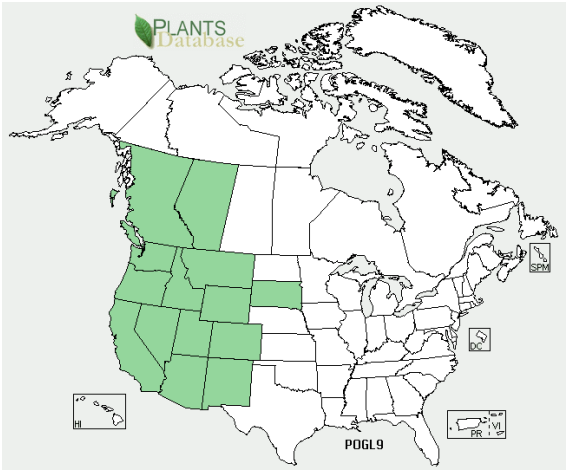
Plant Description

Photo by Ben Legler

Drymocallis glandulosa is highly variable in form and there are many subspecies which intergrade and are not clearly defined. The plant is generally erect but it may be small and tuft-like, measuring just a few centimeters high, or tall and slender, approaching a meter in height. It may or may not have rhizomes. It is usually coated in hairs, many of which are glandular, giving the plant a sticky texture. The leaves are each divided into several leaflets, with one long terminal leaflet and a few smaller ones widely spaced on each side. The flower head (inflorescence) is a cyme of 2 to 30 flowers which are variable in color and size. Each usually has five petals up to a centimeter long, which may be white to pale yellow to gold.

Ecological Importance and Distribution

Drymocallis glandulosa is abundant from mountain meadows to coastal marshes. The plant diversity of local wet prairie meadows has been decreasing due to livestock over-



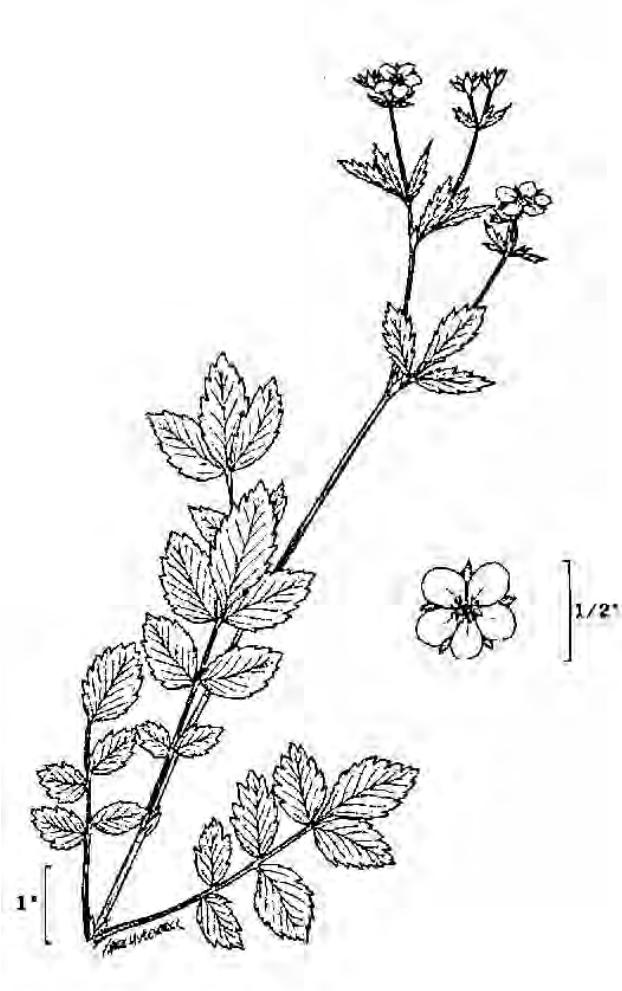
grazing, draining of fields and the increase of aggressive grasses used for forage. DRGL could be an important component of wet prairie restoration. These prairies, if restored, could provide a greater diversity of blooming species and longer blooming periods in summer to compliment the drier upland habitats. Numerous pollinating insects use the flower as a nectar source. Building up stock for wet prairies from the few remaining plants in damaged habitats is a challenge for regional restoration ecologists. Our nursery restoration will involve developing cultivation protocols and building up plant material over a long time span.

Growth and Reproduction

Photo by Steve Hurst

Drymocallis and *Potentilla* species (*Drymocallis glandulosa* is synonymous with *Potentilla glandulosa*) germinate erratically over a long time period and patience is required in the germination and seedling phase. The seed is moderately small, 2800 seeds per gram, and the seed is covered with soil and gravel. A large number of seeds per cell are sown to make up for the poor germination. Seed is sown in early summer after a cold-stratification of 30 days.

Drawing from USDA NRCS. *Wetland flora: Field office illustrated guide to plant species.* USDA Natural Resources Conservation Service



Sowing Information
- Seeds per gram: 2800
- Seeds per cell: 5
- Cover: soil and gravel
- Stratification: 30 days
- Germinates: temperatures below 15°C

Drymocallis gracilis •slender cinquefoil • DRGR

Rosaceae Rose Family

Plant Description

A perennial that grows to a height of 1-2 feet, slender cinquefoil has large oval, palm shaped (palmate) leaves divided into 5-9 leaflets. Flowers are few to many in a loose cluster on ascending stalks (cyme).

Palmate (like a palm of your hand) and compound (joined just at the base) leaves of DRGR with downy, silver undersides to the leaves as seen in the reversed leaf on the right.

Photo by Robert H. Mohlenbrock.

A cyme flower stalk alternates branching up the stem and is not symmetrical (even) but the flowers tend to create an arching umbrella shape cluster.

Photo by BA Wilson

Ecological Importance and Distribution

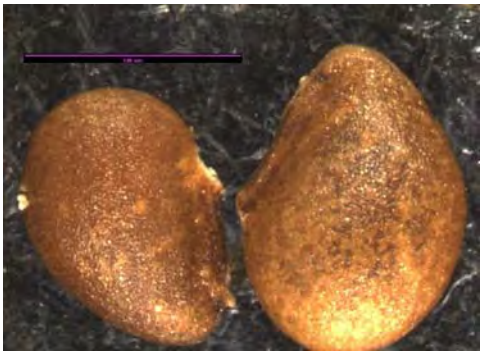
The distribution of this species is wide, from meadows to open forests and roadsides, from low to alpine elevations. Slender cinquefoil blooms in late spring or early summer, and is found throughout Washington and the rest of the western United States.
An extensive study at Oregon State University (McIver and Erickson, in press) examined the interaction and pollination of slender cinquefoil with sulfur cinquefoil (*Drymocallis recta*), which is native to Eurasia and is now widespread since being introduced in North

Drymocallis gracilis- slender cinquefoil in the state of Washington

America before 1900. The slender cinquefoil was found to flower first for about five weeks, with the sulfur cinquefoil following for five weeks with two weeks of overlap in mid-June. The native cinquefoil attracted a more diverse set of pollinators (93 species, 619 individuals) compared to the non-native species (74 species, 543 individuals). Interestingly, only 2% of the native's pollinators were European honeybees, with honeybees composing 16% of the pollinators in the non-native. Aggressive exclusion of pollinators reduced seed number in the sulfur cinquefoil (non-native), but did not reduce seed quantity in the slender cinquefoil (native). However, nearly twice as many seeds germinated from the non-native compared to the native species. This was attributed to less seed predation and a much more prolonged germination sequence in the non-native, lasting almost an entire year. The authors concluded that these two cinquefoils use different adaptive strategies for survival, with the native using a 'stress-tolerant' strategy and the non-native employing a 'ruderal' approach (growing on waste ground).

Growth and Reproduction

DRGR is common on Puget lowland prairies even if many other native plant populations have been reduced. Though common, the flowers provide an important nectar source throughout spring. The nectar value of the plant makes it a vital part of prairie restoration. The seed readily germinates after one month in cold stratification, emerging in one week. Water the cells lightly but frequently to keep the seeds from "floating" around the cells before germination.



DRGR seed, Photo by Lisa Hint

Sowing Information
- Seeds per gram: 2000
- Seeds per cell: 5
- Cover: soil and gravel
- Stratification: 30 days
- Germinates: temps <15°C

Erigeron speciosus • showy fleabane • ERSP
Asteraceae Aster Family

Plant Description

The showy fleabane displays large yellow disk flowers surrounded by contrasting purple rays in late spring through early summer. From the long-lived, woody, perennial rootstock grows a rosette of rounded-lance shaped leaves at the base and numerous flower stems are topped by a corymb-shaped cluster of flowers (inflorescence). The plant is found in gravelly and rocky soils in areas of moderate rainfall from Western Washington into the high elevations of the Rocky Mountains.

ERSP, Curtis's Botanical Magazine v.64: t.3606. 1837. showing corymb branched flower heads

Ecological Importance

The showy flowers of these plants are not lost to native pollinators on the prairies. The contrasting colors of the flowers make them a favorite of bees and wasps (order *Hymenoptera*) and butterflies. The long bloom time from May into July makes for abundant and valuable nectar and pollen resources. On Puget lowland prairies, ERSP is common on the deeper soil such as mound tops and deep swales; this may be because those soils retain moisture longer into the spring than soils that are shallower.

Growth and Reproduction

The plant emerges from a woody rootstock base in late winter, makes slow even growth then explodes with flowers in late spring. Blooming and pollination occurs from late May through July if there is adequate moisture. The flowers are visited by brushfoot butterflies and bees, all contribute to pollination. Seeds are held in the flower heads and like other members of the aster

Photo by Rod Gilbert

family the seed is surrounded by a hard achene with an attached pappus. The seeds ripen from June through August. Seed production is normally abundant and the amount of filled, viable seed is quite high.
Seed is dispersed in summer when the pappus carries the seed in the wind. The seed is quite small, ~5,000 per gram. Germination of ERSP is facilitated by a short cold-moist stratification period followed by light exposure. Sowing of stratified seed should be on the surface of gravel and the light seed should be kept moist until germination is complete 14 to 21 days later. In the nursery ERSP is a quick grower, filling the propagation cells in 12 weeks. Frequent deep watering is vital once the propagation cells are filled with roots.

Erigeron speciosus

herbarium.usu.edu

www.swibiodiversity.org

Sowing Information
Seeds per gram: 5000
Seeds per cell: 5
Cover: into gravel
Stratification: 30 days
Requires light to germinate

Eriophyllum lanatum • Oregon sunshine • ERLA

Asteraceae Aster Family

Plant Description

Oregon sunshine grows 10-100 cm tall from a woody rootstock. The leaves are linear to oval, gray-green, covered with wooly (lanate) hairs. The leaf shape resembles a feather (pinnately divided) when mature but not divided (entire) when young. Flowers are bright yellow, with 8-13 yellow ray flowers surrounding many yellow disk flowers.

Ecological Importance and Distribution

The Fender's blue butterfly, (*Icaricia icarioides fenderi*) and Puget blue butterfly (*Icaricia icarioides blackmorei)* use Oregon sunshine as a primary nectar source. The plant requires pollinators like the Fender's blue for seed set. Oregon sunshine is adapted to areas with dry, rocky or well-draining sandy soil. In these areas, it has been shown to be very drought tolerant, partially due to its white wooly hairs that conserve water by reflecting heat and reducing air movement across the leaf surfaces. This drought tolerance allows for the species to grow from sea level to well over 10,000 feet across the western United States.

ERLA is one species that provides a root host to *Castilleja hispida* and C. *levisecta*. Its rapid growth and efficient carbohydrate production supplies *Castilleja* plants with carbohydrates and basic plant nutrients. Consequently, all new plantings of *Castilleja* include some ERLA or Roemer's fescue, another efficient host plant.

Fun Facts

Both the genus and species name relate to the other common name of this species, wooly sunflower. The genus name, *Eriophyllum*, is from the Greek “erion” meaning wool and “phyllon” meaning leaf. The species name, *lanatum*, means “covered with long wooly hair”. The first known collection of this species was by Lewis and Clark along the Clearwater River near Kamiah, Idaho on June 6, 1806. This species was used by the Miwok tribe as a poultice bound to aching body parts. The Skagit people rubbed the leaves on skin to prevent chapping and the Chehalis used the dried flowers as a love charm.

Growth and Reproduction

Oregon sunshine spreads to form small clumps about 0.5 m wide by underground roots (rhizomes) and short woody stems. Bright yellow flowers appear in June and July making a cheerful appearance in the summer sun. Pollination is from butterflies, syrphid flies and many species of native bees.

Determining the length of cold stratification prior to sowing ERLA has been problematic for nursery production. The length of time varies from 10 to 30 days depending upon the year of collection and the area where the seed was collected. The plants establish and grow rapidly, being ready to plant out within four months of sowing.

Sowing Information
Seeds per gram: 2710
Seeds per cell: 5
Cover: soil and gravel
Stratification: >15 days
Germinates Best at temps below 15°C

ERLA seedlings two weeks after sowing Photo by Carl Elliott

Festuca roemeri • Roemer's fescue • FERO
Poaceae Grass Family

Plant Description

Roemer's fescue is a bluish, gray-green tufted bunch grass that grows in British Columbia (southeastern Vancouver Island and the Gulf Islands), and west of the Cascade Mountains in Washington, Oregon and Northern California. These areas are typically temperate, with maritime influence. Roemer's fescue grows from sea level to about 750 m. The species is also found in thin-soiled windswept shorelines on the islands of the Puget Sound, the Strait of Juan de Fuca and the Straits of Georgia.

Ecological Importance

Roemer's fescue is the most common native grass found in the glacial outwash prairies and those that have a history of anthropogenic burning. Making sure the prairies have an abundant amount of FERO is a vital goal of prairie restoration. The plant's bunchgrass nature allows for the growth of all the other important prairie species, including associated species: common camas (*Camassia quamash*), field woodrush (*Luzula comosa*), spike goldenrod (*Solidago simplex*), early blue violet (*Viola adunca*) and prairie lupine (*Lupinus lepidus*) to name a few. Additionally, the low growth of the leaves reduces competition for light and allows for a diverse number of flowering species to exist in the prairie plant community.

Roemer's fescue in full flower
Photo by Rod Gilbert

Growth and Reproduction

As a bunch grass, Roemer's fescue only reproduces from seed. The blooms emerge from the evergreen foliage in late May through June and the flowers are wind pollinated. The seed ripens rapidly after pollination and is often ready to harvest in early July. The seed shatters or falls from its protective layer (palea and lemma) very easily. The seed is harvested in the milky stage (when the seed is cut in half the starch is still milky and not yet solid, this stage can often last only three or four days).The morning dew often holds the seed in the sheath during cutting so harvest is done from dawn until around 10 am to minimize the loss of seed.

Parts of a FERO flower L to R: Lemma and palea on rachis, lemma and awn, palea w/ seed, palea then lemma

A stem inflorescence of FERO. Photos by Seeds of Change

Who is this Roemer guy anyway?

Roemer's fescue is named for Swiss physician, professor of botany and entomologist Johann Jakob Roemer (1762-1819). Roemer was best known for one of the greatest achievements in the history of Swiss entomology, the *Genera insectorum Linnaei et Frabricii*. Roemer also published the 16th edition of Carlos Linnaeus' *Systema Vegetabilium.*

Sowing Information
- Seeds per gram: 1050
- Seeds per cell: 5
- Cover: soil and gravel
- No stratification

Fragaria virginiana • Virginia strawberry • FRVI
Rosaceae Rose Family

Plant Description

Photo by Ben Legler

Virginia strawberry grows profusely by runners (stoloniferous). The stems and leaf stems (petioles and peduncles) are green/red and lightly hairy (pubescent). The flower stems (scapes) are usually shorter than the leaves, thus the flowers are often mixed in with the foliage. The leaves are three lobed (trifoliate), and each leaflet is round to ellipse formed (obovate to elliptic-obovate), and 2-7 cm long. The leaflets are smooth and blue-green on the upper surface, silky on the lower surface, with coarse, rounded serrations along the edge of the leaf; the teeth of the serrations at the very tip (terminal) are shorter than the adjacent teeth. Flowers are 5 oblong petals surrounding numerous pistils upon a receptacle that becomes the fruit. The seed is immersed in the fruit, which grows up to 1 cm broad, is fleshy and red, having a good flavor because it is a strawberry.

FRVI leaf, note small terminal tooth on center leaflet. By Elizabeth Farnsworth. Copyright © 2012 Elizabeth Farnsworth

Ecological Importance and Distribution

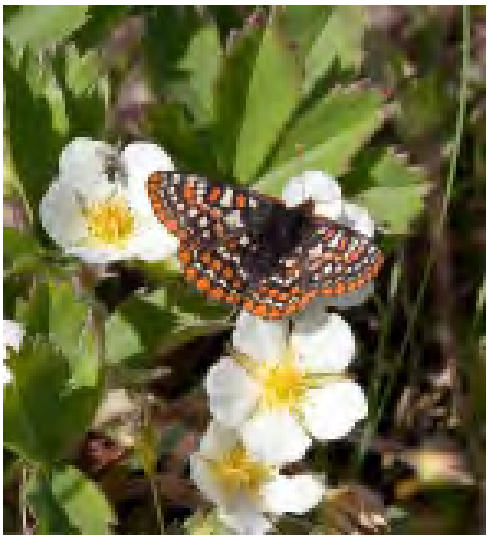


Photo by Rod Gilbert

.The May flowers of strawberries emerge timed to provide nectar sources for butterflies, in particular the Taylor's checkerspot. The open flowers and long blooming period provide abundant nectar and pollen resources to a wide number of other pollinators. The rapid and vigorous vegetative reproduction of the strawberry makes it an important ecological component of prairies after prescribed burns. The fruit is often set in large quantities; however people rarely can compete with birds and small mammals for the quality fruits. The FRVI is the most common strawberry of North America found across the continent.

Distribution of FRVI across North America; the sub-species found on the prairies is *Fragaria virginiana* ssp. *platypetala* represented in the map on the right.

Growth and Reproduction

Virginia strawberry makes fruit covered with numerous seeds; however, collection of the fruits and seeds is difficult due to the number of birds that also find the fruit tasty. The most common method of propagation both in the wild and in the nursery is by stolons or runners. Each node along a runner is cut from the mother plant. The propagule consists of a vegetative growing tip and small roots from below the crown. Each is planted so that the growing point sits just above the soil. The plants are kept moist and shaded until well rooted which takes one to three weeks.

FRVI Runners with propagules. Photo by U of Florida

Gaillardia aristata • blanket flower • GAAR

Asteraceae Aster Family

Plant Description

Blanket flower is a tap-rooted perennial, with large showy yellow and reddish brown flowers. Leaves are alternate, 8-15 cm long with coarsely-toothed and deeply divided margins. The species is moderately long-lived, and re-seeds in abundance once established. Distributed throughout the northern part of North America and the Western United States, it's found in dry open spaces in prairies, mountain foothills and roadside clearings.

Ecological Importance

Blanket flower is a nectar and food source, also providing resting spots and protective cover, for many important pollinators and beneficial insects. Edward's fritillary (*Speyeria edwards*) butterflies rely on the species as a nectar source in their adult stage. A moth species, (*Schinia masoni*), is camouflaged to specifically mimic the yellow ray flowers and purplish-brown disk flowers to aid in avoiding predators. Throughout western North America, the soft-winged flower beetle (*Listrus senilis*) pollinates blanket flower. Blanket flower and its associated beneficial insects are crucial components of many northern grassland ecosystems, breaking down organic matter, increasing soil fertility and improving soil water-holding capacity and water infiltration.

Blanket Flower with a sweat bee pollinator. Photo by Carl Elliott

Growth and Reproduction

Blanket flower emerges late in the spring to put on rapid growth, blooming in early summer. Though tolerant of low water conditions, summer growth and abundance is limited by adequate moisture from late spring rainfall. Water availability is also reduced by competition with vigorous invasive grasses.

The primary limitation to reproduction for the blanket flower on Puget lowland prairies seems to be seed fecundity (the amount of seed that is fertile per year). More research is needed to address questions about nutrient and water limitations on seed set. Additionally, limitations upon populations of pollinators through reduced nesting sites and yearly fluctuations of nectar sources need to be studied.

Due to low proportions of fertile seed, germination rates vary from year to year. The seed is large, 450 seed per gram, and easy to sow. The seed is enclosed in bristles and a long pappus that easily floats to the surface after sowing. Cover well and re-cover with a soil gravel mix if seeds are seen on the surface two weeks after sowing. Warm temperatures (above 20°C) seem to befit GAAR both in germination and plant establishment.

GAAR seeds with bristles and robust pappus often cause the seed to float on top of the sowing medium. Photo by Peter Dzuk

Sowing Information
- Seeds per gram 450
- Seeds per cell: 6
- Cover: soil and gravel
- Stratification: 45 days
- Germinates best at temperatures over 20°C

Heuchera chlorantha • tall alumroot • HECH

Saxifragaceae Saxifrage Family

Plant Description

Strong-growing perennial from a branched crown with short rhizomes. Leaves only occur at the base; the leaf blades are cordate (heart-shaped) to ovate (oval-shaped), 4-8 cm long and broad, with 5-9 rounded shallow lobes. The flower stem is green with brownish, spreading hairs.. Flowers are on a spike-like panicle (similar to many grasses) up to 15 cm long and with 7-9 mm long greenish petals.

Ecological Importance and Distribution

HECH prefers gravelly prairies, rocky bluffs along the edge of the maritime Northwest and partially wooded, rocky hillsides. The plant is found as far north as the Queen Charlotte Islands and is quite common along the coast of British Columbia. The saxifrage family is one of the least examined flower families for pollinators though bumble bees seem common visitors to the flowers of HECH.

Growth and Reproduction

HECH blooms from May to August. The fruits are capsules that hold thousands of tiny seeds. We have not calculated the seeds per gram for this species. The plant has basal leaves and thus during most of its growth in the nursery, it will consist of leaves close to the ground, until it produces the scapes/stalks that will support the flowers. To date we have observed that germination is erratic and slow. We are hoping to gather more information on successful germination in the coming years.

Sowing Information
- Seeds per cell: 5
- Cover: soil and gravel
- Stratification: at least 90 days

Hieracium scouleri • Scouler's hawkweed, hounds tongue hawkweed • HISC

Asteraceae Aster Family

Plant Description

An upright, rosette growth form with no runners, the base leaves are oblong, 8-25 cm long, covered with soft to bristly hairs; the few stem leaves decrease in size along on the upper stem. Flower heads are 25-50 cm in an open, branching cyme (see *Drymocallis gracilis* for cyme branching patterns), each flower occurring on a short stalk. Cup floral heads are short, blackish at the base (calyx), with glandular (sticky gum)-tipped hairs, 15–20 yellow, ray flowers emerge from the calyx. Synonym: *Hieracium cynoglossoides*

Photo by Rod Gilbert

Ecological Importance and Distribution

Hounds tongue hawkweed grows in prairies and mountain meadows across the inter-mountain west. The plant reproduces from short underground rhizomes but does not run above the soil (stolons) like many of the invasive non-native hawkweeds. In fact, the plant rarely produces much seed at all but the individual plants can be long lived. The small ray flowers produce a moderate amount of nectar in late spring.

Growth and Reproduction

HISC is very slow to reproduce in the wild. The plant produces few seeds and often the seed is aborted due to low amounts of late spring rainfall. The maternal plant does survive low moisture; however, the poor seed set makes increasing the plant in a nursery condition a long process. The seed is small but not tiny and remains clasped in the bract making it hard to clean and generate clean seed for sowing. Often we are sowing a mix of chaff and seed. The seeds need light to germinate effectively and emerge from the soil with greater vigor if cold-moist stratified for at least 30 days.

Large pappus hairs and small seed of HISC.

Photo by Cal photos U.C. Berkeley

Sowing Information

- Seeds per gram: 3704
- Seeds per cell: 4
- Cover: into gravel
- Stratification: cold-moist 30 days
- Germination: needs light to germinate

Lithophragma parviflorum • smallflower prairie star or Steilacoom flower • LIPA

Saxifragaceae Saxifrage Family

Plant Description

Photo by Rod Gilbert

Lithophragma parviflorum is a perennial upright herb with a naked flowering stem. The leaves are located low on the stem, each cut into three lobes or divided into three lobed leaflets. The stem bears up to 14 flowers (calyx), each in a cup of red or green leafy structures surrounding the petals (sepals). The five petals are bright white, up to 1.6 centimeters long, and usually divided into three tooth-like lobes. The plant produces numerous underground storage roots, both rhizomes (horizontal roots with sprouting capabilities) and a clustered caudex (bunched storage leaves).

Ecological Importance and Distribution

It is native to much of western North America from British Columbia to California and east to South Dakota and Nebraska, where it grows in several types of open habitat. The plant can be found on coastal bluffs, prairies, shrub-steppe and rocky mountain outcrops. Almost all open and well drained soils with ample sunlight will be good habitat for this species. Though the plant has a wide range, the open rocky habitat in the Puget lowland region has been paved over for residential construction. The plant has been extirpated (locally extinct) from Steilacoom, the town that was once synonymous with the flower.

Lithophragma parviflorum is pollinated by a number of generalist insects and a rather drab moth, *Greya politella,* which pollinates and feeds on only the most fragrant *Lithophragma* in an area. This is a bit of a pollination gamble for the plant as the moth larvae feed on the developing seeds after the parents have fed on the nectar. This has led ecologists to hypothesize that the high variation in fragrance among individual *Lithophragma* plants in a population may be caused by the plants' attempts to hedge their bets against the predation by moth larvae.

Growth and Reproduction

Lithophragma parviflorum is considered an ephemeral perennial (short-lived, but more than one season) on the landscape. The species may be well adapted to winter rainfall and well drained soils across its range. The leaves emerge quickly in late winter making a rosette. The flower stems shoot up on long stalks in early spring with seeds quickly forming, and the plants are fully dormant by late spring. This short annual appearance makes them difficult to propagate in a nursery. We are experimenting with sowing times and pot sizes to deliver these plants within 3 to 5 months of sowing them. The plants can then go dormant in the field and emerge from the storage roots (caudex) the next winter.

Seed Dimensions

Average Measurement Range: Brown dust

Sowing Information

- Seeds per gram: 30,000
- Seeds per cell: 5
- Cover: into gravel
- No stratification seems to be necessary

Lomatium nudicaule • barestem biscuitroot • LONU
Apiaceae Carrot Family

Plant Description

Barestem biscuitroot is a perennial herb arising from a stout taproot. The plants reach a mature height of 20 to 45 cm. The leaves are divided into groups of three leaflets (compound ternate to bi-ternate). The leaflets are larger than the finely dissected leaflets common to other biscuitroots and very distinctive for the genus. Each leaflet is 2 to 5 cm long and shaped like an elongated egg (ovoid to orbicular) in outline with coarse teeth near the tip. The flower heads (inflorescence) are in umbrella shaped clusters (umbels). Each cluster is made up of 7 to 27 pale yellow ray flowers (flat, strap-shaped petals), 8 to 10 cm long.

Ecological Importance and Distribution

Barestem biscuitroot is found in western North America, British Columbia, Idaho, Utah, Washington, Oregon, Nevada and California. It is naturally found in dry, open to sparsely wooded places in lowlands to middle elevations. It is often found growing in sagebrush, pinyon-juniper, ponderosa pine, and mountain brush communities in the Intermountain West. Barestem biscuitroot may be adapted to grow in sandy or glacial outwash soils in areas receiving at least 35 cm or more mean annual precipitation, such as Western Washington prairies. All the *Lomatium*s, and plants in the *Apiaceae* family, provide ample nectar and pollen to insects. They bloom over a long period and the floral structure (open wide umbrella shapes) allows for efficient sharing of plant resources by numerous species of insects. LONU has some of the largest seeds on the lomatiums and the seed was extensively used and traded for food among the Native Americans.

Growth and Reproduction

Flowering occurs from April to June and seed is typically harvested in mid-July. A cold-moist stratification is necessary for germination, and 90% germination can be achieved

by a 45-day stratification period followed by placement in cool germination temperatures, 15˚C. The plants are slow to mature, and recommended growing time is 12-16 months. Dormant roots are easily transplanted with high establishment success.

In the field, biscuitroot species can be broadcasted or drill seeded. Best results can be obtained from dormant fall seeding into a firm, weed-free seedbed. Seed should be placed at a depth of 0.6 to 1.2 cm and packed to ensure good seed-to-soil contact. New techniques are being investigated regarding the feasibility of growing biscuitroot species in rooting beds at high densities prior to field establishment. This method would allow a nursery to sacrifice a much smaller area in the first 1 to 2 years of plant development before the plants produce seed.

Seed Dimensions

- Average measurement: 10.7 x 4.9 x 0.9 mm
- Measurement range: L: 9 – 12.5 mm, W: 4 – 5.75 mm, D: 0.5 – 1.1 mm
- Shape: Seeds widely winged. Hilum (point where seed was attached to the plant) puckered.
- Color: Wings and ribs off-white to tan. Hilum is darker. Outer seed face has light to dark brown center, with three tan ribs that cross longitudinally (lengthwise) from hilum to opposite end. Inner seed face is bisected by one major rib, and then has darker brown stripes mixed with tan stripes.
- Surface: Seeds smooth and not glossy.
- Latitudinal cross-section: elliptical 
- Longitudinal cross-section: elliptical 

Sowing Information

- Seeds per gram: 92
- Seeds per cell: 5
- Cover: soil and gravel
- Stratification: cold-moist 45 days

Photos by USDA

Lomatium triternatum • nineleaf biscuitroot • LOTR

Apiaceae Carrot Family

Plant Description

Nineleaf biscuitroot is an herbaceous forb in the carrot family that grows from a large taproot. Mature plants reach 70 cm tall. Leaves divide in multiples of three (ternate-pinnately compound) with 9 to 21 leaflets or segments from leaf stems (petioles) up to 20 cm long. The leaf stems form a sheath around the main stem. Leaflets range from 1 to 13 cm long and 1 to 1.5 cm wide. The flower head (inflorescence) is umbrella shaped (umbelliferous) with 4 to 20 stems ending in bright yellow flowers.

Ecological Importance and Distribution

Nineleaf biscuitroot is native to western North America, occurring from northeastern California to British Columbia and east to Alberta and Colorado. This species is common on sunny valley bottoms, open ridges and slopes of foothills and lower mountains. It sometimes ranges into higher elevations, in association with big sagebrush, pinyon-juniper and alpine plant communities at elevations from 1,300 to 2,900 m (4,200 to 9,500 ft).

Nineleaf biscuitroot begins growth very early in the spring, often just following snowmelt, providing crucial early forage for many wildlife and domestic animals. It is considered one of the most valuable forage species of the genus due to its large stature and high production levels. Early flowering make this an important species for early spring pollinators and other insects.

The roots of nineleaf and other biscuitroot species are edible and were used as an important food source by Native Americans. Roots could be eaten raw, cooked as a vegetable, or ground into flour for bread meal. An infusion of roots was taken for chest troubles. The seeds were also used as condiment and spice.

Growth and Reproduction

Flowering takes place from late spring through mid-summer with seed ripening in July and August. Wild seed is easily hand collected. The seed detaches readily from the stems, and shaking ripened inflorescences over a bag or tarp can make very clean, small collections. Minor screening to remove sticks provides excellent purity. Seed viability in proper storage conditions remains high for 3 to 4 years. There are approximately 168 seeds per gram.

LOTR seedling, note finely compound leaflets and leaf stems wrapping around the main stem. Photo by Jaal Mann

For greenhouse plant production, a cold/moist stratification period is required. A 45-60-day cold/moist stratification can achieve over 90% germination. Best results are obtained when seed is sown in late fall or early winter and left outside to stratify naturally. Containerized plants should be grown for a full season and overwintered before transplanting the following spring. Transplants are very hardy, and if weeds are controlled, 100% establishment can be accomplished.

New techniques are being investigated regarding the feasibility of growing nineleaf biscuitroot in rooting beds at high densities prior to field establishment. This method would allow a nursery to sacrifice a much smaller area in the first 1 to 2 years of plant development before the plants produce seed.

Seed Dimensions

- Average Measurement: 9.5 x 3.3 x 1 mm

- Measurement Range**:** L: 7.25 - 12.5 mm, W: 3 – 4 mm, D: 0.5 - 1.5 mm

Photo by USFS

Sowing Information

- Seeds per gram: 146
- Seeds per cell: 5
- Cover: Soil and gravel to prevent seed floating
- Stratification: 45-60 days cold moist

Lomatium utriculatum • spring gold • LOUT

Apiaceae Carrot Family

Plant Description

Lomatium utriculatum, or spring gold, grows in upright clumps with mostly basal leaves. Leaf blades are dissected into very narrow, fern-like delicate leaflets. The plant has the appearance of a tiny carrot. Flowers are small and bright yellow, and clustered in open umbrella shapes (umbels).

Photo from Swan Lake Nature Sanctuary

Ecological Importance and Distribution

Spring gold grows in meadows, woodlands, and open rocky areas from California to British Columbia. *Lomatium utriculatum* has been found to be a primary nectar source of Taylor's checkerspot (*Euphydryas editha taylori*) and mardon skipper (*Polites mardon*) butterflies in certain locations. In restoration efforts, planting of important nectar source species, like spring gold, near larval host plants such as harsh Indian paintbrush (*Castilleja hispida*) is important because Taylor's checkerspot butterflies do not move a long distance when foraging for nectar or laying eggs.

Growth and Reproduction

Lomatium utriculatum is one of the first flowers to open on the Puget lowland prairies. Its beautiful gold flowers herald spring and provide nectar to early butterflies and bees. It sets large amounts of seed on umbrella shaped seed heads, 20 cm high, that are easily spotted and collected amidst the grasses. The white carrot-like root persists for many years in the ground making the plant a long lived perennial.

All *Lomatium* seeds, no matter what species, easily “float” above the soil medium when watered after sowing. Cover the sown seed lightly (1-2 mm of soil and 1-2 mm of gravel) to reduce floating seed. Go back a few days after sowing and re-cover with a 50/50% gravel/soil mix if many seeds are sitting on top of the soil. Water well but do not flood the cells as this will cause more floating seeds. Seed germinates readily after 45 days of cold-moist stratification. The seeds, seedlings and roots are a favorite food of small birds and mammals. This can lead to a reduced population of plants both in the nursery and on the prairies.

Photo by Jaal Mann

Sowing Information
- Seeds per gram: 580
- Seeds per cell: 5
- Cover: soil and gravel
- Stratification: 60 days
- Germinates best at temperatures below 15°C

LOUT Seed Measurement Range:
L: 5.25 – 6.5 mm, W: 2.5 – 4 mm,
D: 0.25 – 0.6 mm

Luzula comosa • Pacific woodrush • LUCO

Juncaceae Rush Family

Plant Description

Luzula comosa has flat leaves (50-150 mm x 3-7 mm) that generally grow from the base (basal). The leaf covering (sheath) margins are fused or overlapping and generally have two ear-like extensions at the leaf (blade) junction; blades are round and flat, with a margin of hairs. Flower clusters (inflorescence) are head-like or single flowers, variously arranged, with small leaves below the flower (bracts subtending inflorescence, generally leaf-like). The *Luzula comosa* flower is generally complete (both male and female), and the fruit is a capsule (loculicidal).

Ecological Importance and Distribution

Luzula comosa, a monocot, is a perennial herb that is native to western states and provinces in North America. It is common to meadows, open woods, and coniferous forest, 50-3200 m in elevation. The woodrush is a common and often overlooked member of the prairie monocot community (grasses, rushes, sedges and members of the lily family). In prairies with harsh climatic conditions (more rain, cold or wind than average) the woodrush can make up larger proportions of the plant community and play an important role in creating habitat and forage for many species.

Growth and Reproduction

Flowering occurs from April to July and fruiting happens throughout the spring and summer. Seeds are usually collected by hand as they ripen over a long period of time. There are ~2000 seeds per gram. Seeds are best sown in trays to spend at least 30 days in cold-moist winter conditions. Seeds become gelatinous in refrigerated stratification and are difficult to handle.

Seed Dimensions

Seeds often have white appendages on one or both ends.
Seed size: 1–1.5 mm, cylindric, red-brown to brown; outer seed coat (appendage) 1/4–1/2 seed-body length.

Sowing Information

- Seeds per gram: 2000
- Seeds per cell: 5
- Cover: soil and gravel
- Stratification: 30 days

Photos by Rod Gilbert

Micranthes integrifolia • *w*hole-leaf saxifrage, swamp saxifrage • MIIN

Saxifragaceae Saxifrage Family

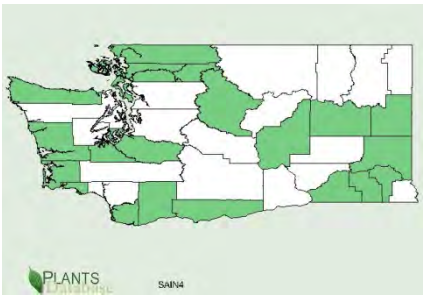
Plant Description

This plant is a perennial, with long straight flower stems growing to be 10-30cm tall. The plants are aggressively rhizomatous, meaning that they are singular stalks connected under the ground by roots. The narrow leaves emerge from the woody plant base in a rosette pattern. The flower clusters (inflorescences) are dense but the nectar producing part of the flower is very accessible to insects. The individual flowers have 5 white oval-shaped petals.

Photos by Ben Legler

Ecological Importance

This herb is found on the western side of the Cascades from British Columbia to Oregon, in prairies, grassy mountain slopes, and vernally moist (spring moisture but dry in summer) areas. They have the ability to live at sea level and up to subalpine climates. They are most abundant on Puget lowland prairies in areas that have been frequently managed with controlled burns. In the wild they offer a long blooming period to support wildlife in many different habitats. The open floral structure produces an abundance of nectar over a very long period in spring.



Micranthes integrifolia distribution in WA

Growth and Reproduction

MIIN blooms from March to July. The seeds are narrow, pointed and golden brown in color. The seed is the smallest we sow, it is practically like dust. Often it is sown into small gravel in late winter. Germination usually occurs in March and April. This allows for a long period of moist weather which the small seedling seems to need in order to become established. Once the seed has germinated care must be taken to not overwater, but also not to allow the seedlings to dry out excessively. The seedling watering often needs to be checked at least twice a day. This type of special care is common with many of the small seeded species cultivated in the conservation nursery.

Photo by Shaun Hubbard

Sowing Information
- Seeds per gram: 40,090
- Seeds per cell: 12
- Cover: into gravel
- Stratification: 60 days
- Germinates best at temperatures below 15°C

Microseris laciniata • cutleaf silverpuffs • MILA
Asteraceae Aster Family

Plant Description

Microseris laciniata is a perennial herb growing up to a meter tall with a branching stem. The plentiful leaves are 10 to 50 cm long and variable in shape, with smooth, toothed, or lobed edges. The flower head is borne on a tall, erect or curving flower stem (peduncle). The flower head may be 3 cm long when in bud and wide when in bloom, bearing up to 100 or more long yellow ray florets (flowers with petals).

A single seed is held in a dry, shrunken fruit (achene) with a gray or brown body a few millimeters long. At the tip of the achene body is a long collection of hairs (pappus) made up of 5 to over 20 scales, each of which may exceed one centimeter in length.

Ecological Importance and Distribution

Microseris laciniata is a flowering plant in the aster family known by the common name cutleaf silverpuffs. It is native to the western United States from Washington to northern California and Nevada, where it grows in forest and grassland habitats.

Microseris laciniata has four distinct subspecies, separated geographically across the range (allopatric subspecies). The differences among them, for a botanist, are found mainly in the tiny leaves that surround the flower head (phyllaries) and the number or form of hairs at the end of the seed (pappus). These subspecies co-exist with the greatest diversity occurring in the Klamath Mountains of northern California and southern Oregon.

Growth and Reproduction

Microseris makes a beautiful cluster sheath of leaves in early spring. The leaves seem to spear out of the ground almost overnight. The plant looks a lot like a dandelion or hawk-weed but this species provides more floral resources to insects. The species requires pollination from other plants to produce seed (consistently self-sterile and outcrossing), something neither dandelion or hawk-weed require as they are self-fertile. Thus *Microseris* may offer up more nectar or pollen to attract pollinators than the two invasive look-a-likes.

The plant sets seed in May through June and can easily be mechanically harvested as all the seed ripens at once. There are approximately 924 seeds per gram. Seed cleaning requires removal of the long pappus (see photo at left) to facilitate manual and mechanical sowing.

Seed Dimensions

- Average Measurement: 5.6 x 0.8 x 0.8 mm
- Measurement Range: L: 4.75 – 7 mm, W: 0.5 – 0.9 mm, D: 0.5 – 0.9mm
- Shape: Seed tubular with puckered hilum (detachment scar)
- Additional Structures: Pappus fibers are attached in a circular pattern around the end. Individual hairs exceptionally broad and 1/10 – 1/3 as long as seed body.
- Color: Hilum white, seed body tan or light brown.
- Surface: Seed body has 10 – 15 grooves running longitudinally from hilum to pappus. Hilum is glossy but seed body is smooth and matte.
- Latitudinal cross section: elliptical 
- Longitudinal cross section: elliptical 
-

Sowing Information

- Seeds per gram: 968
- Seeds per cell: 4
- Cover: into gravel (need light to germinate)
- Stratification: 90 days

Packera macounii • Siskiyou Mtn. or Macoun's groundsel • PAMA

Asteraceae Family

Plant Description

Macoun's groundsel makes dense clumps or rosettes close to the ground from a woody rootstock. The leaves are linear-lanceolate (lance shaped) carried at the end of long petioles (leaf stems). There are rarely teeth or wavy edges to the leaves. The leaves are covered with short, dense, matted hairs (tomentose) giving the leaves a complete grey cast, especially later in the season as the weather becomes drier.

The flowers are borne atop stems to 20 cm in June and July with the seed ripening soon after. The aster-like seed is held in small flower heads with 5-10 seeds per head. A short seed covering (achene) is topped with short hairs on the end of the seed (pappus, like a dandelion).

Ecological Significance

Range of *Packera macounii, showing CA, OR, WA and BC* from *Wildflowers of the Pacific Northwest*

This plant is common in southern Oregon and the Willamette Valley, especially in rocky prairies and outcrops. Northward into WA and BC the plant becomes rare and its habitat more fragmented. This plant is listed with the State of Washington as critically imperiled due to the reduction in native prairie acreage. Though it was once found in a wider range, the only known remaining population in south Puget lowland prairies is on Joint Base Lewis-McChord. The plants we raise are from that small source population.

Growth and Reproduction

Photos by Keir Morse, Calphotos, UC Berkeley

Packera macounii exhibits the growth and reproduction habit common to many perennial members of the aster plant family growing on the West Coast of the United States. Many bloom in late spring to early summer and ripen seed in the hottest, driest part of the year. Summer rain is uncommon in most lowland areas of western North America. Thus, plants need to develop adaptations to set seed under seasonally dry conditions. The leaves can persist and provide nutrients to the developing seed by being small, linear and covered with grey hairs. This reduces water loss and overheating during the summer. Often the seed is quite small and ripens quickly after pollination further reducing the plant's need for moisture.

Packera grows in sites where there is little competition from other vegetation. The seed is adapted to germinate in such conditions, requiring a broad spectrum of light to germinate. For propagation purposes the seed is sown on the surface of the soil. Fresh seed needs no stratification but we are experimenting to provide a more detailed protocol.

Seed Dimensions

Measurement Range: L: 4-6 mm W: 0.5-1 mm D: 0.5-0.7 mm
Surface: elongate with longitudinal grooves, colored black and tan, short pappus hairs

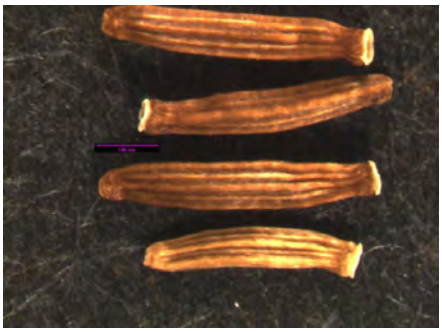


Photo by Lisa Hintz

Sowing Information

- Seeds per gram: 2410
- Seeds per cell: 2
- Cover soil: into gravel
- Stratification: no stratification necessary with fresh seed; no information available for stored seed

Perideridia gairdneri • yampah • PEGA

Apiaceae Carrot Family

Plant Description

Perideridia gairdneri is a perennial herb which may approach 1.5 m in maximum height, its slender, erect stem growing from cylindrical tubers measuring up to 8 cm long. Leaves near the base of the plant have blades up to 35 cm long which are divided into many narrow, subdivided lobes. Leaves higher on the plant are smaller and less divided. The flower cluster (inflorescence) is a compound umbrella-shaped branch (umbel) of many spherical, small white flowers. These yield ribbed, rounded fruits, each a few millimeters long

Perideridia gairdneri Gaidner's yampah

Photo by Rod Gilbert

Ecological Importance and Distribution

Perideridia gairdneri is native to western North America from southwestern Canada to California to New Mexico, where it grows in many types of habitat. A number of swallowtail butterflies use the plant as a larval host throughout its range. As a member of *Apiaceae*, or the carrot family, this plant provides ample nectar to insects. It often grows in deeper soils on Puget lowland prairies, providing summer bloom and forage. The roots are eaten extensively by Mazama pocket gophers. Yampah (*P. gairdneri*) was an important food plant, even a staple food, for Native American groups. The tuberous roots could be eaten like potatoes, roasted, steamed, eaten fresh or dried, made into mush or pinole, used as flour and flavoring, and also used medicinally. The plant smells strongly of parsnips, including the tuber, flowers, and fruit. The plant can be propagated by seed or by dividing the smaller tubers.

Growth and Reproduction

The plant emerges from the soil in mid-spring. Flowering occurs from July into August if the soil has adequate moisture and the plants are robust. Both population and seed set by plants decrease in numbers in response to heavy competition from invasive grasses. The plant can colonize quickly after fire or other disturbance. Thus fire is an important regenerative tool for this species.

Hand collect seeds in August when seeds have turned brown and are easily stripped off of flowers into paper bags. Store seeds in sealed containers at 5º C. Seed will retain viability for up to five years. Sow seeds in the fall and allow natural stratification, or sow stored seeds in the spring after six to eight weeks of cold, moist stratification.

Seed Dimensions

Average Measurement: 2.3 x 1 x 1 mm
Measurement Range: L: 1.5 – 3 mm W: 0.8 – 1.1 mm D: 0.75 – 1.3 mm
Latitudinal cross section: ovate (egg-shaped – pointed at tip)
Longitudinal cross section: elliptical (oval)
Shape: Seed schizoid (clusters split along an axis into multiple seeds), flat on one plane, and rounded on the opposite plane. Lots of irregularity in shape.
Color: Various shades of green and brown. Hilum (detachment scar) is usually white. Some seeds have pink from remnant flower structure at tip.
Surface: Seeds have five ridges on outer seed face that run from hilum to tip longitudinally (lengthwise). Inner seed face has one white rib that bisects (splits in two parts) the seed face.

Sowing Information

- Seeds per gram: 1614
- Seeds per cell: 4
- Cover: soil and gravel
- Stratification: ~ 50-60 days, sow to over winter in cells

Plantago lanceolata • narrowleaf plantain • PLLA

Plantaginaceae Plantain Family

Plant Description

Narrowleaf plantain is a non-native perennial that forms rosettes and is a common weed of pasture land, roadsides, and waste places. The basal leaves are lance shaped and spreading, scarcely toothed with 3-5, distinct parallel veins. Flower stalks end in an oblong floral structure (inflorescence) with many small flowers, each surrounded by a modified leaf called a bract. Each flower can produce two seeds.

PLLA foliage and flowers
Photos by Leo Michels and Kristain Peters

Ecological Importance

This species, native to the British Isles, is considered an invasive weed in North America and is widespread throughout North and South America, as well as in Australia. This species is grown in support of the reintroduction effort for the Taylor's checkerspot butterfly. This butterfly species uses narrowleaf plantain for oviposition, laying its eggs on the plant. Before this invasive plant species was present, Taylor's checkerspot butterflies predominantly used *Castilleja hispida* or *C. levisecta* for oviposition. The current patchy and degraded nature of the

remaining butterfly habitat has allowed for the growth of narrowleaf plantain and the butterflies have responded by changing the plant onto which they lay their eggs.

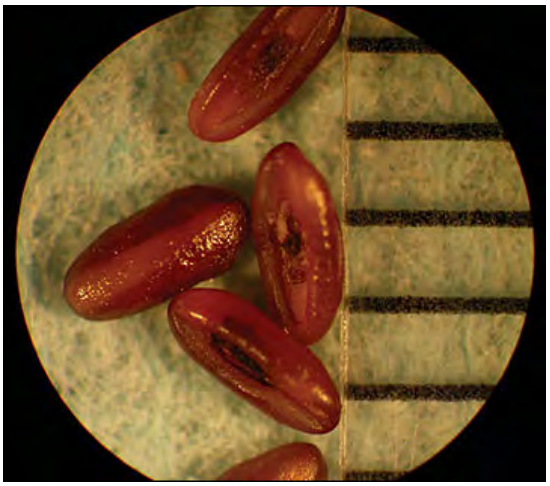
Growth and Reproduction

The foliage of plantain emerges early in the year when most other herb plants are still dormant. This allows for early butterfly larvae to find food as they come out of diapause (a winter dormant life stage). Blooming occurs in late spring, numerous flowers are produced per head and large amounts of seed are produced. Seed is the primary form of reproduction and the plants are short lived. The seed requires light to germinate and the species has been an important model in the study of weedy or “ruderal” plant response to disturbance. It commonly sprouts up along roadsides and “waste” ground where cars, livestock and human traffic disturb the soil and create bare ground. For propagation, the seed can be sown directly on top of the gravel cover layer and watered in to create soil contact. Germination is quick with no stratification needed.

Fun Facts

Strong arguments are made on both sides of the debate of planting a non-native plant species to support an endangered butterfly species. Some argue that a non-native species should never be grown and planted out, especially in already fragile habitat. However, others say that since the butterfly is in imminent danger of going extinct, and the species itself has adapted to the change in vegetation in its habitat, that plans to recover the species must adapt as well.

Sowing Information
- Seeds per gram: 900
- Seeds per cell: 5
- Sow: into gravel
- Stratification: none necessary



PLLA seed, dimension in mm,
U of Missouri

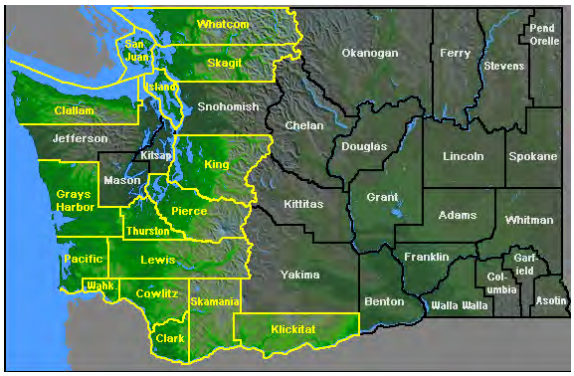
Plectritis congesta • shortspur seablush, sea blush, rosy plectritis • PLCO

Valerianaceae Valerian Family

Plant Description and Distribution

Photo by Rod Gilbert

An annual herb with a single stem growing 10-61 cm tall and nearly hairless throughout. The leaves are arranged in opposite pairs on the stem, entire, 1-6 cm long and 0.25-2 cm wide; the lowermost leaves resemble a spatula (spatulate) or a rounded spoon (obovate). The upper leaves lengthen, thin out and clasp the stem (sessile). The flowers are in a dense, head-shaped cluster of small pink or rarely white flowers. The fruit is of two forms (dimorphic): with or without lateral wings. It is found at low elevations in open, seasonally moist slopes and meadows, growing in well-drained soils.



Distribution of *Plectritis congesta* in WA. Map Courtesy of The Burke Museum of Natural History and Culture

Ecological Importance

Rosy plectritis is recognized as an important nectar source for the Taylor's checkerspot butterfly (*Euphydryas editha taylori*). The plant has become very rare in the south Puget lowland, and has been rescued from very few, small, remnant populations. Conservation and restoration have increased that original population 10,000-fold across the landscape. Increased seeding and prescribed burning have aided in the recovery of this species. Annual flowering plants in general were never abundant in Western Washington but prairie ecosystems are an exception. Therefore, rosy plectritis remains an important annual plant for habitat restoration purposes throughout the Puget lowland prairies and into the Canadian islands of the Georgia Strait.

Growth and Reproduction

Growing an annual for seed production or restoration means there is a quick turnaround from sowing to plant out. The plants fill their growing tubes in ten weeks and are then ready to plant in the seed beds to grow another ten weeks until blooming. The fruit is set in June and July and often fails to fall from the stalks. The seeds are mechanically or manually collected. The seed can be winged or wingless. The percentage of wingless seeds can vary from 1-46% depending on the population. This characteristic of having two types of seed (seed dimorphism) has allowed the species to be a model to study how the environment that the mother plant grows in creates selection pressure for the genetic trait of winged or wingless seed in future generations. Rosy plectritis seed germination increases significantly (by 30% +/- .04) when the seed is treated with smoke infused water. This may be one cause of the increase in germination on the prairies after a prescribed burn.

Winged/keeled seed of rosy plectritis.
Photo by Lisa Hintz

Sowing Information
- Seeds per gram: 1699
- Seeds per cell: 5
- Cover: soil and gravel
- Stratification: 15 to 30 days
- Germinates best at temperatures below 15°C

Ranunculus occidentalis • western buttercup • RAOC

Ranunculaceae Buttercup Family

Plant Description

A common perennial, growing from 15-76 cm with upright, usually branched hollow stems adorned with soft hairs. Basal leaves are 2.5-7.5 cm long, softly hairy and oval to heart shaped. Small yellow flowers with 5-6 petals are up to 2.5 cm wide. Found in moist soils, meadows, coastal bluffs and forests from sea level to high elevations, it is often confused with an invasive buttercup species from Europe, *R. repens.* However, that species is usually shorter, with leaves divided into three lobes, and found more often in waste places, roadside clearings and fields at low elevation.

Western Buttercup with first blooms.
Photo by Rod Gilbert

Ecological Importance

Western buttercup is widespread throughout western North America, and has many identified subspecies throughout its range. Western buttercup produces early season, nectar rich blossoms for pollinating insects. It is recognized as a main nectar species for the Taylor's checkerspot butterfly (*Euphydryas editha taylori*) in its Oregon range. South Puget lowland sites have a higher abundance of western buttercup along with Oregon sunshine (*Eriophyllum lanatum*), Strawberry *(Fragaria virginiana)*, and Puget balsamroot *(Balsamorhiza deltoidea)*, making all important nectar sources. In contrast, *R. occidentalis* is less abundant in comparison with harsh Indian paintbrush (*Castilleja hispida*) as a nectar species for the butterfly in forest clearings and meadows on the Olympic Peninsula.

Small but distinct nectar producing scale at the base of the RAOC flower petal
Photo by Rod Gilbert

Growth and Reproduction

New growth on the perennial plant begins from a fleshy rootstock in late winter. Unlike other members of the plant genus, *R. occidentalis* does not produce above-ground stems that spread out and root at the leaf nodes (stoloniferous reproduction). Seed is its only method of reproduction. The large seed is gathered by small rodents or birds and winter nursery seed trays are sometimes raided for their contents.

Western buttercup germinates well with a cold-moist stratification ranging from 14 to 32 days, with little sprouting of seed below 5°C. Cover seed with ~2 mm of soil and 1 mm of gravel. Germination begins within 14 days but occurs over a two month or more time span.

Photo by Lisa Hintz

Seed Measurement Range:
L: 3 – 4 mm
W: 2 – 3 mm
D: 0.75 - 1.25 mm

Sowing Information
- Seeds per gram: 413
- Seeds per cell: 5
- Cover: soil and gravel
- Stratification: 30 days
- Germinates best at temps <15°C

Fun Facts

The timing of flowering of western buttercups was used as a seasonal indicator for coming of summer salmon runs among the Shasta tribe. This species' smooth, flat, and orbicular (disk- or ring-shaped) seeds were used alone or mixed with other seeds to make a pinole, sweetened flour, considered a staple of the Mendocino and Pomo tribes.

Ranunculus occidentalis • western buttercup

Ranunculaceae • buttercup family

Description:
Duration: perennial
Growth habit: subshrub, forb/herb
Active growth period: spring and summer
Occurrence: moist meadows, grassy slopes, open and shaded forests, clearings, sea level to subalpine elvations

Morphology:
Flower color: yellow
Foliage color: green
Roots: fibrous
Stems: hairy
Growth form: multiple stems
Orientation: erect

Rod Gilbert

Steve Matson

WA distribution of *R. occidentalis*

http://plants.usda.gov

Conservation Status: Secure; Common, widespread, abundant

Ranunculus orthorhynchus • straight beaked buttercup • RAOR

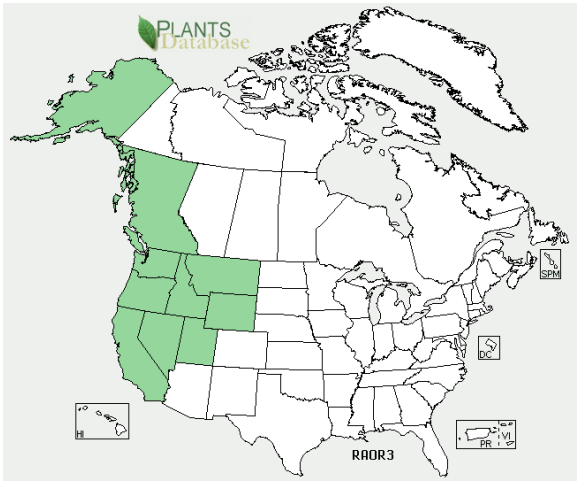
Ranunculaceae Buttercup Family

Plant Description

Photo by J. William Thompson

Straight beaked buttercup is a perennial herb sprouting from a fleshy, dense rootstock. The stems sometimes exceed half a meter long and may be upright or snaking along the ground (erect or decumbent). The stem may be hairy to hairless in texture. Leaf blades are each divided into several toothed leaflets and are borne on long leafstalks (petioles). The flower has five to eight shiny yellow petals, each 1 to 2 cm long with a tight cluster of stamens and pistils at the center. The fruit is small, dry, and does not open to release seed (achene), borne in a spherical cluster.

Ecological Importance and Distribution

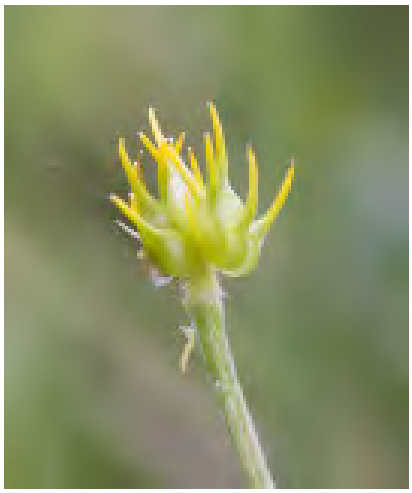


This buttercup has become increasingly rare in wet prairies and streamsides in Western Washington though it is abundant in mountain meadows and coastal marshes. The plant diversity of wet prairie meadows has been decreasing due to livestock over-grazing, draining of fields, and the increase of aggressive grasses used for forage. *Ranunculus orthorynchus* could be an important component of wet prairie restoration. These prairies, if restored, could provide a greater diversity of blooming species and longer blooming periods in summer to compliment the drier upland habitats. Building up stock for wet prairies from the few remaining plants in damaged habitats is a challenge for regional restoration ecologists. Our nursery restoration will involve developing cultivation protocols and building up plant material over a long timespan.

Growth and Reproduction

Ranunculus orthorhyncus produces numerous seeds, each enclosed in a dry, one-seeded fruit (achene or shell). The seed germinates at low temperatures after a cold/wet stratification of 40 days. *Ranunculus orthorhyncus* seeds are large, 225 per gram, so it is sown with a cover of both soil and gravel. Rodents love to eat the seeds if sown over winter but do not seem to bother spring sown seed. The plant grows quickly in the cells becoming ready to plant out in 120 days from germination. All *Ranunculus* species are susceptable to aphid infestations and should be monitored regularly.

RAOR flowers with ants collecting the nectar from the base of the pistils, photo by Bud Kovalchik



ROAR with beaked achenes (seed coverings). Photo by Rod Gilbert

Sowing Information
- Seeds per gram: 225
- Seeds per cell: 3
- Cover: soil and gravel
- Stratification: 40 days
- Germinates best at temperatures below 15°C

Sidalcea malviflora • prairie mallow • SIMA

Malvaceae Mallow Family

Plant Description

Sidalcea malviflora is an herbaceous perennial that grows from trailing and freely rooting lateral roots (rhizomes), and can reach 60 cm tall. The flower has five petals ranging in color from light pink to purple, sometimes reddish or rosy colored. The leaves are kidney shaped, and are 2 to 8 cm broad. The whole plant is uniformly covered in light hairs (pubescent). The petals (calyx lobes) are not widened above the base and are tapered evenly to the tip.

Ecological Importance and Distribution

Sidalcea malviflora has been found in open meadows, along fence lines, along roadsides, upon grassy hillsides, and in low mountain areas. The population in Washington is found in the Thurston County area in open prairie land. In Oregon, it is known to occur in rolling upland, wetland prairies, wetlands, and deciduous and evergreen forests of the Willamette Valley. *Sidalcea ssp.* occur in prairie and meadow environments that have been historically maintained by fire. Fire may be an important aspect of maintaining appropriate habitat. This species is endangered in Washington due the *extremely* small size of the one known population (one plant that has produced some seedlings through self-pollination). The extremely small size of the Washington population puts it at great risk. Conifer and non-native shrub encroachment are an ongoing concern.

Growth and Reproduction

Sidalcea malviflora germination is enhanced if seeds are scarified prior to sowing. The seed coat is hard and does not easily imbibe water. Two pieces of course sandpaper (40 to 50 grit) can be used to vigorously scrape 3g of seed at a time. After sanding, seed should be examined under a hand lens to ensure adequate scarification. Some seed will be damaged but most will just have visible scaring on the seed coat. Repeat scarification if less than 60% of the seed is scarred. Additionally, cold/moist stratification must be applied to further overcome seed dormancy. Stratification can be as short as 30 days. This combinational germination strategy is rare or at least is yet to be discovered among many species. That is because most researchers do not separately examine stratification and scarification and compare those results with a combination of the two techniques. Once the scarification and stratification requirements of the seed are met, germination is rapid at cooler temperatures; <15°C.

Sowing Information

- Seeds per gram: 293
- Seeds per cell: 5
- Cover soil: soil and gravel
- Scarify: Course sand paper
- Stratification: 30 days or less

Silene scouleri • Scouler's campion • SISC

Caryophyllaceae Pink Family

Plant Description

Silene scouleri is a species of flowering plant in the pink family known by the common name Scouler's campion. There are at least three subspecies which all vary in size, shape, habitat preference, and distribution. Some individuals are difficult to assign to a subspecies. In general, the species is a perennial herb producing one or more erect stems from a woody, branching base stem (caudex). The stem is usually unbranched, or simple.

Silene scouleri flowers have 5 deeply forked petals, 2 paler, petal-like appendages at the base of each petal, and a sticky, glandular-hairy, green-striped or purple-striped 10-veined petal-ring (calyx) composed of fused leaflike structures enclosing the petals (sepals) (these are the puffed pouches behind the flowers in the picture at left). The flowers are followed by the production of elliptical or egg-shaped seed capsules that are the same length as the petal-ring (calyx, cup-like part) or a bit longer. The leaves are green, opposite, covered with short, fine, flattened hairs, and broadly to narrowly lance-shaped or sometimes linear in shape. The stems are green, hairy, leafy, and erect to leaning. The glandular hairy foliage is sticky and can trap small insects.

Ecological Importance and Distribution

Silene scouleri is native to western North America from British Columbia to California to Colorado. The name "catchfly" (Scouler's catchfly is one of its common names) comes from the sticky hairs on the surface of the leaves and calyces that trap small insects trying to steal nectar without pollinating the flowers.

Silene scouleri is a very complex species that appears to be in the process of diverging into at least three different subspecies. Differentiation among these three forms is incomplete and plants that are a clear mixture among subspecies are frequently encountered in areas away from the main population centers of the three subspecies. In

northern Oregon and Idaho there appear to be populations connecting *S. scouleri* with *S. oregana*. They have some of the characteristics of *S. oregana* but not all. They may represent a more luxuriant form growing in taller vegetation, but their status needs further study.

Growth and Reproduction

The perennial plant prefers a sunny situation in gritty loam. Established plants begin growing when shoot dormancy is broken in late November to January. Most shoots partially die back during summer droughts. Summer drought can kill both juvenile and mature plants as well as limit the amount of flowering and seed set. The mature shoots that survive form flowering stems in June or early July, and flowers open in late August or early September. Seeds ripen in September or October. Collection of seed is often limited by summer drought or early fall rains that rot the seed capsules on the plant.

Seed Dimensions

Seeds brown or grayish brown, kidney-shaped (reniform), 1-1.5 mm, margins with small protrusions (papillate), rugged (rugose) on sides.

Sowing Information

- Seeds per gram: 717
- Seeds per cell: 6
- Cover: soil and gravel
- Stratification: 60 days

SISC seeds, dimensions in mm.
Photo USDA

Sisyrinchium idahoense • Idaho blue-eyed grass • SIID

Iridaceae Iris Family

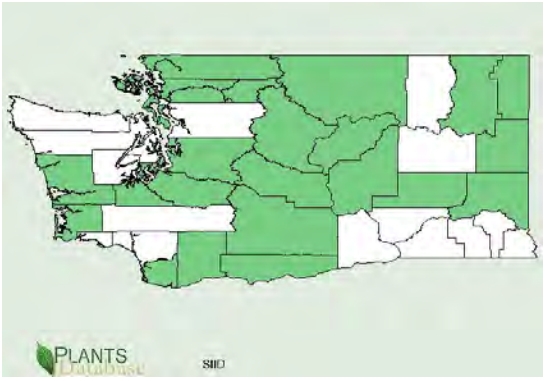
Plant Description:

The Idaho blue-eyed grass that we find here in Washington is a tufted perennial herb, with smooth (glabrous) leaves and stems that are simple, usually flattened and 1-2.5 mm wide and 15-45 cm tall. The leaves are mostly from the base of the plant (basal), narrowly linear and up to 30 cm long. Their little flowers are light to deep bluish/violet with a yellow center and dark violet lines creating a “striped” effect on the 6 petals.

Photos by Ben Legler

Ecological Importance and Distribution

The Idaho blue-eyed grass serves many important ecological services. The plant inhabits moist pockets, such as seeps or steam beds within drier sites. It provides nectar to solitary bees of the family *Megachilidae*, which are mainly responsible for cross-pollination in natural populations. In south Puget lowland prairies, the plants are limited to those areas that have deeper stream-side (alluvial) soils or become very moist in spring due to localized topography.



Sisyrinchium idahoense distribution in WA

Their habitat is seasonally wet areas and marshes, near sea level to mid-elevations in the mountains. They are also common in roadside ditches, believe it or not!

Growth and Reproduction

This little field plant blooms between April and July. Its fruits are egg-shaped capsules approximately 6 mm long, with black seeds. Numerous seeds are produced over a long period in summer. The large seed, 626 per gram, is sown after 90 days cold-moist stratification or winter conditions, followed by warm-moist stratification in summer. This dual combination of stratification has rarely been documented for plants from Puget lowland prairies. In order to find out more about this species' requirements for germination more comparisons and observations will need to be made in the nursery.

Fun Facts

– The name "blue-eyed grass" is given because the flowers appear like beautiful blue "eyes" from the side of a grass-like stem.
– Historically, this herb was picked and used to alleviate certain stomach and digestion issues.

Sowing Information
- Seeds per gram: 626
- Seeds per cell: 6
- Cover: soil and gravel
- Stratification: check with coordinator

Solidago missouriensis • Missouri or prairie goldenrod • SOMI

Asteraceae Aster Family

Plant Description

Photo by Rod Gilbert

This native perennial plant is about 60-90 cm tall and unbranched, except for the flowering stalks near the growth tip (apex). Missouri goldenrod produces both flowering and non-flowering shoots. The central stem is light green to dark red, round, and hairless; the lower portion of this stem may become slightly woody with age. A panicle of yellow flower heads develops at the tip of fertile shoots, spanning up to 15 cm long and 10 cm across. This panicle has flowering stalks that curve down towards the ground (recurved). Each flower head is about 3 mm across; it consists of several yellow disk florets that are surrounded by about 8-13 ray florets. The seed is surrounded by a hard shell (achene) with small hairs at one end (pappus).

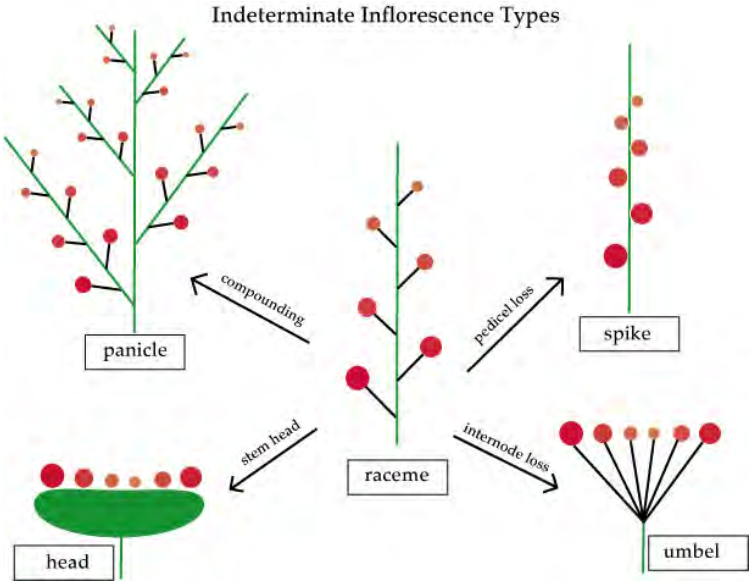
Ecological Importance and Distribution

Missouri goldenrod blooms at mid-summer making food available for important pollinators on the prairies. The flowers appear in July and persist in some years into August. This bloom window is between the plethora of blooms in spring and the late summer season members of the *Asteraceae*, like Hall's or Eaton's aster. *Solidago* foliage is also a preferred plant of a wide number of "pest" insects that go on to feed the birds and small mammals of the prairies. In Washington, this goldenrod is restricted to prairie soils and habitats on both sides of the Cascades. However, the species has a very wide distribution in North America. This is the most common goldenrod on the short grass and bunch grass prairies west of the Mississippi River and east of the Continental Divide.

Growth and Reproduction

Missouri goldenrod reproduces vegetatively by offsets (short underground roots) and sexually by seeds; it often forms sizable vegetative colonies in which only the outer shoots are fertile and produce flowers. The inner shoots of such colonies are infertile and usually smaller in size. Frequently, seed set can be low in the larger colonies found in natural habitats, younger plants or middle aged populations produce more viable seed. SOMI takes advantage of disturbance regimes on the prairies by being able to germinate on the surface of bare soil. The small seeds require light to germinate well. In the nursery, seed is sown on a surface of gravel and kept moist for 14 days until germination occurs.

Photo by Seeds of Success



SOMI is a good plant to use to describe different types of flower heads (inflorescences). Flower heads are classified by the form that the flowers take when emerging from the stem. Many members of the *Asteraceae* Family have panicle inflorescence forms (compound branching leading up to the flowers) with the flowers themselves composed in a head or receptacle.

Sowing Information

- Seeds per Gram: 3715
- Seeds per cell: 5
- Cover: into gravel
- Cold-moist stratification: 15 days
- Requires light to germinate

Solidago simplex ssp. *simplex* var. *simplex* • Mt. Albert goldenrod • SOSI

Asteraceae Aster Family

Plant Description

Photo by Rod Gilbert

SOSI is a smooth leaved (glabrous) perennial from a short woody base or lateral root (rhizome), 5-80 cm tall and somewhat sticky to the touch (glutinous), at least in the flower buds and stems (inflorescence and peduncles). Basal leaves are rounded spears (oblanceolate) to spoon shaped (spatulate), toothed on the edges or nearly entire and blunt. The stem (cauline) leaves are few, short and compact on most prairie specimens. The flower heads are often on long stems (peduncles) with blunt; ray flowers, normally 8, disk flowers 13, all yellow.

Ecological Importance and Distribution

Solidago simplex, as a species, is a model organism for form and structure (morphological) plasticity (the ability to change structure of leaves, stems and/or flowers) in different environments. The species is found from central Mexico, NE to Quebec and NW to the Arctic Islands of the Northwest Territories. There are three main subspecies further divided into 12 varieties that have unique characteristics that set them apart from one another. The two varieties that are found on Puget Sound prairies are separated by the time of bloom; an April and a June bloom. At this time, they have not been officially separated by variety but both are also common on rocky clearings below 2000 m in the Cascades, the Yakima and Columbia River canyons and along the coastal dunes.

Growth and Reproduction

Many members of the *Asteraceae* family have small light seeds with attached pappus (the fuzz on the dandelion seed). This adaptation of the seed allows the plants to colonize new areas rapidly. They frequently move into areas that have had some sort of ecological disturbance: flood, landslide, fire, volcanic eruption or, more commonly in our age, human disturbance. A unique characteristic of the seed of the *Asteraceae* colonizers is the need to have light to germinate. The small seeds land on bare soil with minimal competition and the water-imbibed seed responds to the sunlight and heat by rapidly germinating. In the nursery, SOMI is sown on the surface of gravel after undergoing a 90 day stratification period. Germination begins at 14 days and continues for approximately a month.

Sowing Information
- Seeds per gram: 3446
- Seeds per cell: 6
- Cover: into gravel
- Stratification: 90 days
- Requires sufficient light to germinate

Symphyotrichum chilense spp. *hallii* • Hall's aster • SYHA

Asteraceae Aster Family

Plant Description

SYHA is a well-branched perennial 20 to 100 cm tall, its size dependent on available moisture. The plant emerges from woody under-ground stems (rhizomes) producing long, linear leaves that are alternately arranged up the stem. The flowers are at the ends of divided stems and branches to make wide spreading plants. The blooming stems let loose with a starry display of white to lilac flowers in July and August. On south Puget lowland prairies, the plant is found along seasonal streams that go dry during the summer.

Hall's aster in full bloom
Photo by Regina Johnson

Distribution and Ecological Importance

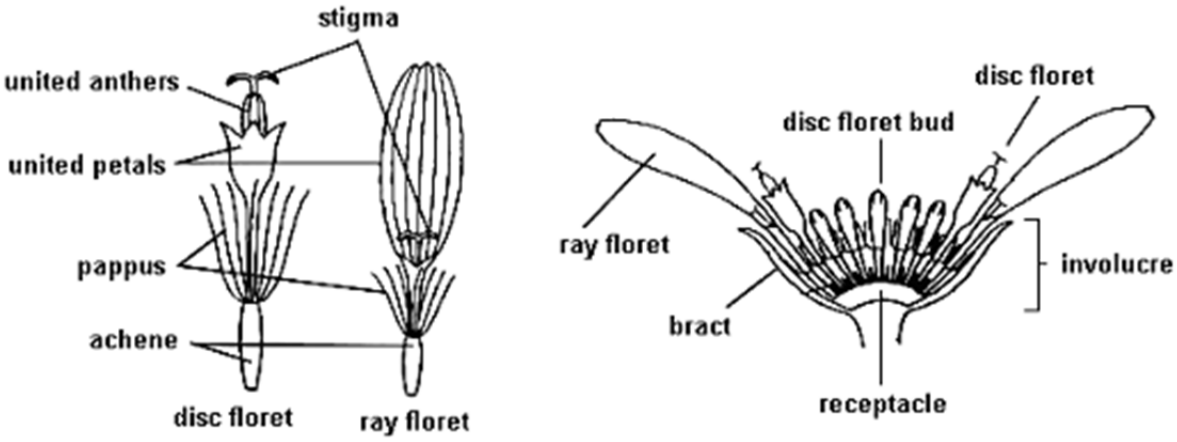
Hall's aster is known to have only a few populations in Oregon and Washington States. All known populations are on State or Federal Lands. The rarity of the plant makes it a species appropriate for propagation and increase. All asters provide significant nectar resources during the mid-summer months when little else is blooming on the prairies.

Growth and Reproduction

Many members of the Aster family reproduce vigorously by underground stems known as rhizomes. Hall's aster is no exception; the plant produces large clumps over many years. SYHA is a good example to use to describe how the flowers of the Aster family are often structured. All the flowers are held erect in a flattened receptacle. The outer

flowers, known as ray flowers, have long petals attached. The inner flowers (disk flowers) often have very shortened, united or fused petals that are almost non-distinct. The full flower is made up of the yellow center (disk flowers), outer petals (ray flowers), surrounding overlapping bracts on the outside (involucre) and the receptacle at the base.

PARTS OF AN ASTER FLOWERHEAD



The most robust and fertile seeds are produced by the disk flowers. When the aster seed is threshed, it is commonly difficult to clean as the seed is mixed with heavy seed coverings (achene) and the fluffy pappus (the fuzzy part like in a dandelion). Cleaning seed for sowing requires a number of steps to remove the pappus or sometimes the achene and separate them from the seed. Additionally, cleaning can be tedious as the seed of Hall's aster is very small with ~5,000 seeds per gram.

Many of the aster family germinate at higher rates when the sown seed is exposed to full spectrum sunlight. The sunlight cues the seed that there is reduced plant competition and plenty of bare space to occupy. The need for sunlight and the small seed makes sowing fairly easy. The seed is rather thickly sown at a rate of 7-10 seeds per cell (or what looks like seed but is a mix of seed and chaff). The seed is directly sown into a light covering of gravel over the potting soil. The seed is then lightly watered in to create soil contact with the seed but the seed is not really covered with soil. If cold stratified for 14 days prior to sowing, seed germinates readily in one week.

Sowing Information

-Seeds per gram: 3000
- Seeds per cell: 7-10
- Cover: into gravel
- Stratification: 15 days
-Requires sufficient light to germinate

Symphyotrichum chilense • Pacific aster • SYCH
Asteraceae Aster Family

Plant Description

Photo by Ben Legler

The 90-150 cm tall Pacific aster is a fibrous-rooted perennial sprouting from a rhizome (underground stem) or branched base. The lower leaves are rounded lances (oblanceolate) on short stems (petiolate), and slightly hairy (pubescent). The older leaves fall early while the leaves around the stems get progressively more linear and small. Flower heads are many in an open inflorescence, with a few erect, pointed, linear bracts below each flower head. Scales on the back of the receptacle (involucre) are 5-7 mm high, the scales are papery below and green above (see photo at right); disk flowers numerous, yellow; ray flowers 15-40, blue or pinkish, 7-15 mm long. Seed hairs (pappus) have numerous bristles with distinct veins.

Photo by Ben Legler

Ecological Importance and Distribution

Native aster species (including *Symphyotrichum* spp.) are good late-season pollinator plants, providing a critical pollen source for bees that are active in the late fall, including new bumble bee queens building up their energy reserves before winter dormancy. They also serve as nectar sources and host plants for checkerspot and crescent butterflies.

Distribution of SYCH endemic to Western North America

Pacific aster grows in a variety of habitats including grasslands, meadows, salt marshes, coastal dunes and bluffs, coastal scrub, and open or disturbed areas. It is adapted to fine to medium-textured soils, full sun to partial shade, is relatively drought tolerant, and has a high salinity tolerance. Pacific aster is distributed in coastal regions from southwest British Columbia to Southern California at elevations below 500 m (1600 ft).

Growth and Reproduction

Pacific aster does not enter seed dormancy, so untreated seed can be sown any time of year. Naturally it generally germinates in the spring when soils are moist and temperatures reach 15˚C (60°F). The seed germinates readily if sown on the surface of gravel and kept moist until germination occurs. There are 1,800 seeds per gram. Plants are easily established from transplanted plugs in the fall. If seed is not available, plants can be propagated from divisions of the rhizome or root crown in early spring, but this method is time consuming and generally not preferable if other methods are available.

Photo by Annie Young-Mathews, NRCS, 2010

Sowing Information

- Seeds per gram: 1,800
- Seeds per cell: 5
- Cover: into gravel
- Stratification: 15 days
- Requires sufficient light to germinate

Symphyotrichum eatonii • Eaton's aster • SYEA

Asteraceae Aster Family

Plant Description

Eaton's aster rapidly spreads by rhizomes or underground roots. The branching foliage reaches 100 cm at maturity under good growing conditions. The pale lilac to white ray flowers surround cheery yellow disk flowers that fade to raspberry pink after pollination. The flowers are actively visited by pollinating insects throughout the growing season. Though uncommon on regional prairies, the plant is often found at higher elevations in the Cascades, Olympics and Okanogan highlands in Washington along seasonal streams and washes.

SYEA with crab spider (left). Photo by Rod Gilbert.
Sweat Bee (right). Photo by Kort Krame.

Ecological Importance

All asters provide significant nectar resources during the late summer months when little else is blooming on the prairies. Asters provide nectar and pollen for a bee genus often overlooked for its ecological value. Sweat bees (genus *Halictid*) feed on nectar and pollen during the summer and may be seen with impressive pollen loads on their hind legs as they return to their nest with food for their eggs and young (larvae). Founding females dig branching burrows in bare soil, on flat surfaces to vertical banks. The female provisions cells at the end of each branch of tunnels with pollen balls and nectar. She lays her eggs in the ends of the provisioned tunnels and the developing larvae feed on the balls of pollen and nectar. Sweat bees usually overwinter as larvae or pupae in burrows in sandy, loose soil.

Growth and Reproduction

Though not as rare as SYHA across the American West, locally in Washington State it is uncommon. The seeds are almost twice the size of SYHA but still quite small with ~3,000 seeds per gram. This makes the sowing techniques for both *Symphyotrichum eatonii* and *S. hallii* essentially identical. Carefully sow the small seeds into gravel to allow for light to stimulate the developing seedlings.

Sowing Information
- Seeds per gram: 3000
- Seeds per cell: 5
- Cover: into gravel
- Stratification: 15 days
- Requires sufficient light to germinate

SYEA seed measurement range: L: 5-7 mm, W: 1-2.5 mm, D: 1.5 – 2 mm
Photo by Lisa Hintz

Viola adunca • early-blue violet • VIAD

Violaceae Violet Family

Plant Description

Viola adunca, or early-blue violet, is a compact perennial with short slender underground roots (rhizomes). Leaves are alternate and heart shaped to oval (ovate). The flowers of this viola are blue to deep violet, but can often be whitish at the base with a distinct hook where the petals come together. Flowers have 5 petals, and bloom from April to August. Fruit are born in capsules with three valves that force an explosive splitting of the capsules, spreading the seeds.

Early-blue violet. Photo by Rod Gilbert

Ecological Importance and Distribution

Viola adunca is a wide spread species found across the cooler states and provinces of North America and also in Northern Europe and Asia. The plant is commonly found in coastal sand bluffs and woods and other well drained soils throughout its range. Another common name for the plant is the sand violet.

Though common, in most habitats were VIAD is found it provides an important nectar and larval food source for local butterflies. In Puget lowland prairies, the Mardon skipper (*Polites mardon)* butterfly depends on *Viola adunca* as a spring-flowering nectar source. The small orange butterfly is found on two South Sound prairies, and is listed as a state endangered species and is a federal candidate species. Zerene fritillaries (*Speyeria zerene*) also use *Viola adunca*, but as a larval host. Three subspecies of the zerene fritillary are listed on the U.S. Endangered Species List, including the Oregon silverspot, which is classified as threatened in California, Oregon and Washington.

Studies have found that *Viola adunca* are poor competitors, and are easily displaced by invasive species. Non-native grasses increase thatch density and vegetation height, compete for resources and eliminate open space for germination, thus reducing *Viola adunca* populations. Experiments also show that fire reduces plant competition and stimulates germination in *Viola adunca*. Fire could be used to increase *Viola adunca* populations and provide more area for nectar and larval hosting for butterflies.

Growth and Reproduction

The plant emerges from a fleshy rootstock base in late fall and makes slow even growth through the winter and early spring. Blooming and pollination occurs from late February through June if there is adequate moisture. The flowers are visited by butterflies and bees, who all contribute to pollination. Seeds are held in capsules and ripen from June to August. The tiny capsules point upward when the seed is ripe and explosively disperse soon after; this makes *Viola* seed very difficult to harvest.
Seed is dispersed in the late spring and early summer and germination occurs after a 90 to 160 day range of cold moist stratification. *Viola adunca* germinates erratically as well as slowly and patience is required to keep the seed moist during this long process. The germination process is enhanced by cooler, alternating day/night temperatures (10°/4°C).

Fun facts

Violet leaves contain more vitamin A than spinach, and a half-cup of leaves has more vitamin C than four oranges! Now, don't go out and start eating, *Viola adunca* is a very important larval host and nectar source for threatened butterflies. Another reason to limit consumption: its rhizomes, fruits and seeds are poisonous. *Adunca* means hooked, and other common names include the hooked-spur violet and the western dog violet.

Sowing Information
- Seeds per gram: 1300
- Seeds per cell: 5
- Cover: soil and gravel
- Stratification: 90 days
- Germination: long, 90 to 160 days

Viola praemorsa • canary violet • VIPR

Violaceae Violet Family

Plant Description

Viola praemorsa is a perennial herb that grows up to 20 centimeters in maximum height. The thick, fleshy leaf blades are lance-shaped to oval with pointed or rounded tips; the lower (basal) leaves are up to 8.5 centimeters long and those higher on the stem are the same or slightly longer. The leaf blades are often coated densely in hairs and are borne on long stems (petioles). A solitary flower is borne on each long, upright stem. It has five yellow petals, the lowest three veined with brownish purple, and the upper two often with brownish purple coloring on the outer surfaces. The flowers of stream violet and trailing yellow violet could easily be confused for *V. praemorsa*. However both these other species lack the distinct ovoid, hairy leaves.

Ecological Importance and Distribution

Viola praemorsa is not as common on Puget lowland prairies as *V. adunca*. This violet seems to grow in oak savannah and edges of oak woodlands. It occurs as part of a diverse community of other native annual and perennial wildflowers including common camas, spring gold and Pacific sanicle. It is common in deeper soils with little exposed bedrock and richer soils with oak leaf litter. The species distribution seems to be confined to western North America as opposed to *V. adunca*, which is found across the Northern Hemisphere.

Growth and Reproduction

This species has a dual reproduction strategy, producing two types of flowers. The earlier, larger flowers bloom in April – May and require cross pollination while the later, inconspicuous self-pollinating flowers are produced late May-June. This violet does not reach flowering stage until at least its second year. It is probably pollinated by a variety of insect species. In mid-summer, the fruits rupture explosively and disperse seeds up to one meter from the parent plant. They may also be dispersed by insects (ants). This makes collection in the field and on the seed farm difficult. The long range plan is to produce seed of both *V. adunca* and *V. praemorsa* at nurseries in corrections centers. This will facilitate daily collection of the seed pods.

Seed Dimensions

L: 2-2.5 mm, W: 1-2 mm, D: 1-2 mm

Sowing Information

Seeds per gram: 236
Seeds per cell: 5
Cover soil: soil and gravel
Stratification: N/A

Seed of *Viola praemorsa*, scale in mm. Photo from USDA.

Wyethia angustifolia • narrowleaf mules ears • WYAN

Asteraceae Aster Family

Plant Description

Wyethia angustifolia is a perennial sunflower-like plant that grows to a height of 1 ½ to 2 feet. Leaves grow in clumps close to the base, are lance-shaped, 20 inches long, tapering to a point and lightly covered with hairs. Flowers face upward, one per stem, and are a deep yellow similar to sunflowers. There are 20-40 soft-haired, 1 in. long, leafy bracts that surround the flowers. The flower is a cup containing 8–21 ray flowers, each 1/2–1 3/4 in. long, and many central disk flowers. This native flower blooms in late spring and early summer and can be found throughout south and western Washington grasslands below 6500ft.

WYAN Mature Plant Photo by JS Peterson

Notice the thick basal clumps of leaves, all lace shaped ending in points. The flower heads are borne singly on a stem.

The flowers are very similar to sunflowers in both shape and color. The inflorescence is the name for the whole flower which is made up of rays (large petals) and disk flowers (center). Each inflorescence is made up of hundreds of flowers.

Photo by USDA

Ecological Importance and Distribution

An extensive study at Oregon State University examined the relationship between Fender's Blue Butterfly and prairie plants native to Washington and Oregon. The ecologists found that Fender's Blue Butterfly is dependent on native prairie plants, like *Wyethia angustifolia* and equally the native prairie plants depend on the butterflies for pollination and protection. In prairies from British Columbia to California, WYAN is found in moist seeps or at the edges of water courses that have richer soil and more moisture than upland dry prairies. These pockets of moisture surrounded by dry prairie provide vital habitat diversity to insects and larger fauna.

The numerous First Peoples along the Western Coast utilized the roots and stems for food and medicinal purposes and the seed can be dried, crushed and used as a thickener in soups.

WYAN U.S. Range; In Washington WYAN is most commonly found in the southern counties.

Growth and Reproduction

The highest germination success occurs when seeds are stratified. If stratifying, use cool-moist stratification methods for 60 days to promote a high germination percentage. Germination occurs over a 30 to 45 day period. Growth is slow in pots and most plants will only put on 2-5 true leaves the first year but the root system is quite extensive and a large storage roots form within 5 months. The plants often go dormant in the summer (senesce), and some thrip and aphid damage is common in late spring so monitor often. Planting out in the field occurs in fall of the first year. Wyethia plants can take up to 3-5 years to begin blooming and are quite long lived; 30 years or more.

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A WYAN open inflorescence exposing the developing seed and the disk flowers. Each seed is surrounded by an achene or covering like spiting the "shell" on the sunflower seed. The top will develop into a pappus or cluster or fuzzy hairs, similar to a dandelion. Photo by Seeds of Success

Seed Measurements of WYAN

Measurement Range: L: 7 – 8mm, W: 2 – 3mm, D: 1.9 - 2.5mm

Latitudinal Cross Section: circular

Longitudinal Cross Section: elliptical

Shape: Seed is long and narrow. Seed is narrow at hilum and broadens at opposite apex.

Additional Structures: Pappus that is attached at apex opposite hilum. Pappus fibers are broad at the base and are attached in a circular pattern. Pappus is very brittle, and about ½ the length of the seed body.

Mature seeds of WYAN; Photo by Seeds of Success

Color: Hilum white, seed body medium brown, and pappus is tan to off-white.

Surface: Seed is matte with short bristles that are concentrated toward the pappus. Seed has many longitudinal ridges.

Sowing Information
Seeds per gram: 86
Seeds per cell; 4
Cover: soil and gravel
Stratification: 60 days