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Guidelines of Establishment of Seed Production Sites on Military Installations

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1. Introduction

The south Puget Sound (SPS) is a region rich in natural resources, yet it hosts one the most threatened ecosystems in the United States. Over 92% of the short grass prairies and oak woodlands of western Washington have been converted to other land uses and only 3% is now considered to be historic prairie. These ecosystems support a wide array of endemic flora with their associated native pollinators, which are now at risk from encroachment by native trees and shrubs and a host of non-native invasive species. Many species have already been extirpated from the SPS prairies and several more species that are listed by Washington State as endangered, threatened or sensitive, are perilously close. Many prairie species, both flora and fauna, have experienced precipitous population declines in recent years and are in danger of regional extirpation without active management.

The open prairie landscape on Joint Base Lewis McChord (JBLM) is used extensively for most military training, including artillery practice, large arms fire, Stryker vehicle training, firebase construction, parachute drop zones and foot training. Approximately two thirds of the remaining SPS prairie habitat now occurs on JBLM. Military training and invasive plants continue to negatively impact prairie quality, which reduces native plant biodiversity, and in turn negatively impacts fauna that rely upon it to survive. Habitat restoration and enhancement efforts allow military trainers greater flexibility in using existing Department of Defense (DoD) lands and support JBLM's commitment to recover federal candidate species. Successful prairie restoration will allow for the reintroduction or translocation of candidate species that will benefit regional recovery efforts and could significantly reduce the potential for listing any of the candidate species. That will benefit regional recovery efforts and will likely reduce the potential for federal listings. If one of the candidate species were federally listed, it could cause serious disruption to training, impacting the type, location, duration and/or timing, and would prove costly, both financially and in terms of maintaining essential military training.

Research has shown that effective restoration must involve seeding or planting of native species once non-natives have been removed. As the capacity for land management agencies to work at larger scales has improved, the availability of native plant materials has become the primary limiting factor in the restoration process. Native plant propagation has emerged as a vital aspect in the conservation of endangered ecosystems in the United States and globally. As directed by Congress, the Bureau of Land Management (BLM) created the Native Plant Materials Development Program in 2001 to help ensure a stable and economical supply of native plant materials for restoration of disturbed lands. This mandate cites private sector growers as one of the key components in the production process. This effectively provides economic stimulus to the nursery industry if basic agronomic factors have been established for the native species of interest. Despite this subsidy, very little information exists for the propagation and growth of many of our most important restoration species. Propagation methodologies need to be

scientifically sound, but also cost effective and easy to replicate for both small and large producers.

This report is intended to serve as a guideline for the establishment of seed production sites for use on military installations based on the experiences and protocols developed in south the Puget sound (SPS) prairie program for use in restoration on JBLM.

2. The Role of Plant Materials in Conservation Strategy

The role of plant materials in the conservation strategy depends upon the scale of restoration actions and site requirements within the ecosystem. Plant materials play a huge role in the restoration of degraded prairie communities. After removal of pest plants either from controlled burns, mechanical or chemical applications, sites receive a variety of native plant materials. The plant materials needed are in direct proportion to site requirements and scale of restoration. The SPS conservation strategy involves both plugging of small scale sites to create high density and diverse floral communities for butterfly reintroduction as well as larger scale direct seeding for overall prairie restoration. Direct seeding of species, especially after sufficient site preparation, is a successful technique. However to restore habitat at multiple scales a source of native seed is needed yearly.

Fig. 1- Bombus species on *Lupinus albicaulis*

Once the role of plant materials for ecosystem recovery are identified and the scale estimated potential partner groups should be identified. Currently the Center for Natural Lands Management (CNLM) manages native plant production for the South Puget Sound prairies, working with a range of prairie conservation partners, see Appendix 1.

The increasing need for seed within highly fragmented ecosystems lends to cooperative conservation actions to provide plant materials for a variety of lands. In addition to federal agencies, demand is increasing from non-governmental agencies and private individuals. This demand may be based upon conservation action plans as well as federal regulations. By working cooperatively funding can be shared between agencies allowing for increased

infrastructure development in production facilities. Establishing a consistent source of a seed will enable successful conservation efforts for all members of partnering groups.

3. Developing Plant Materials Strategy

Before delving into production, a comprehensive plant materials strategy needs to be developed. This overarching strategy incorporates species composition and quantity as well production techniques. The plant materials strategy should incorporate both seed and plug production needs. Other considerations such as genetics should be addressed in the plant materials strategy as well. The strategy needs to be sufficiently flexible to accommodate differing needs in terms of species, amount of seed and changes in temporal needs.

Identifying Species

A diversity of species is needed to support habitat needs for both specific rare species recovery as well as overall restoration of natural systems. Species for production should been present on the site either in existing populations or in historic record. The genetic stock should be localized as to represent the genetics of the ecosystem. If a seed production strategy produces sufficient seed with each of these characteristics then it should help move regional restoration efforts.

Species identified for production should be broken down into two categories: general core species and specialty species.

Core species are those identified by conservation partners as majority of the seed mix. These are usually the most prevalent species in the site along with those that serve a particular restoration goal. These plants are historically present, show resistance to invasives and target either individual species or contribute to overall ecosystem function. In the SPS, species in the core mix are host and nectar plants for butterfly benefit. Most of the core species are suitable for large scale field production due to ease of propagation. Establishment of new habitat with these species will prove very productive to conservation efforts.

Fig. 2 - *Camassia quamash* is a core species in SPS production.

Some species will meet only a few of these parameters. Species such as *Camassia quamash*, have longer establishment periods to reach production stage or produce seed over long periods of time making production more difficult. These species are still considered part of the core mix due to their critical role in the

restoration process. Identifying these first will determine the level of production needed. A long list of core plant species indicates a high level of production.

Specialty species fit into three main categories. In the first category are those that produce very small seeds such as members of the Saxifraga genus and species that only small amounts of seed are needed. Those in category two have limited wild populations for initial collection and production must be ramped up to a level necessary to move production forward. The third category of specialty species are determined to be rare or sensitive In Washington, the Washington Natural Heritage Program (WNHP) monitors rare species populations across the state. Production will need to yield only small amounts of seed to supplement wild populations of these.

Addressing Genetic Concerns

The genetics of the source population for production must also be evaluated on a per species basis. Members of the SPS conservation community initiated seed production in order to establish seedbeds of source verified species. Seed zones or the collection parameters for forb and grass species are currently a hot topic within the conservation community. Seed zones for tree species are fairly well established in most regions of the country but little information exits on the plethora of forb and grass species. The Forest Service has put together a site for estimating seed zones (http://www.fs.fed.us/wwetac/threat_map/SeedZones_Intro.html).

Genetic concerns are typically thought about in terms of geographic distance from a restoration site, but since the reproductive ecosystems, including pollinators differ between species, then recommendations can only be generalized. The strategic stage should focus on species that demonstrate phenotypic differences between populations, populations that were geographically isolated or those that were historically specialized. These species should be kept separate during the production process where the agricultural process can select for vigor and lose diversity.

Fig. 3 - A common garden study by Utah Department of Wildlife

If genetic concerns are an issue a common garden study can be initiated. Common garden studies are scientific studies that examine morphological and phenotypic similarities between species collected from different regions. Accessions are made from various geographic regions and usually elevations. They are grown in a common environment, usually side by side for

comparison and traits such as height, diameter, biomass, emergence, flowering time, hardiness, etc. are measured. These measurements are used to determine a relationship between traits and source location. From this information seed zones are determined on a per species basis for a geographic region and elevation. The Natural Resource Conservation Service (NRCS) center in Corvallis, OR has initiated several studies into prairie species in the Willamette valley (http://appliedeco.org/reports/FINAL.REPORT.HAA051T00.pdf).

To date some pragmatic decisions concerning genetics have been utilized in the South Sound to minimize potential negative impacts while still maintaining efficiency. For rare species, the source population of propagules has been recorded and typically a single source was used to establish any new population. A significant exception to this is golden paintbrush, where the sole original South Sound population, at Rocky Prairie Natural Area Preserve, proved to not be the best source of seed for expansion. Genetic testing and field trials suggested mixing individuals from populations would provide some additional genetic vigor. Essentially a wild population seed mixture is now used to establish this rare plant in South Sound.

Determining Seed Quantity Needed

The scale of restoration and enhancement efforts on South Sound Prairies has increased dramatically over the last few years. This increase has been fueled by the continuing success in invasive species control due to the controlled burn program. These advances in restoration and management increased the number of acres with annual seed needs. Determining the quantity of seed needed is the most difficult aspect of the strategy. However without an estimation of total amount of seed needed as well as the ratio between species, there is not enough information to develop a production plan.

Multiple factors affect the seed production need for each species. These factors include the amount of acreage to be restored, ecological target for the restoration, establishment rate, seed production rate and others. It would be best to determine all of these parameters for each species then production would theoretically match need.

However these parameters vary from year to year.

For instance, seed germination and establishment rates for species under field restoration conditions vary due to weather and natural disasters even.

Fig. 4- Rough Estimate of Fescue Needs

A rough estimate of the needs for *Festuca roemerii* seed should be fairly accurate and easy to produce, since the best information concerning both field and production parameters are available for the most common grass in South Sound prairies and oak woodlands. Considering a reduced set of parameters, here is a rough estimate of annual fescue needed for restoration in South Sound.

Restoration Acres: 75 – 250 ac
Seeding Rate: 1 – 4 lbs/ac
Production Rate: 100 - 350 lbs/ac
Needed Production: .25 – 10 ac

Even fundamentally critical parameters such as the ecological target for restoration vary from year to year based on previous planting success and naturally plant movement.

Conservationists in the intermountain west, who depend upon seed for wildfire restoration, have focused on seed storage as a way to maintain annual production with varying seed demands. Storing seed produced annual makes seed available during peak fire seasons and allows growers to continue production.

Understanding the seed production capabilities of the species identified for production is the first step in determining need. If the species is a heavy seed producer, the size of the seed, viability of wild populations, etc. all play a factor in overall production needs. When little information is known as in most cases with native species, trial production is key to understanding seed needs.

Role of Government Agencies and Private Growers

At this point in the plant materials planning process research on producers and facilities in the region can be beneficial. Due to the increased demand for native plant materials commercial growers are becoming increasing more available and government agencies such as the NRCS Plant Materials Centers (PMC) are targeting research on natives. If genetic concerns are not present these two growers are an excellent production source.

NRCS PMC- for the SPS program the Corvallis PMC has been a vital source of production information. The Corvallis PMC is one of 27 centers and serves western Oregon, western Washington, and northwestern California. The Corvallis PMC's primary mission is to develop new technology in plant and seed production, re-vegetation, restoration, and to test and release plant sources. Their main focus is on native grasses, forbs, and shrubs. Private growers as well as PMC's can provide information such as species seed weights, number of seeds per acre as well as information on propagation.

NRCS PMC's can only contract directly with federal agencies and often do not have the resources for large scale production contracts. Their role is generally more research based so rare species that require protocol information is appropriate for contract grow-out at PMC's. PMC's as well as other federal agencies post protocol information on the Native Plant Propagation Database, a search engine for native plant production information.

Private Contractors- Private contract growers are another resource to consider before initiating in-house production. The major issues with private growers are cost, verified seed sourcing and contract establishment. Seed purchased from private growers is usually costly due to the variable nature of native production and high maintenance and cleaning costs.

It is also difficult for producers to meet contract needs as production amounts vary from year to year and plant longevity is often difficult to estimate. The most efficient contracts involve a one-

time plot establishment fee followed by an annual per pound cost. This allows the buyer to establish a seedbed and only purchase the needed amount of seed per year.

The last concern with private contract growers is issues of seed sourcing. This can be avoided by selecting growers who are large enough to separate seed sources and providing seed directly to the grower. Also look for growers who specialize in certified seed that is state verified and tested. This classification will ensure not only high quality seed but also provide information on viability. The Institute for Applied Ecology maintains The Native Seed Network (NSN), a website for purchasing agencies to find private growers and vice versa. The NSN is a great resource for information on species and to find private individuals who specialize in natives for both contracting and protocol gathering. http://www.nativeseednetwork.org

The greatest strength of the seed production strategy is the ability to match the level of seed production with the use planned for the species. Not all species require larger field production, while scaling upwards to that field production is critical for the core species that will be used to restore on the acre scale. Additionally, this strategy provides a flexible platform over time and throughout potentially changing seed production priorities. New priority species can be rapidly expanded through seed bed production to sufficient levels to initiate field production. Or if possible, a large wild collection effort could lead directly to field production the next year. This flexibility also allows production amounts and techniques to be fine-tuned over time as information on desired target communities and the habitat needs becomes available.

3. Establishing Seed Production

There are three primary conservation uses of native seed.

Seed needed to produce plugs - Plant plugs are an established method for both direct restoration and for initial establishment of seed beds or fields. Planting of fescue plugs was one of the first widely successful methods for prairie restoration in the South Sound region. The use of plugs in direct restoration continues, though the labor intensity of both production and planting has limited it usage. In the SPS program this labor issue has been minimized through a partnership with the Sustainable Prisons Project of Evergreen State College. Through this project, correctional facilities are able to produce up to 400,000 plugs annually. Another 100,000 to 120,000 plugs are produced at CNLM's Shotwell's Landing Restoration Nursery.

Often, the species raised via plugs are specialized and are needed in limited areas. Examples of this usage are specific species for butterfly enhancement units or field out-planting of rare or endangered plants, such as golden paintbrush. Further specialization within plug production is likely as adequate seed is produced of more common restoration species.

Seed for specialized species - Many species are not major components of the seed mix. These species may be naturally rare or occur in sub-habitats, such as mesic prairie, which is rare in the

region. Production of large lots of these species is currently not needed. Small lots may be all that is needed to meet restoration needs over several years.

Seed for large-scale restoration – Core prairie species seed is needed in larger amounts if restoration is to be completed more efficiently and at larger scales. This increased production of native seed is the primary goal of the seed production program. With increased availability of core native seed, then larger amounts of lands can be restored and new partners and lands can be included in restoration efforts. The actual amount of seed needed varies with species, due to establishment rates in the restoration and production rates by the plants.

Primary Seed Production Techniques

The Native Plant Development Process is captured below in Figure 5. Each step is in the process provides additional information on production techniques but also supplies a restoration product. The techniques vary based on species and target needs but essentially all species undergo the native seed collection, evaluation and development and field establishment processes. As demonstrated in Table 1 the first step in process is wild collection followed by establishment of foundation seed beds which evaluate and develop protocols necessary for field production establishment. This process was established by the Bureau for Land Management's plant materials program.

Fig. 5-

Table 1- Summary of native seed production techniques used in the South Puget Sound region.

	Wild Collection	Seed Beds	Field Production	Seed Cleaning
Production Scale	Small	Small-Medium	Large	Various
Locations	Limit sources to regional or sub-regional efforts.	Establish Permanent seedbeds	Establish field production. Private contractors.	Establish permanent seedbeds and field production.
Primary Purpose	Produce initial lots of seed to initiate further production or diversify genetic stock. Wild collection can produce sufficient amounts for certain species but should be limited.	Produce seed for either (a) rare species where only a limited amount of seed is needed, or (b) species that need an increase in amount to establish field production.	Produce large lots of primary species.	Seed needs to be cleaned and stored until usage. Cleaning is especially important if seeding technique involves seed drill or other mechanical methods.
Actions	Development wild collection protocols. Begins with wild collection done by staff of agencies and organizations and volunteers.	Establish foundation beds. Professional staff, interns and volunteers maintain beds and collect seed with minimal equipment.	Establish field production sites requiring mechanized harvesting and processing equipment. Requires staff and labor crews.	A range of seed cleaning equipment is needed. Seed storage facility is also necessary. Cleaning conducted by staff, interns and volunteers.

Each of the techniques has a role in a larger strategy, with the individual functions and limitations of each technique integrating to form a larger seed production strategy that will fulfill the needs of all partners in the region.

Wild Collection

Wild collection of native plant seed involves locating individuals or populations of species and following their phenology in order to time collection with ripeness. This is a time-consuming and meticulous process. While wild collection can produce large amounts of seed, it is best used as a method to collect initial sets of seeds or to help ensure consistent flow of fresh genetics into the production cycle to provide diversity.

In the SPS prairies wild collection typically occurs on prairie preserves as these areas have the greatest abundance of native plants. In addition, access for this type of activity is usually granted, since the plants and seed produced will be used to restore those same locations. Collections on military installations can be challenging as collectors need prior access and military training exercises take priority.

Friends of Puget Prairies, a volunteer group coordinated through the Center for Natural Lands Management, has become central to wild collection efforts in the region. The group has a dedicated team that has been collecting prairie seed for multiple years. These experienced

volunteers have the advantage of on-the-ground knowledge of key plant populations and have gone through training on wild collection techniques.

A seed collection handbook (Appendix 2) guides the collectors and collection process; ensuring safe seed collection techniques are used. These guidelines include such critical basics as: species identification, considerations before collection including phenology and genetics, appropriate sites for collection, and handling prior to cleaning. Appendix 3 is an example of the information used to ensure correct identification of collected seed.

One advantage of wild seed collection is that the species collected each year can vary. This may be important when interest in a species rises. Wild collection has the opportunity of obtaining seed for that species each year, without the longer lead-in times required of other techniques. The regional conservation partners, including volunteers, meet to review species selection each year, delineating priorities and any new species. This coordination meeting also gives an opportunity to link the volunteers with professional staff, allowing plant and seed propagation priorities and any problems with collection to be discussed.

Fig 6 - Volunteers from Friends of Puget Prairies are integral to wild seed collection efforts in the South Sound.

Several limitations are associated with wild collection. For many species wild collection is extremely time-consuming, especially if a large amount of seed is needed. Wild collection also damages wild populations through both limiting native seed rain at the site, but also through direct impacts to the plants. Even careful seed collectors and collection techniques can damage individual plants, at minimum by walking through the area. For instance a seed collector may need to make multiple trips to the collection site in order to ensure collection of ripe seed. This can lead to high variability between specific lots of seed as well as damage to collection sites. In addition factors that are easier to control in production settings become problematic on the wildland sites such as pollination, seed predation and weather-related effects.

Plug Production

Shotwell's Landing Restoration Nursery, located on The Nature Conservancy's Black River Preserve focuses on the propagation of plugs both for restoration plantings and also for seedbed establishment. SPS production is centered on off base production locations. Production facilities located on military installations can be difficult to maintain as constant access is needed to perform maintenance and harvesting actions. Constant access to the site is essential to maintaining both seed and plug production facilities On-base locations with open access such as near natural resources offices or even military correctional centers are great options for hoophouse establishment and or seedbed establishment if available. Small open areas with constant access for labor and contact with water sources are all that is necessary to begin restoration nursery activities. Production at these sites typically begins with plugs.

Seedbeds or production fields started from plug transplants have advantages over direct seeding methods. The large healthy plugs have a head start over weed species and usually produce seed faster than field grown. In addition to providing plugs themselves the plug production process allows for propagation protocol information to be collected. In general little to no propagation information exists on native species. For species where research has yielded little to no replicable protocols germination trials are established. These trials aim to determine the stratification needs for each species. Most species need an established length of cold moist stratification followed by a set temperature in order to germinate. When dealing with new species several treatments are attempted.

Outdoor stratification is the first treatment where seeds are sown in the fall and placed outdoors in hoophouses to be exposed to natural temperatures. The seeds are kept constantly moist and covered with frost cover to prevent freezing and bird predation. The sown flats remain outside until germination occurs which could take up to two years.

Fig. 7- Seed sown in fall await outdoor stratification

The second treatment involves simulated cold moist stratification. Seed is imbibed or soaked in water for 24 hours using a running water bath to replicate the absorption and leaching of the seed by winter rain. The seed is then placed in

a cooler at 35F and examined weekly for germination. The seed is sown at either 30 or 90-120 days depending on species.

The third treatment simulates the alternating spring temperatures. After seed is imbibed it is exposed to alternating temperatures of 25°C daily/15°C nightly for 6 weeks, followed by 7ºC daily/1°C nightly for 6 weeks, followed by 25°C daily/15°C nightly for up to 8 weeks.

Additional treatments are applied when imbibition is not possible due to seed coat dormancy. Scarification is accomplished by rubbing seed with sandpaper or placing in a hot water bath for approximately 1 hour.

Table 2. Example of Species Germination Requirements

Key: f-Forb, s-Sedge, g-Grass, c/m-Cold moist seed treatment

Species	Code	Type	Outdoor Germination Period	Germ treatment	Germination Temperature	Typical Germination Rate
Achillea millefolium	ACMI	f	anytime	none	any	high
Anaphalis margaritacea	ANMA	f	anytime	none	any	high
Balsamorhiza deltoidea	BADE	f	spring	90 days c/m strat	cool	moderate
Brodiaea hyacinthina	BRHY	f	spring	90 days c/m strat	any	moderate
Carex tumulicola	CATU	s	late spring	warm-hot	warm	moderate
Castilleja levisecta	CALE		spring	45 days c/m strat	cool	high
Clarkia amoena	CLAM	f	anytime	none	any	high
Collomia grandiflora	COGR	f	late fall	natural strat Nov 15-Dec 15	cool	high
Danthonia californica	DACA	g	spring	90 days c/m strat	any	moderate
Dodecatheon hendersonii	DOHE	f	spring	90 days c/m strat	any	moderate
Elymus glaucus	ELGL	g	anytime	none	any	high
Eriophyllum lanatum	ERLA	f	spring	90 days c/m strat	any	moderate
Festuca roemerii	FERO	g	anytime	none	any	high

CNLM's Shotwell's Landing Restoration Nursery can produce 120,000 plugs annually in three 2000 ft. hoophouses. In addition to germination requirements, other information on plant growth are evaluated. Plants are usually grown in 7" Ray Leach stubby cone-tainers. These cone-tainers are preferred because they are compact, stackable

Fig. 8- (l-r) Cone-tainer, roo-trainer, dibble.

and individual cones can be removed from the holding tray. This is a great tool for consolidating native species with varied germination. The plants they are grown in the cone-tainers can be transplanted manually either with a hand tool called a dibble or using a gas powered augur. The cones come in two sizes, a standard 7 cubic inch cone and a tap root length 10 cubic inch cone. They are not appropriate for all species such as those with colonizing roots. Species with specialized root issues are best grown in roo-trainers or book containers. They allow for excess root growth and can be easily pulled apart to view roots. Plants are usually only growing in the cone-tainers until the roots forms a tight "plug" that can be pulled out of the cone and not fall apart. This happens within 2-4 months for most species.

Species are sown in a peat based medium with an osmocote slow release fertilizer and only species such as *Castilleja* that are hemi-parasitic are given foliar fertilization. These species need additional support until they can be outplanted with a host plant for nutrient acquisition. After seeds are sown they are covered with grit to prevent seeds from floating and to prevent moss and liverwort development.

Fig. 9- Moss growth on *Erigeron specious* seedlings

The biggest issue with plug establishment in the Pacific Northwest is watering requirements and consequent development of moss and liverworts. In restoration nurseries in particular it is difficult to maintain water needs for all the varying species with one system. With prairie plants it is easy to overwater and moss and liverworts are difficult if not impossible to eradicate after establishment. A spinner mister overhead watering system supplemented by spot watering is necessary for the level of dry down needed to prevent moss and liverwort growth.

Yearly cleaning with a power washer followed by industrial grade vinegar treatments is also necessary to reduce moss and liverwort infestation.

Fig. 10- *Balsamorizha* seedling in cone-tainer

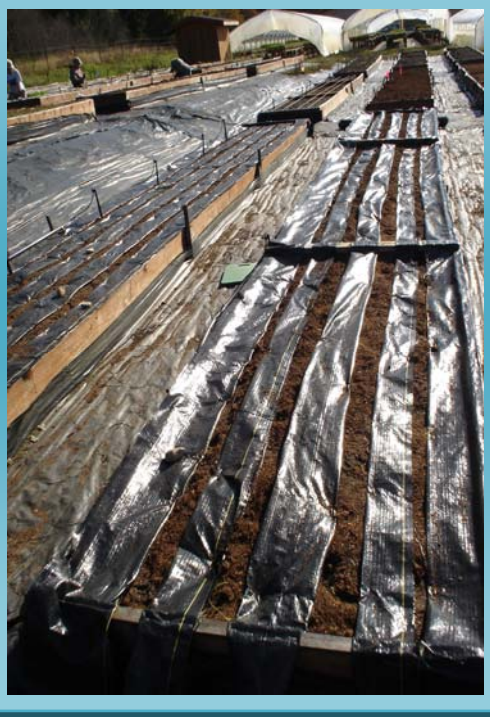
Initial Seed Bed Establishment—Foundation Beds

Fig. 11- *Plectritis congestis* seedbeds at Shotwell's Landing

Seed Bed Production: Production of smaller lots of seed is handled within seed beds. These beds are small enough that most maintenance and collection actions are conducted by hand. This level of attention may be critical for species that have more difficult cultural requirements or as a small initial amount of seed is raised to production levels. Seed beds are also a good testing ground to determine optimal plant densities, plant culture requirements and seed collection requirements in production conditions before a species is planted into larger fields.

The smaller size of seed beds lends them to staff, intern or volunteer actions. Even untrained volunteers are used effectively to weed small beds. The controlled environment of the seed bed, with chosen soil type, water regime and fertilization schedule can help species flourish and increase seed production. Alternatively, for those species that require harsher conditions for seed production, the controlled environment will also allow for water to be withheld allowing senescence of the plant and a single determinate seed ripening event.

Fig 12- Weed suppression techniques at Shotwells Landing



The small controlled setting of the seed bed easily adapts to species that may have significant seed predation problems in the wild. Transfer to the controlled conditions of a nursery may be sufficient to minimize seed predation, or plants can be sprayed with appropriate pesticide to directly target the seed predators. This type of treatment can significantly increase seed production and viability for certain species.

Seed beds can also be used to segregate individual seed lots, if consideration is given to the individual pollination systems and sufficient precautions are taken. This can be helpful with rare species where local adaptation may be important and the seed produced within the bed used to augment a current population.

The limitations of the seed beds include the amount of seed produced and the efficiency of producing that seed. Small seed beds are by definition limited in their absolute level of production. In addition, the use of manual labor to tend these beds makes them inefficient compared to field production. This is especially true as the number of beds and species increases. Then timing of various actions varies and the amount of specific attention and record taking increases.

Fig. 13– Seed beds at Shotwell's Landing allow individualized culture and collection efforts for rare species or species requiring additional regulated care

Shotwell's Landing Restoration Nursery

Following collection on prairie sites, seed is moved to Shotwell's Landing Native Plant Nursery where these small lots are cleaned by hand using volunteers, interns and professional staff. Seed is then incorporated into small bed production through either direct seeding or establishment of native plugs that are later used to initiate bed production.

Through small bed production, production parameters are evaluated including germination, grow-out procedures, harvesting and processing needs. Currently Shotwell's hosts 62 small seed beds, each with 128 square feet of production space. Beds were developed using treated lumber filled with growing medium and either plugged or directed seeded. These seed beds often times have multiple species per bed or remain empty waiting for native plugs from greenhouse production.

Beds are established with irrigation systems that can be adjusted for micro-misters or drip irrigation systems. Micro-misters can be problematic during windy condition but drip irrigation systems are also problematic causing erosion. Beds contain both options to be adjusted for varying species.

Beds are also outfitted with frames for frost covering and shade cloth based on the particular needs of the species. Frost covering is particularly important for fall germinating species including most annual species. They are particularly susceptible to the hard fall freezes.

Over the next five years Shotwell's Landing will continue to facilitate intensive cultivation on a custom scale, replacing priority crops as needed with rare plant needs or small seed needs. The diversity of rare and problematic-for-production species will increase and priority crop species such as *Lupinus albicaulis* will be phased out at small bed production in favor of larger scale grow-out.

4. Establishing Field Production

Fig. 14- Field production of *Castilleja levisecta* with host plant

Field production uses mechanical methods and acres of land to produce large lots of seed efficiently. If seed needs are large enough then truly commercial scale production can be implemented. These methods borrow from agricultural production, with mechanical and chemical soil preparation and maintenance, seeding and harvesting using tractors and farm implements.

At a smaller scale, field production is modified small bed production, where portions of the required work are mechanized. This intermediate scale production allows general field preparation and some weed control and seed harvesting procedures to be mechanized. It also facilitates production of multiple species of plants over smaller patches of fields. Plant species can be segregated to half or quarter rows to further increase species diversity.

Stand Establishment

Fields are established after the history of the field has been evaluated for weed issues, water holding capacity, nutrient needs, etc. The more information available on the growing conditions the better. Prior to weed control, the field should be disked or cultivated and rows shaped and rototilled to form a firm uniform seedbed for good seed contact.

After cultivation at least two seasons of treatment with grass specific and broadleaf herbicide should be applied. If the site has lain fallow for multiple years fumigation may be needed to deplete seedbank. Fumigation is expensive and can destroy ground nesting native pollinators.

Solarization is another alternative. It involves covering the site with black or clear plastic and heating the ground to destroy seedlings and potentially seeds in the seedbank. This can be a tricky process in northern climates.

Stand establishment is accomplished in either the fall or spring. Species can be established by transplanting greenhouse plugs, manually sowing single rows or mechanically sowing multiple close rows with a drill seeder.

Fall transplanting is done with either a mechanized transplanter or by hand in September or October before winter rains. Spring transplanting is done in late March after a spring application of broadleaf herbicide to control spring weed germinates.

Seeds sown manually into single rows are generally tarped into furrows. The seed must be well cleaned and detached from any pappus or awns so it can fall evenly out of the seeder. Single row seeders are cheap and fairly accurate for most species as depth and density are easily adjusted. A chain can be attached to lightly cover seeds. Between rows furrows of weed tarp are lain to act not only as weed suppression but also as a surface for seed to fall. This is particularly helpful for species that have easily shattered seed or that drop small amounts of seed over the season-mainly indeterminate species. Manual weeding is still needed within the row but is greatly reduced.

Fig. 15- *Microsteris gracilis* sown with a one row seeder

Seeds can also be sown mechanically using a drill seeder. This works well for larger seeded fall germinating species particularly grasses. Seedlings can emerge within two weeks depending upon weather and dormancy requirements. In the spring, grasses grow rapidly and will flower but produce very little if any seed the first year. For species with dormancy, an application of glyphosate can be applied as late as possible to remove all fall and early spring germinating weeds before the crop germinates. Spring-sown grass fields will usually not flower their first year. Broadleaf herbicides can be applied to grass fields to remove broadleaf weeds but grass weeds must be removed by hand or with spot applications of herbicide.

Fig. 16- Hooded Sprayer on ATV

If possible irrigation should be available to prevent seedlings and recent transplants from drying. Continued irrigation can also increase flower development during periods of summer drought. But all irrigation needs to stop when the crop begins to ready to pollination as water can wash away pollen. Irrigation can also postpone seed ripening if applied during the ripening period.

Weeding is the biggest issue for maintenance of seedbeds. Weeding is labor intensive and involves a large amount of manual labor with hoes and cultivators. While rows and irrigation lines can be sprayed using a hooded sprayer, within the rows spot spraying with cupped sprayers or weed wipers must be used to avoid contact with target plant. Once plants are established mulch can be utilized to reduce weeds but must be applied regularly.

Harvesting

Fig. 17- Burning holes into weed tarp

The most important factors in determining harvest methods are:

1) How evenly the seeds are maturing on each plant?

2) How evenly are they maturing across the field?

3) Do the seeds shatter as soon as they mature?

4) How easily can the seeds be removed from the plant material?

Species that are indeterminate and ripen slowly over long periods of time are good candidates for a Fail-Vac seed stripper. This piece of equipment works like a vacuum cleaner but fits on the front-end loader of a tractor. A rotating brush gently brushes seed into a collection bin. This machine allows for multiple harvests over the same field and reduces waste of seed. It is essential for species with a pappus such as Aster species.

Fig. 18- (l-r) Flail-vac seed stripper, tow behind swather

The PMC in Corvallis uses several of the following methods. Direct combining- a combine is fitted with a reel and plants are cut by the combine and pushed into the combine by the reel. Seeds and plant material needs to be slightly dry to flow

through the combine. This method works best for fields that evenly mature or for species that do not shatter easily.

Swath and combine- all plant material is cut by a swather that lays the cut material into rows to dry in the field. The combine is fitted with a "pick-up" belt that can lift the swaths of material off the ground and feed it through the combine. This method works well for crops that have a lot of green material and have seeds that can ripen after the plants are cut. Most large-scale grass seed fields are harvested this way. This method doesn't work well for most forbs or grasses that shatter easily or don't mature evenly.

Swath/collect method- plant material is cut by a swather-like machine and collected instead of leaving it to dry on the field. Cut material is laid on tarps to dry and catch seed. Corvallis PMC has a two custom built machines that perform this type of harvesting. This works well for species that shatter when they dry, but ripen relatively evenly.

Weed tarp is the passive form of seed collection that is perfect for seed that ripens unevenly and shatters. As mentioned above, furrows between rows can be tarped or rows can be tarped and plugs transplanted into holes burned into tarp (see Figure 16). Seed is then allowed to fall onto tarp and is vacuumed. It is essential that tarps are kept clean prior to seed fall to prevent weed seed and dirt contamination.

Fig. 19- *Viola adunca* plugs were transplanted into burned weed trap

Seed Processing

Drying

After harvesting, seed must first be dried so that moisture levels are low enough to withstand cleaning equipment. This is determined by testing plant materials for dryness. A hoophouse is used as a drying shed allowing for seed to be spread out and turned in amplified sunlight. After drying, seed is moved to be processed

Fig. 20- Seed drying in drying hoophouse

or cleaned using a suite of equipment.

Hammermill

Since harvesting usually involves cutting a large amount of the plant including the seed heads, a large amount of material is present. A hammermill is a piece of equipment that simply chops up large amounts of plant material to make processing through other machinery easier and more efficient. For use with native species the hammermill has been retrofitted with a variable speed controller to allow for use at reduced speeds in order to protect seed from damage. Usually material needs to be hand-screened after this process to remove large stems and debris. This machine is used mainly for species that do not release seed from the seedhead easily. Species such as *Eriophyllum lanatum* and *Lupinus albicaulis* are good candidates for the hammermill.

Fig. 21- A hammermill chops large amounts of plant material

Fig. 22- Hand screening is usually required after using the hammermill

Brush Machine

For other species, initial processing involves the use of a Westrup-Brush machine. The brush machine functions by spinning brushes around a circular screen. It is useful in breaking open seed pods as well as de-bearding perennial species and de-awning grasses. By removing beards or pappi from forbs and awns from grasses, seed is easier to disperse into the field as well as better prepared for storage. Species in the *Asteraceae* family and other plants that have a pappus such as *Erigeron specious* are cleaned using the brush machine.

Fig. 23- Brush machine

Air Screen Separator

Two different Clipper air screen separators are the most well-used pieces of equipment in the arsenal. The smaller laboratory version allows for use on smaller seedlots and for larger seeded species. The large Eclipse version allows for use in large seedlots through a variety of species. They are both air screen separators which function by filtering seed from chopped up plant material by shaking seed through a series of screens. Each species has its own screen sizes and the machinery is only effective at separating seed by size.

Fig. 24- The well-used air screen separator (laboratory version)

Fig. 25- Large Eclipse air screen separator

Air Column Separator

Fig. 26- The final step: air column separator

The final step in seed cleaning is with an air column separator which separates seed by weight. This piece of equipment allows for more fine cleaning and is particularly useful for removing non-viable seed. The non-viable seed does not have embryo to fill the seed and therefore it weighs less. The air column is a simple series of chambers with a source of air flowing through that is adjustable based on weight of seed. Light material rises to the top and the seed falls to the bottom.

The objectives of seed cleaning are to separate pure seed from chaff and other plant material, to remove the seed of any contaminating species, and to remove most of the small unfilled seed that is unlikely to germinate. While vegetative debris does not functionally inhibit the use of the seed, this debris hinders the ability of the seed to flow through machinery as well as reduces seed viability when stored with seed. Hand seed cleaning is generally done by sieving by size and shape using a variety of brass soil sieves for cleaning of small quantities of seed, and for the final "finishing" step of cleaning some large seed lots.

Seed Storage

Large amounts of clean seed can be stored in polypropylene sacks used for sandbags while smaller amounts of rare seed can be stored in glassine envelopes. Additional seed storage devices are glass jars which are both costly and bulky but provide the best sealant against humidity. It is important that seed is protected from insects, rodents and chaff material that can hold bacteria and moisture to the seed causing mold. Since species specific information on storage protocols is not yet available, general storage protocols are for 40 degrees F and 40% relative humidity. Seed should be arranged by species and each envelope or bag should be labeled with species ID, seedlot ID, collection site, year and weight.

5. Additional Considerations

Fig. 27- Grass field production

Record Keeping- A database for seedlot tracking is essential for production facilities. The database contains an inventory of all seedlots and tracks additions and withdrawals of seed. In addition a database can be helpful in tracking germination rates and plug propagation information. Successful record keeping of seedlot information such as seed sourcing through allocation is necessary when dealing with rare species as well as core species. Land managers will need this information when deciding on appropriate locations for plant material.

Seed testing - Also important to production success is purity and viability testing on seedlots. Purity is the proportion of the bulk weight that contains pure mature seeds. It is determined by taking random samples from a seedlot. Viability is tested in one or both of the following ways; germination tests or tetrazolium (TZ) test. Germination test are performed in a germination chamber that simulates ideal propagation conditions controlling light, moisture and temperature. A TZ test is a quicker determination of viability where a dye (TZ) is applied to a seed to determine embryo presence. Either of these methods are indicators of pure live seed content which is used to calculate seeding rates.

6. Conclusion

The availability of locally sourced plant material is a key hurdle to successful restoration of many ecosystems including prairie. One tool for overcoming this hurdle is the inclusion of a seed development strategy within the larger conservation strategy. This development strategy is a key exercise to understanding production priorities, genetic concerns, annual production needs and the potential avenues for establishment. The use of government agencies for both research and production can be a valuable tool as well as the use of private contractors for grow-out if available and species appropriate.

If the seed development strategy identifies a need for seed production infrastructure to be developed, then the process should follow the plant materials development process as outlined by the federal plant materials development program. The steps to follow as outlined in this document are best accomplished using cooperative conservation involving multiple partnering federal, state, non-governmental and private organizations. This cooperative approach allows for shared funding and larger infrastructure creation to meet group needs. This approach can also be helpful when military bases do not have open access areas to host production facilities particularly for field production.

Establishment of a strategic, source identified and cooperative plant production program is the first step towards establishing long term management tools for restoration of natural systems. These actions ensure that sufficient plant materials are available when needed for various scales of restoration activity. Plant production aids in the creation of habitat suitable for rare and extirpated species while minimizing the adverse effect of seed collection within natural habitats. Production maximizes efficiency and ease of the collection process and produces more seed than a naturally seeding.

Established seedbeds should focus on target species that are essential for survival of rare and federal candidate species, providing sufficient seed for future restoration actions and thereby maintaining biodiversity and preventing local or regional extirpation.

APPENDIX 1 – South Puget Sound Prairies Native Seed Partners

Conservation organizations
Center for Natural Lands Management
Friends of Puget Prairies
The Nature Conservancy
Institute for Applied Ecology
Whidbey Camano Land Trust
Washington Native Plant Society
Native Plant Salvage Alliance
Seed of Success Program

Academic organizations
Evergreen State College Sustainable Prisons Project
Washington State University, Vancouver
University of Washington

Washington State agencies
Washington Department of Fish and Wildlife
Washington Department of Natural Resources
Washington Department of Corrections

US agencies
US Fish and Wildlife Service
Natural Resources Conservation Service
Joint Base Lewis-McChord
Natural Resource Conservation Service, Corvallis Plant Materials Center

Private Agencies
Heritage Seedlings
Fourth Corner Nurseries

APPENDIX 2 – Seed Collection Handbook 2011

(updated annually)

WILD SEED COLLECTION

Purpose

1. To restore native populations through the increase of plant materials.
   a. Plug Production -- restores small areas, increases rare populations and aides in quicker establishment of seed beds
   b. Seed Production – provides seed for direct seeding techniques for larger scale restoration
      i. Direct seeding of annual and perennial forbs and grasses
      ii. Increases availability of rare seed
      iii. Decreases pressure on wild populations
         (a) Refresh cultivated genetics in already established seedbeds

B. Who

1. Roles
   a. Property or Land Managers
      i. Determines species needs for specific restoration sites
      ii. Provide site specific information such as restricted access units, research plots or monitoring areas to avoid
      iii. Provide information on best seed collection areas for specific plants and or GPS coordinates
   b. Plant Production Coordinator
      i. Compiles collection lists by species, site and priority based on information from property managers
      ii. Determines volume of seed to be collected
      iii. Coordinates with Seed Collection Coordinators on general seed collection schedule
      iv. Disperses seed collection materials such as flagging and labels

v. Tracks seed as it is collected, and provide up-dated information on seed needs to Seed Collection Coordinators

vi. Coordinates seed cleaning -- setting priority for order in which seeds are to be cleaned, and identify use to which the seed will be put

c. Seed Collection Coordinators
   i. Develop and share general seed collection schedule with property managers and regular seed collectors. Inform property managers of collection days and species beforehand
   ii. Keep informed of conditions in the field, modify general seed collection schedule, and share revisions on an ongoing basis with property managers and regular collectors
   iii. Keep informed of seed needs from the Nursery Manager in terms of volume of seed collected and shifting priorities over collection season
   iv. Assign seed collection leaders, experienced with the particular seed to be collected, to every seed collection team, on an on-going basis
d. Seed Collection Leaders
   i. Before Collection Day
      (a) Review the list of seed to be collected from the site(s) that day
      (b) Verify the location of any and all research plots and restricted areas
      (c) Prepare maps or other identification materials
   ii. Collection Day
      (a) Inform seed collectors of plots & restricted area, and identifying markers
         (i) Describe collection area boundaries in terms of landmarks
      (b) Identify the plant species for the seeds to be collected that day, the total volume needed and amount needed from each plant, and the time allotted
      (c) Discuss the need for seeds to be representative of all the plants--biggest is not necessarily the best
      (d) Spread the collectors out over the entire area from which seed is to be collected

(e) If on-base have Range Control Authorization in hand and follow phone protocol when arriving and leaving

C. Where

1. Determine collection locations and the associated land managers or landowners.
   a. Off-base
      i. Acquire signed collection permission from non-base land managers or landowners.
   b. On-base
      i. Contact Range Control for authorization of training area access. Must have Range Control Authorization in hand when accessing area and range control must be notified by phone on collection day.
2. Aerial and topographic maps need to be acquired and GPS units prepared for field use.

D. When

1. Ripeness
   a. General indicators
      i. Size
         (a) Capsules should be fully formed; smaller shriveled capsules may not be fully formed or non-viable
      ii. Color
         (a) In general seeds should be darkened, either brown, black or tan
      iii. Hardness
         (a) When pinched between your fingers, capsules should be hardened and dry
         (b) A slight bend when pinched is normal
      iv. Other
         (a) Capsules should show signs of opening in most cases.
         (b) Occasionally collect seed early for after-ripening in order to maximize collection.
2. Determinant vs. Indeterminate

a. Determinant: Typically all flower blooms are formed before the first buds open resulting in more or less a one-time bloom.
b. Indeterminate: Flowers develop and bloom from the base. The terminal bud is unaffected and growth can continue well into the season.
c. Snood (cover the green seedhead with a pollinator exclusion bag to prevent seed dispersal) these species for maximum collection or revisit throughout the season.

3. Effects of Weather
   a. Bloom time—Cooler weather can delay bloom or prolong
   b. Pollination/Seed Development---Cooler weather can affect pollinator presence and consequently seed development, warmer weather can speed up seed development
   c. Seed Collection
      i. General Rule: DO NOT COLLECT IN THE RAIN, wet seed easily molds
4. Effects of Elevation and Microclimates
   a. Know your collection area as even a small change in elevation, water availability, etc. can cause seed to ripen differently

E. How To Basics

1. General *(numbers, % of population, identification, etc.)*
   a. Identification is key, locate when plants are in bloom and mark extensively
   b. Collect for genetic diversity. Do not focus on one hot spot but instead collect across the site and several sites if possible. Also collect several times within the collection period to increase genetics of early versus late flowering plants
   c. Collect no more than 20% of more common species populations and never more than 10% of rare species population. This means knowing where species are located and avoiding double collection within your group.
   d. Collect all shapes and sizes within population. Do not focus on the most vigorous.
2. Locating
   a. Identification is key, take herbarium samples for comparison
   b. GPS boundaries of significant populations and individual plants of singular or uncommon species
   c. Take Notes: Important for describing multiple locations within one area

3. Stem vs. head/capsule
    a. Use family based collection techniques provided below to determine best collection method for each species
    b. If species needs after-ripening, collect whole head with at least half a stem
    c. If dealing with pappus seed, simply shake seed into envelope
    d. Remember whatever goes into the envelope has to be separated from the seed, never crush seed heads into envelope
4. Insect control
    a. Avoid plants with known infestations, look to collection leaders for assistance on pest identification
    b. Drop seed at nursery ASAP for quick insect removal
5. Materials
    a. Containers
        i. Always collect in size appropriate paper envelopes with taped seams or mesh bags
        ii. Seed will be removed at nursery facility to more appropriate containers
    b. Labeled envelopes and pencil—label with species, code, collection site, GPS coordinates and collectors initials
    c. Additional equipment
        i. Snoods for wide dispersing species
        ii. Herbarium sample equipment
6. Aftercare
    a. Drop-off at Nursery ASAP
    b. If you are unable to do so within the day, keep plant species separate and spread out to dry in area away from direct light
    c. Fill out provided seed drop off information for record keeping

SPECIFICS FOR COLLECTION

A. Aster / Composite (Asteraceae)

1. Fluffy Seed (seed with pappus): Fleabanes--*Erigerons*; White-topped Aster--*Sericocarpus rigidus*; Hall's Aster--*Symphyotrichum hallii*; Hound's Tongue Hawkweed--

Hieracium cynoglossoides; Cutleaf Microseris--*Microseris laciniata*; Goldenrods--*Solidagos;*

a. Gently pull fluff/pappus with seed attached from flower head. If fluff appears glued together, don't collect. Don't pack seeds tightly in the collection bag or envelope.

2. Non-fluffy Seed (no pappus attached): Puget Balsamroot--*Balsamorhiza deltoidea*; Oregon Sunshine--*Eriophyllum lanatum*; Blanket Flower--*Gaillardia aristata*;
   a. *Balsamorhiza* , shake into bag--don't crush. If the whole stem must be collected, leave several inches of stem and place head down in bag.
   b. *Eriophyllum* and *Gaillardia, flick into envelope or bag.* Examine to differentiate between dried flower petals and seed, and check for insects. Leave the seed heads with insects on the prairie.
3. Special consideration: Common Yarrow / *Achillea millefolium*; Often collected too early or too late. Need to work closely with Shotwell's staff and botanists to hone in on best field indicators of ripe seed. General advice is to collect when pedals have fallen off and seed head is light tan.

B. Pea (Fabaceae): Lupines--*Lupinus*; Clovers--*Trifoliums*; Wooly Vetch--*Vicia American;:* Small-flowered Lotus--*Lotus micranthus;*

1. Seed does not easily "after-ripen" or continue to ripen after collection. This suggests that others in the pea family should also be allowed to ripen on the plant. If hand collecting, the pods should be very crisp, frequently popping open as you pull them off the plant. Always check the pods for worms/larva and insect frass/poop. If a plant or an area is heavily infected. Only save the seeds from uninfected pods.
2. Snoods are an efficient way to collect pea seeds, though they should not be used in areas of heavily infected pods. For example, the large sleeve-type snoods work well on *L. albicaulis,* the hairnet style on *L. lepidus, and the smaller sleeve-type on Lotus micranthus.* Snoods can be slipped on after the pedals have dried as the pods are forming. They can be left until the pods pop open and then the snood can be cut off with the entire branch or plant intact. Place the snood loosely in large paper bags. The snoods should be open and seed separated from chaff as soon as remove insects.

C. Lily (Liliaceae)

1. Most Lilies: Harvest Brodiaea--*Brodiaea coronaria;* Ookowo or Cluster Lily--*Dichelostemma congestum*; Common Camas--*Camassia quamash;* Chocolate Lily--*Fritillaria affinis;* pour or shake into envelope or bag--don't crush. If the whole stem must be collected, leave several inches of stem and place head down in bag.
2. Special consideration; *Trilliums* should be snooded when the flower begins to fade to protect the ripening seed from ants. Ants will gather the ripening seed for the fleshy structure attached to it (the Elaiosomes), which they carry to their nests for food. Get seed into secure location ASAP, as mice are also attracted to the oily seeds.

D. Figwort (Scrophulariaceae)

1. Paintbrush--*Castilleja*; collect when capsules have begun to split open.
2. Blue-eyed Mary—*Collinsia,* Blue Toadflax—*Nuttallanthus:* collect when capsules have begun to split, tip plant into envelope for maximum collection.

E. Grasses (Poaceae) See *Prairie Grasses Spreadsheets*--Appendix 4

1. California & Poverty Oatgrasses--Danthonias; June Grass--*Koeleria macrantha*; these grasses are collected when the seed comes off easily by running the hand up the stem to strip the seed into a bag. If necessary, cut the stem at least 5 inches long and lay head down in envelope or bag.
2. Special consideration; Roemer's Fescue--*Festuca roemerii*--be very clear on the distinction between Roemer's and Red Fescue (*Festuca rubra*). WHEN IN DOUBT, LEAVE IT OUT! Otherwise collect in same manner as *Danthonias.*

F. Buttercup (Ranunculaceae):

1. Western Buttercup--*Ranunculus occidentalis*; collect when seed brushes off easily into hand, even if slightly green. If collected somewhat green, spread out to after-ripen.
2. Red Columbine--*Aquilegia formosa*; Larkspurs--*Delphiniums*; collect by pouring into envelope. Seeds can be somewhat moist, sticky, so do not over fill envelope and spread-out to dry ASAP.

G. Carrot (Apiaceae): Spring Gold, Desert Parsley, Nine-leaved Lomatium-- *Lomatiums;* Gairdner's Yampah--*Perideridia gairdneri*; gently pull seeds from head. Can be collected in rain by cutting stems and same day spreading out on cloth to dry.

H. Violet (Violaceae):

1. Early Blue Violet--*Viola adunca*; collect stem, at least 3 inches long if possible, when capsule points straight up. Put directly into jar, or collect in envelope then put in jar the same day. Do not overfill the jar as capsules need to dry to open and pop out seed.
2. Yellow Montane Violet--*V. praemorsa*; collect as with *V. adunca*, or use small sleeve-type snood on capsules that are not yet standing up. Collect snoods when capsules have opened by cutting stem below the snood. Empty snoods indoors, being careful not to spill the seed.
3. Yellow Wood Violet--*V. glabella*; have yet to collect. The plants in a bed all quit blooming and forming seed heads at the same time. If this occurs in the wild, they would be good candidates for hairnet-type snoods.

I. Primrose (Primulaceae): Shooting Stars--*Dodecatheons;* forms up-right, open seed cup; pour into envelope. If necessary, once stem and cup are tan-colored, collect whole stem and place upside-down in envelope. Allow space around envelope for seed to dry.

J. Iris (Iridaceae): Blue-eyed Grass--*Sisyrinchium idahoense*; small, dark seeds in an up-right cup. Collect like *Delphinum* by pouring into envelope. If seeds are somewhat moist, sticky, so do not over fill envelope and spread-out to dry ASAP.

K. Plumbago (Plumbaginaceae): Thrift/Sea-pink--*Armeria maritima;* collect when seeds are tan and the papery husk have no green coloration. Flick off the seed with the husk attached.

L. Campanula (Campanulaceae): Harebell--*Campanula rotundifolia;* papery, tan seed capsule hangs down. When ready to collect, there will be several small holes near the stem end of the capsule. Carefully turn the capsule upside down and shake seeds into an envelope as if it were a salt shaker.

M. Rose (Rosaceae):

1. Potentillas have multiple papery cups holding dark, reddish brown seed. Turn the head over an envelope and shake. All the heads on the plant do not ripen at the same time.
2. Virginia Strawberry--*Fragaria virginiana*; generally stolons are harvested rather than seed collected. The runners/stolons are cut from the plant several inches from were joints/nodes are developing new roots. Arrangements must be made with the nursery ahead of time, so that the harvested nodes can be planted into pots before the roots dry

N. Valerian (Valerianaceae): Seablush--*Plectritis congesta*; plant develops two different fruits/seeds--fruit polymorphisms. Both types of seed can be easily shaken into an envelope or bag when ripe. All the plants do not ripen at the same time. Special care must be taken when cleaning seed as their shape and size differs.

O. Dogbane (Apocynaceae): Spreading Dogbane--*Apocynum androsaemifolium*; seed is inside a long slender pod. When it splits open it appears very feathery, with a long pappus. Collect when pods begin to turn black and split, avoid pods that are milky when split open. Could also be enclosed in sleeve-type snoods once the pedals have withered.

P. Sedge (Cyperaceae):

1. Long-stoloned Sedge--*Carex inops;* fruit forms a cup, when dry opens to expose several small, black seed. It holds seed for reasonable period of time.
2. Lateral Sedge--*Carex unilateralis;* no experience collecting.

Q. Gourds (Cucurbitaceae): Manroot--*Marah oreganus*; collect when prickly skin of fruit is dry and papery. Contains about 4 large brown seeds. Does after-ripen if seeds have begun to harden.

R. Saxifrage (Saxifragaceae): Grassland Saxifrage--*Saxifraga integrifolia;* collect when the capsules have begun to open by gently shaking them into the collection bag. DO NOT CRUSH!

S. Borage (Boraginaceae): Fragrant Popcorn Flower--*Plagiobothrys figuratus;* Indeterminate. While the uppermost flowers are still in bloom, collect seed from base flowers by cutting only those stems and gently placing them in a bag that is large enough to leave the vegetative material loose. Because these plants are small and multi-stemmed, it is difficult to shake them into the collection bag. Repeat several times during the season.

T. Mustard (Brassicacea): Tower Mustard--*Arabis glabra;* collect when the siliques, or elongated capsules, begin to split open.

U. Evening Primrose (Onagraceae): Farewell-to-spring--*Clarkia amoena;* collect when the capsules are dry and dull brown in color and if possible just when they show evidence of beginning to open. Clip or break them off and place in collection bag. If already opened but still containing seed, tip them into the collection bag.

Phlox (Polemoniaceae): True Babystars--*Leptosiphon bicolor*; Pink Microsteris--*Microsteris gracilis;* collect when small roundish oval capsules are dry, tannish looking and come loose easily.

V. Pink (Caryophyllaceae): Field Chickweed--*Cerastium arvense*; collect directly into envelope when capsules are tan to brown in color and splitting open.

W. Purslane (Portulacaceae): Red Maid or Desert Rock Purslane--*Calandrinia ciliata*; Indeterminate. While the uppermost flowers are still in bloom, collect seed from base flowers by cutting only those stems and gently placing them in a bag that is large enough to leave the vegetative material loose. Repeat several times during the season.

Appendix 3--Example of Necessary ID Information for Wild Seed Collection

Grasses of the South Puget Prairies

Characteristics		Occurrence	Roots	Height	Sheath	Ligule	Auricle	Blade	Inflorescence	Spikelet	Awn
Scientific Name	Duration	Sites, Rarity	Rhizome, bunchgrass		Open, closed	Length, fringed, membranous	Pres/Abs, Shape	Width	Spike, Panicle (open, narrow)	# flwrs	Present (length), absent
Agrostis capillaris	P		rhizome, stolon	20-75cm	smooth	1-2mm, truncate, ciliate	abs	2-5mm	open panicle, filiform branches	1	P or A
Agrostis gigantea	P		rhizome	30-50cm	smooth to minutely roughened	3-6mm	abs	to 4mm	open panicle	1	A
Agrostis pallens	P		rhizome	15-30cm	open	1-3mm	abs	1.5-3mm	narrow panicle	1	A
Aira caryophyllea	A		tufted annual	5-25cm	minutely roughened, occ. smooth	1.2-8mm	abs	1mm	open panicle	2	P
Aira praecox	A		tufted annual	5-25cm	minutely roughened, occ. smooth	1.4-5.3mm	abs	0.3-2mm	narrow panicle	2	(3-4.5mm)
Anthoxanthum odoratum	P		bunchgrass	30-60cm	open	2-3mm	.5mm or abs, hairy	1-2mm	narrow, spike-like	3	P
Arrhenatherum elatius	P		usu. bulbous base	to 1.5m	open	1-2mm, truncate, ciliate	abs	4-8mm	narrow panicle	2	Y- 1st lemma
Dactylis glomerata	P		tufted, short rhizomes	1.5m	closed	3-4mm, fringed	abs	5-10mm	open panicle	3 to 5	present, short
Danthonia californica	P		bunchgrass	0.3-1m	open	short hairs	abs	2-5mm	open panicle	3 to 8	Y- bent
Danthonia spicata	P		bunchgrass	20-70cm	open, pubescent	short hairs	abs	0.8-3mm	narrow panicle		(5-8mm), bent
Dichanthelium acuminatum var. *fasciculatum*	P		bunchgrass	.15-1m	glabrous or pubescent	pilose	abs	2-12mm	panicle		absent
Dichanthelium oligosanthes var. *scribnerianum*	P		bunchgrass	20-75cm		pilose	abs	4-15mm	panicle		absent
Elymus glaucus	P		bunchgrass	.5-1.5m	open	>2mm	Present	5-10mm	spike	2	P or A
Elymus repens	P		rhizome, stolons	0.1-1.8m	open	membranous, truncate	present	5-10mm	spike	1 to 11	present

APPENDIX 4 – Seed Collection Schedule and Priority Table

Location Key—GH=Glacial Heritage, RP=Rocky Prairie, WH=Wolf Haven, TA#=Training Area #, R#= Range #, AIA=Artillery Impact Area

Species Information					Collection Locations			
Species	**Code**	**Flowering Period**	**Collection Period**	**Volume Needed**	**GPS Location**	**On Base Location**	**Off Base Location**	**Site Specific**
Priority 1								
Apocynum androsaemifolium	APAN	July-Sept.	Sept.-Nov.	Medium	Yes	TA7S, TA13	RP	Yes
Aquilega formosa	AQFO	May-June	July-Sept.	Medium	Yes	R76, JP	RP, GH	
Priority 2								
Balsamorhiza deltoidea	BADE	April-June	July-Aug.	Large	Yes	TA7S, R76, JP	GH	Yes
Brodiaea coronaria	BRCO	May-June	Aug.-Sept.	Medium	Yes	TA7S	GH, RP	Yes
Priority 3								
Carex inops	CAIN	May-June	July-Sept.	Small		All TA's	RP, WH	
Castilleja levisecta	CALE	April-May	July-Aug.	Medium	Yes	AIA	RP, WH	Yes

APPENDIX 5 – Example of Plant Profiles Established by CNLM

SCIENTIFIC NAME: *Aquilegia formosa* **FAMILY:** Ranunculaceae

ENGLISH NAME: Western columbine, Crimson columbine, Scarlet columbine, **OTHER NAMES:**

DESCRIPTION:

General: Glandular, glabrous to densely pubescent perennial from a branched to simple woody base, the several stems 1.5-10 dm. tall.

Leaves: Leaves mostly basal, long-petiolate, the blades triternate; leaflets thin, obovate with a wedge-shaped base, 2-3 times lobed, glaucous and pubescent beneath, 1.5-5.5 cm. long.

Flowers: Flowers usually several, nodding; sepals 5, petal-like, pale to deep red, oblong-lanceolate, 1.5-2.5 cm. long; petals 5, yellow, with straight spurs 10-15 mm. long, the blades 2-5 mm. long; stamens numerous, the inner ones sterile and scale-like.

Fruit: Follicles 5, 2 cm. long, copiously glandular-puberulent.

GEOGRAPHIC RANGE AND HABITAT REQUIREMENTS:

Distribution	Alaska to California, coastal and inland to Alberta and Wyoming.
Ecological Setting	Open woods, lowlands to mid-elevations in the mountains
Soil Texture	Medium to coarse, moist, rocky soils, but will grow in dry, nutrient poor soil.
Soil Reaction / Salinity	6.0-7.5 pH – no salinity tolerance
Moisture Regime	Medium moisture use – medium drought tolerance
Shade Tolerance	Sun or part shade – shade tolerant

USES:

Site Rehabilitation	Pollinator food source
Wildlife	Attracts hummingbirds, high palatability for browsing and grazing animals.
First Nations	The nectar was eaten as a candy by the Gitxsan and Wetsuweten peoples. The young leaves of variety *truncata* were gathered before flowering, boiled, and eaten as greens by indigenous peoples of California.

PROPAGATION:

Flowering, Fruiting and Seed Characteristics:

Flowering Time	Fruit Ripening Time	Seed Collection Time	Crop Intervals	No. seeds per lbs.	Seed Viability
May - August	August-September	Mid August-October	Perennial	248000	Unknown

Fruit and Seed Collection

Seeds may ripen and be shed before the pod has turned brown. If seeds in greenish follicles are black, they are ready to collect. Cut the fruiting stalk and keep in a dry bag for a few days until the seeds shake free. For large scale production, tarp due to continuing seed drop.

Seed Extraction

Plant follicles normally dry and split open at maturity. Gently crush dried seed heads to release remaining seed trapped in follicles. Further clean the seed with the Clipper seed cleaning machine through the air-screen. The papery, light pod chaff is easily separated from the seed.

Seed Storage

Due to lack of information on temperature and humidity requirements on *A. formosa* as well as information on yearly loss of viability, the *A. formosa* is kept at a standard storage of 40F and 40% humidity.

Fruit/Seed Dormancy and Treatment

Sow outdoors in October for natural stratification or cold moist stratify for 45 days and sow in early spring under cool temperatures.

SOURCES:

http://plants.usda.gov/java/charProfile?symbol=AQFO

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

http://biology.burke.washington.edu/herbarium/imagecollection.php

http://www.wnps.org/landscaping/herbarium/pages/aquilegia-formosa.html

SCIENTIFIC NAME: *Armeria maritima v. californica* **FAMILY:** Plumbaginaceae

ENGLISH NAME: Thrift, Sea-thrift **OTHER NAMES:**

DESCRIPTION:

General: Scapose, perennial herbs, the 1-several scapes glabrous, 1-5 dm. tall.
Leaves: Leaves all basal, in dense tufts, narrowly linear, tough and persistent, 5-10 cm. long and 1-3 mm. broad, glabrous to puberulent.
Flowers: Flowers in dense, head-like clusters subtended by purplish involucral bracts, 1.5-3 cm. broad, terminal on the scapes; flowers in clusters of 3 on short pedicels, subtended by 2 transparent bracts; calyx 5-lobed, funnel-shaped, dry and chaffy, 10-nerved, 5-6 mm. long; corolla 5-lobed nearly to the base, pinkish or purplish; stamens 5, opposite the corolla lobes; styles 5, distinct.
Fruit: Fruit achene-like.

GEOGRAPHIC RANGE AND HABITAT REQUIREMENTS:

Distribution	Alaska to California, also Newfoundland and Europe.
Ecological Setting	Gravelly tundra, along beaches and coastal bluffs, occasionally inland.
Soil Texture	Medium to coarse, moist to dry, well drained soils
Soil Reaction / Salinity	4.7-7.5 pH – low salinity tolerance
Moisture Regime	Medium moisture use – low drought tolerance

USES:

Site Rehabilitation	Persistent
Wildlife	Attracts bees, low palatability for browsing and grazing animals.

PROPAGATION:

Flowering, Fruiting and Seed Characteristics:

Flowering Time	Fruit Ripening Time	Seed Collection Time	Crop Intervals	No. of seeds per pound	Seed Viability
March - July	July-August	Mid July-October	Perennial		Unknown

Fruit and Seed Collection

Collect Armeria when seeds are tan and the papery husk has no green coloration. Flick off the seed with the husk attached. Take care to collect only when entire seed head is tan to black as seeds do not after-ripen. For larger scale collection, plants can be swathed as seed head holds seed well.

Seed Extraction

Seed is best cleaned using a Westrup LA-H Brush Machine with size 40 round mantle. Afterwards seed and husk chaff can be separated using a Clipper Eclipse Air Screen Separator with a 9 round top screen and a 16X22 bottom screen. Seed comes out into bottom tray. Screens need to be constantly cleaned top and bottom screens by tapping or rubbing them.

Seed Storage

Due to lack of information on temperature and humidity requirements on *A. maritima v. californica* as well as information on yearly loss of viability, the *A. maritima v. californica* is kept at a standard storage of 40f and 40% humidity.

Fruit/Seed Dormancy and Treatment

Seeds do not need pre-treatment and are fairly quick to establish. Sow in late May or early June for fall outplanting.

SOURCES:

http://plants.usda.gov/java/profile?symbol=ARMAC2

http://www.wildflower.org/plants/result.php?id_plant=ARMA6http://biology.burke.washington.edu/herbarium/imagecollection.php

SCIENTIFIC NAME: *Balsamorhiza deltoidea* **FAMILY:** Asteraceae

ENGLISH NAME: Deltoid balsamroot **OTHER NAMES:** Puget balsamroot

DESCRIPTION:

Leaves: Basal leaves long-stalked, the blades mostly triangular, 10-50 cm long, 10-20 cm wide, green, inconspicuously stiff-hairy and often glandular, prominently nerved, round-toothed; stem leaves few, lanceolate to linear, greatly reduced.

Flowers: Heads with ray and disk flowers, 1-4, the disk 2.5 cm or more, the lateral heads smaller; involucral bracts lanceolate to oblong-lanceolate, slightly woolly, the outer ones 1-4 cm long and herbaceous, exceeding the inner ones; ray flowers 13 or 21 in a terminal head, yellow, 2-3 cm long; disk flowers 5-7 mm long, yellow.
Fruits: Achenes glabrous, 7-8 mm long; pappus lacking.

GEOGRAPHIC RANGE AND HABITAT REQUIREMENTS:

Distribution	Pacific Coast states west of the Cascades. Grows sporadically in dry, open, grassy habitats in the Strait of Georgia, Puget Sound area and south to California, at low elevations.
Ecological Setting	Salt water shorelines, prairies, meadows, shrub steppe and other open areas at low elevations, mostly in the Puget Sound trough. Mostly restricted to open dry sties but prefers deeper soils than most prairie perennials.
Moisture Regime	Dry soil
Shade Tolerance	None

PROPAGATION

Flowering, Fruiting and Seed Characteristics:

Flowering Time	Fruit Ripening Time	Seed Collection Time	Crop Intervals	No. of seeds per pound	Seed Viability
March - July	July	Mid July-October	Perennial	70306.45	Unknown

Fruit and Seed Collection

Shake into bag and do not crush. If the whole stem must be collected, leave several inches of stem and place head down in bag (for small lots of seed collection). Fall large scale collection use Flail-vac seed stripper to lightly brush seeds from seed head. Un-ripe seed will fall as well as ripe so properly monitor collection window to ensure latest possible brushing.

Seed Extraction

Use the Clipper seed cleaning machine with a medium amount of air flow, through screen size 9RD and 6RD. Discard the chaff from port #2 and drawer 3, 4, and 5. Recover the course chaff with seed that did not fall through the top screen (9RD). Save the very clean seed from main drawer. Take the course chaff/seed and seed that dropped into main tray and re-run through the Clipper once or twice to ensure cleanest seed.

Seed Storage

Due to lack of information on temperature and humidity requirements on *B. deltoidea* as well as information on yearly loss of viability, the *B. deltoidea* is kept at a standard storage of 40f and 40% humidity.

Fruit/Seed Dormancy and Treatment

Species produces large amount of non-viable seed. This is possible due to issues with pollination and seed predation. A 90-day cold moist stratification recommended with an early spring sowing or sow in late November through January for natural outdoor stratification.

SOURCES:

http://www.wildflower.org/plants/result.php?id_plant=BADE2

SCIENTIFIC NAME: *Castilleja hispida* **FAMILY:** Orobanchaceae

ENGLISH NAME: Harsh Indian paintbrush **OTHER NAMES:**

DESCRIPTION:

General: Perennial, the stems mostly unbranched, clustered, erect or ascending from a woody base, 2-6 dm. tall, finely villous.
Leaves: Leaves alternate, lanceolate or broader, finely villous, the lower ones entire and reduced; upper leaves with 1-2 pairs of lateral lobes, these much narrower than the mid-blade.
Flowers: Inflorescence showy, short and broad, becoming elongate, scarlet or red, occasionally yellow; bracts broad and deeply 3- to 5-lobed; calyx 15-30 mm. long, deeply cleft above and below, its primary lobes again divided into 2 segments; corolla 20-40 mm. long, its puberulent upper lip about equaling the tube, the lower lip only 1/5 as long, dark green, thickened; stamens 4.
Fruit: Capsule.

GEOGRAPHIC RANGE AND HABITAT REQUIREMENTS:

Distribution	Both sides of the Cascades, British Columbia to Oregon, east to Montana.
Ecological Setting	Grassy slopes and forest openings, from sea level to moderate elevations in the mountains.
Soil Texture	Medium to coarse, well-drained soil
Soil Reaction / Salinity	6.0-8.0 pH – no salinity tolerance
Moisture Regime	Low moisture use – high drought tolerance

Shade Tolerance	Shade intolerant
Successional Status	Early

USES:

Site Rehabilitation	Pollinator food source
Wildlife	High palatability for browsing and grazing animals.
First Nations	Used to trap hummingbirds after being covered with snail slime, as well as its nectar being a source of candy for the Nitinaht tribe.
Other	Hemi-parasite

PROPAGATION:

Flowering, Fruiting and Seed Characteristics:

Flowering Time	Fruit Ripening Time	Seed Collection Time	Crop Intervals	No. of seeds per pound	Seed Viability
Late April - August	August	Mid August-October	Perennial	350000	Unknown

Fruit and Seed Collection

Clip the seed pods from the plant when they begin to turn black and split for wild or small lot collections. For large lot collection direct combine but this is difficult when grown with host plant. Possibly mow down host plant before collection.

Seed Extraction

Seeds are cleaned first using a Westrup LA-H Brush Machine with 40 round mantle. Seed is then produced using an Eclipse Air Screen Separator with 9 round top screen and 1X16 bottom screen. Double scalp course material. Seed and fine chaff out port #2. Main tray and course chaff port port will have discard material. Run seed and dirt from fine chaff port #2 with 1X16

top screen and 40X40 bottom screen. May need to roll hard seed pods with heavy roller to open before running through brush machine.

Seed Storage

Store at a low-temperature (5° C) in a dry, dark place. It is best to use seeds within 1-2 years.

Fruit/Seed Dormancy and Treatment

Germination requirements may vary depending on the source of the seed. In general, seeds must be stratified for 6-8 weeks. After 4-6 weeks, seedlings may be transplanted into a container with a host plant such as *Eriophyllum lanatum* or *Festuca roemeri* or foliar fertilizer treatment applied weekly.

SOURCES:

http://plants.usda.gov/java/charProfile?symbol=CAHI9

http://biology.burke.washington.edu/herbarium/imagecollection.php

http://depts.washington.edu/propplnt/Plants/castilleja%20hispida.htm

http://herb.umd.umich.edu/herb/search.pl

SCIENTIFIC NAME: *Erigeron speciosus*

FAMILY: Asteraceae

ENGLISH NAME: Showy fleabane, Aspen fleabane

OTHER NAMES:

DESCRIPTION:

General: Perennial from a short, woody base, 1.5-8 dm. tall, the stems clustered, amply leafy, glabrous below the inflorescence.

Leaves: Leaves glabrous, triple-nerved, entire, the lower oblanceolate or spatulate, petiolate, mostly deciduous, the other becoming sessile but ample.

Flowers: Heads 1-13 in a open inflorescence; involucre 6-9 mm. high, glandular; rays 65-150, blue or rarely white, 9-18 mm. long and 1 mm. wide; pappus 20-30 bristles, a few of the outer ones shorter.

Fruit: Achenes 2-nerved.

GEOGRAPHIC RANGE AND HABITAT REQUIREMENTS:

Distribution	British Columbia to Oregon, east to Wyoming; more common west of the Cascades.
Ecological Setting	Open woods or openings in wooded areas, foothills to moderate elevations in the mountains.
Soil Texture	Dry to moist soils
Shade Tolerance	Sun
Successional Status	Early

PROPAGATION:

Flowering, Fruiting and Seed Characteristics:

Flowering Time	Fruit Ripening Time	Seed Collection Time	Crop Intervals	No. of seeds per pound	Seed Viability
June - August	August- Sept	Mid August-October	Perennial	2,433,964	Unknown

Fruit and Seed Collection

Seed develops rapidly in the 2-3 weeks following bloom period. Collect seedheads in a paper bag when the heads begin to turn a whitish-brown. For small seed beds vacuum directly off the plant with a backpack vacuum. For large scale collection, collect with Flail-vac seed stripper.

Seed Extraction

Seed is easily cleaned using a Westrup LA-H Brush Machine with 40 round mantle. May need additional hand screening to remove pappus dust.

Seed Storage

Due to lack of information on temperature and humidity requirements on *E. speciosus* as well as information on yearly loss of viability, the *E. speciosus* is kept at a standard storage of 40F and 40% humidity.

Fruit/Seed Dormancy and Treatment

Seeds may be sown outside in early fall or the following spring without any cold treatment. Viability appears to be low, sow thickly. Seeds require light to germinate. A more practical method of propagation is division.

SOURCES

http://plants.usda.gov/java/profile?symbol=ERSP4

http://biology.burke.washington.edu/herbarium/imagecollection.php

http://www.wildflower.org/plants/result.php?id_plant=ERSP4

SCIENTIFIC NAME: *Gaillardia aristata* **FAMILY:** Asteraceae

ENGLISH NAME: Common gaillardia, Great flowered gaillardia, Blanketflower, **OTHER NAMES:**

DESCRIPTION:

General: Perennial from a slender taproot, usually with several simple, hairy stems from the base, 2-7 dm. tall.
Leaves: Leaves narrow, linear-oblong to lance-ovate, up to 15 cm. long and 2.5 cm. wide, entire to coarsely toothed.
Flowers: Heads solitary or few, on long peduncles, the disk 1.5-3 cm. wide, purple or brownish-purple; involucral bracts pointed, loosely hairy; rays usually 13, 1-3.5 cm. long, yellow but purplish at the base; disk corollas with dense woolly hairs toward the tip, which tend to obscure to pointed lobes.
Fruit: Receptacle covered with chaffy bristles that are longer than the achenes; pappus of 6-10 awned scales.

GEOGRAPHIC RANGE AND HABITAT REQUIREMENTS:

Distribution	Uncommon east of the Cascades from British Columbia to Oregon
Ecological Setting	Dry, open areas at low to mid-elevations
Soil Texture	Medium to coarse, well-drained, infertile soil
Soil Reaction / Salinity	5.5-7.9 pH, low salinity tolerance
Moisture Regime	Medium water use – medium drought tolerance
Shade Tolerance	Shade intolerant
Successional Status	Early

USES:

Site Rehabilitation	Pollinator food source
Wildlife	Attracts butterflies, low palatability for browsing and grazing animals
First Nations	Used for numerous purposes ranging from soothing the sore nipples of nursing mothers (an infusion of whole plant applied topically) to curing cancer (an infusion of the whole plant is drunk).
Other	Warning: The plants fuzzy hairs can cause a skin irritation in some susceptible people.

PROPAGATION:

Flowering, Fruiting and Seed Characteristics:

Flowering Time	Fruit Ripening Time	Seed Collection Time	Crop Intervals	No. of seeds per pound	Seed Viability
May - September	August-October	September-October	Perennial	186436	Unknown

Fruit and Seed Collection

Seeds are collected when achenes separate easily from the receptacle. Seed easily shatters so vacuuming with a backpack vacuum is easy in small bed production. In large scale production use a Flail-Vac seed stripper over the site several times to capture slow ripening seed.

Seed Extraction

Seeds are cleaned by using a Westrup LA-H Brush Machine with a 20 round screen. Additional hand screening may be necessary depending on level of chaff brushed with collection.

Seed Storage

Due to lack of information on temperature and humidity requirements on *G. aristata* as well as information on yearly loss of viability, the *G. aristata* is kept at a standard storage of 40f and 40% humidity.

Fruit/Seed Dormancy and Treatment

Cold stratification not required but a cold moist stratification period of 30 days shortens germination period. Sow thickly for low viability in late spring.

SOURCES:

http://plants.usda.gov/java/charProfile?symbol=GAAR

http://biology.burke.washington.edu/herbarium/imagecollection.php

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

SCIENTIFIC NAME: *Ranunculus occidentalis* **FAMILY:** Ranunculaceae

ENGLISH NAME: Western buttercup **OTHER NAMES:**

DESCRIPTION:

General: Stiff-hairy perennial from slender fibrous roots, the 1-several stems erect, usually hollow, freely branched, 1.5-4 dm. tall.

Leaves: Basal leaves long-petiolate, the blades 2-3.5 cm. long, deeply 3-lobed, the lobes with coarse, rounded teeth; cauline leaves alternate, more deeply dissected, reduced upward to the entire bracts.

Flowers: Pedicels single-flowered, up to 10 cm. long; sepals 5, greenish or pinkish-tinged, spreading but sharply reflexed at mid-length, hairy, early-deciduous; petals 5, yellow, oblong, 9-12 mm. long and nearly half as broad; nectary scale broadly wedge-shaped, 1 mm. long, the lateral margins free ¾ their length; receptacle ovoid; stamens 30-60; pistils 10-20.

Fruit: Achenes obovate, strongly flattened, 2.5-3.5 mm. long, glabrous and smooth; stylar beak slender, 1-2 mm. long, slightly curved and hooked at the tip.

GEOGRAPHIC RANGE AND HABITAT REQUIREMENTS:

Distribution	West of the Cascades, Alaska to California, and east to the Blue mountains in Oregon
Ecological Setting	Moist to well-drained soil, low to mid-elevations in the mountains

Soil Texture	Light (sandy), medium (loamy) and heavy (clay) moist soils
Nutrients	Nitrogen-medium soils
Soil Reaction / Salinity	The plant prefers acid, neutral and basic (alkaline) soils
Moisture Regime	Water-shedding or water-receiving sites
Shade Tolerance	Shade intolerant, it can grow in semi-shade (light woodland) or no shade.
Successional Status	Early seral, herbaceous and grassy communities

USES:

Landscaping	Meadow communities, lawn conversions or borders
First Nations	The juice from the flowers was used as a poison. Seeds can be cooked and used as piñole either on their own or mixed with other seeds. The seed must be parched in order to remove an acrid principle.
Other	Warning: Toxins are likely to be present in all parts of the plant and can be destroyed by heat or by drying. Many, if not all, plants in this genus also have a strongly acrid juice that can cause blistering to the skin.

PROPAGATION:

Flowering, Fruiting and Seed Characteristics:

Flowering Time	Fruit Ripening Time	Seed Collection Time	Crop Intervals	No. of seeds per pound	Seed Viability
April - June	June-August	July-September	Perennial	184,158	Unknown

Fruit and Seed Collection

For wild collection and in small lots, collect when seed brushes off easily, even if slightly green. If collected when the seed are somewhat green, spread out the seed to after-ripen. For large lots collect when seed begins to fall from head using a swather and spread thinly in sun for drying.

Seed Extraction

Seeds are extremely difficult to remove from seed head. Extensive drying allows for seeds to be more easily removed. First run seed through hammermill to remove 60-70% of seed. Seed is then run through an Eclipse air screen separator with a 6 round top screen and 6X24 top screen. This results in fairly clean seed however if seed is to be used for plugs, run through air column separator on low air.

Seed Storage

Due to lack of information on temperature and humidity requirements on *E. lanatum* as well as information on yearly loss of viability, the *E. lanatum* is kept at a standard storage of 40F and 40% humidity.

Fruit/Seed Dormancy and Treatment

Seed is cold moist stratified for 20 to 30 days and sown in late spring early summer due to quick establishment period. Can be easily divided for vegetative propagation.

SOURCES:

http://plants.usda.gov/java/profile?symbol=RAOC

http://biology.burke.washington.edu/herbarium/imagecollection.php

http://www.wildflower.org/gallery/result.php?id_image=9508

http://www.pfaf.org/database/plants.php?Ranunculus+occidentalis

http://www.goert.ca/propagation_guidelines/forbs/ranunculus_occidentalis

(Klinka *et al.*, 1989).