Department of Defense
Legacy Resource Management Program

Legacy 09-213

Strategy for the Cooperative Recovery of Rare Species Affecting Training Ranges:

Native Seed Production Strategy-
A Key Piece of South Puget Sound Prairie Conservation

Center for Natural Lands Management

November 2011

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Funded by:

Department of Defense Legacy Program

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1 The Need for Seed

The prairies of the South Puget Sound region are central to conservation of one of the rarest ecosystems in the U.S. – the grasslands and oak woodlands of Cascadia. These open grasslands are a welcome respite from the coniferous forests that are common in the region, and offer unique habitats for both humans and wildlife. They host a range of species that are globally rare and endangered of extinction. In the South Sound region, this includes a set of federally listed and candidate species, ranging from plants to invertebrates, birds and mammals. The range of rare life forms illustrates the overall decline these grasslands and their habitats have faced, over 93% in the South Sound.

Fig. 1 - Spring bloom at a South Puget Sound prairie.

Restoration and active management is a critical conservation strategy for South Sound prairies. The majority of remaining prairie sites has been degraded due to the invasion of pest plants, fire suppression and other threats. Restoration on these sites has progressed through initial control efforts for most pest plants and is now in the process of shifting to enhancement of native species, especially to create habitat for several of the rarest species in the prairies, the prairie butterflies. Direct seeding of species, especially after sufficient site preparation, is a successful technique. In order to restore habitat at scale a sufficient source of native seed is needed yearly.

There is an increasing need for a core seed mix that can be used for prairie restoration on a variety of lands. Traditional protected prairie lands in need of enhancement with native plants are increasing as pest plant control efforts succeed on current preserves and as new lands are protected. In addition, demand is increasing from agencies and private individuals. This demand may be based upon a voluntary desire to enhance prairies, or an agency mandate or regulation to consider prairie restoration. Similarly, demand from regulated mitigation projects has begun to increase. A verified consistent source of a prairie enhancement seed will help enable all of these conservation efforts to succeed.

This seed source should have several specific characteristics. First, seeds should be from native species that are a current component of the South Sound prairies. Introduction of new species

for reasons such as climate change adaptation may be desirable, but should be treated as separate projects. Second, a diversity of species is needed to supply habitat needs for both specific rare species and a variety of other native animals. This is especially true for forb species, since the grasslands are naturally diverse in these species. And third, the genetic stock should be localized so that restoration efforts are least likely to change the genetic make-up within the ecosystem. If a seed production strategy produces sufficient seed with each of these characteristics then it should help move regional restoration efforts forward over the next decade or more.

Currently the Center for Natural Lands Management manages native seed production for the South Puget Sound prairies, working with a range of prairie conservation partners, see Appendix 1. The prairies under protection and restoration range across Thurston County, from Joint Base Lewis-McChord at the north, to areas near Chehalis at the south, Fig. 2. The Washington program of the Center for Natural Lands Management has a 17 year history of prairie restoration in the South Sound, implementing on-the-ground conservation through land protection and restoration.

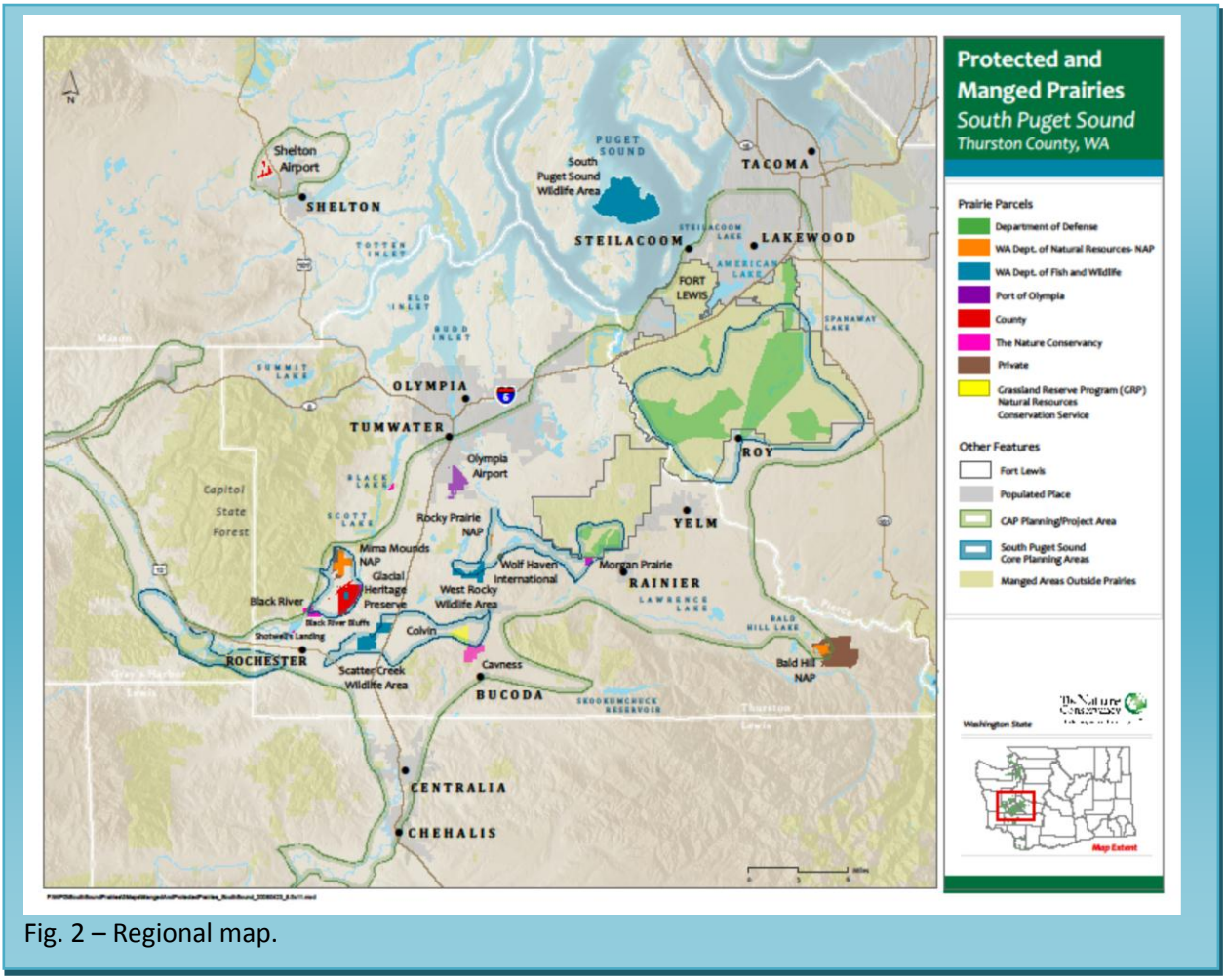

Fig. 2 – Regional map.

2 A Flexible Strategy

A variety of seed production techniques can be integrated into an overarching production strategy. That strategy needs to be sufficiently flexible to accommodate differing needs in terms of species, amount of seed and changes in temporal needs.

Native Seed Needs

Native seed is used for several different conservation purposes. Generally seed produced in one year is available immediately for restoration purposes in the fall, or plant production in the spring. This currently utilized timeline increases the effects of year to year variation in seed production. Yet currently, production has not exceeded need and has therefore precluded any significant ability to store seed between years. There are three primary conservation uses of native prairie seed in South Sound.

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 recent years, 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 Shotwell's Landing or through individual partners.

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 prairie grasslands. 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 partners' 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 and specific needs, as discussed later. A general sense for the amount seed needed is in the hundreds of pounds of seed.

Primary Seed Production Techniques

Three primary techniques of production have been developed: wild collection, seed bed production and field production (Table 1). Each of these techniques can produce differing amounts of seed and involve varying amounts of labor and equipment. The techniques also vary according to the genetic make-up of the seeds produced, viability and rates of germination.

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.	Shotwell's Landing	WA Dept. of Natural Resources – Webster's Nursery & Fourth Corner Nursery	Shotwell's Landing
Primary Purpose	Produce initial lots of seed to initiate further production or diversify genetic stock. Wild collection can produce sufficient amounts for certain species. Wild collection should be limited to minimum amount needed.	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.
Staffing, Equipment	Friends of Puget Prairies volunteer group has well-developed collection program. Staff of agencies and organizations also supplements volunteers.	62 seed beds have been established at Shotwell's Landing. Professional staff, interns and volunteers maintain beds and collect seed with minimal equipment.	Maintenance of fields requires mechanized and hand-intensive actions. Seed collection methodology and techniques are still evolving. Staff and labor crews have been used for maintenance.	A range of seed cleaning equipment is available at Shotwell's Landing. Seed storage facility is also available. 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, following their phenology in order to time seed collection correctly and proper collection of the seed. This is a time-consuming and meticulous process. While wild collection can produce large amounts of seed, it is best used as method to collect initial sets of seeds or to help ensure the genetic make-up of propagated plants is diverse.

Wild collection typically occurs on protected prairies of the South Sound, merely because 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.

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 developed a set of sometimes unique solutions to solving collection of seed from difficult species.

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.

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 3. - Volunteers from Friends of Puget Prairies are integral to wild seed collection efforts in the South Sound. Here volunteers collect seed.

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. Wild seed collection also tends to create a high number of different seed lots, which may need continued separate record keeping and handling. Finally, sometimes it may be more difficult to wild collect absolutely ripe or mature seed. 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. 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.

Fig. 4 – Seed beds at Shotwell's Landing allow individualized culture and collection efforts for rare species or species requiring additional regulated care.

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, since it is similar to what they have done in their own flowerbeds at home. 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 5. – Field production of the native grass *Koelaria* at Webster's Nursery.

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 6. --. Swather.

Field Production: Field production uses mechanical methods and larger scales 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.

Fig. 7. Field production of *Castilleja levisecta* at Webster's Nursery.

At a smaller scale, field production is modified small bed production, where portions of the required work are mechanized at larger scales, but individual rows of species differ in harvesting or other methods. 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.

Harvesting equipment need for field production is generally broken down into two categories based on seed type. 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. It allows

multiple harvests over the same field and reduces waste of seed. The other piece of equipment is a type of swather or a mower that cuts plant material and deposits it into a tow-behind trailer. This equipment works for species that the seed does not shatter or fall from the plant when cut, such as *Eriophyllum lanatum*.

Genetic concerns need to be addressed whenever large numbers of propagules are being produced in a single location. Tracking of original source seed and determining what is an acceptable range of source populations are critical. Cross pollination of related species can also be problem, in fact, recent concerns about crossing between *Castilleja levisecta* and *C. hispida* has led to modifications of field production of these species in the South Sound.

An additional concern with field production is that a large percentage of seed production is dependent on a single site or sites. If localized conditions, such as flooding or a pest invasion, impact the site then a significant portion of anticipated seed production will be lost. A similar concern occurs when a section of the field needs to be replaced to minimize any selection of certain characteristics of the plants. The change over needs to planned so that production is not lost. This may be more difficult in a field setting for perennial species, where space may limit having duplicate rows of species, and establishment periods are extensive.

Matching Seed Need with Production Techniques

Integrating the seed production techniques and matching those with the production needs yields a basic native seed production strategy. This action follows the trend set by Congress as part of the last version of the Farm Bill. This provision mandates the usage of native plant materials for restoration when available. The phrasing of "when available" has propelled Natural Resource Conservation Plant Materials Centers to move towards establishing protocols for agricultural production of native species on the regional scale. Congress also mandated that the materials needed to be produced using private growers, allowing for diversification in agricultural crops. Protocols produced by Plant Materials Centers are then available for private growers to access and use for their own production.

Fig. 8 - Seed cleaning is another time-consuming process.

The cycle of production as identified by this process is the triad of wild production, seed beds and field production. Wild seed is collected and used for initial seed bed establishment until production techniques are established, then the cycle moves to field bed establishment for large scale production, and eventually ends with outplanting. In the South Sound

the seed needed for field production is either produced in seed bed production, collected from wild populations or a combination of both. The technique selected matches with the amount of seed produced. Wild collection is best suited to amounts needed for plant plug production and seed of specialized species. Seed beds produce seed for the same two needs, while field production yields amounts suitable for growing large number of plugs or large-scale restoration efforts. The seed from all three production techniques must be cleaned before use. Seed cleaning is a central need for all types of production.

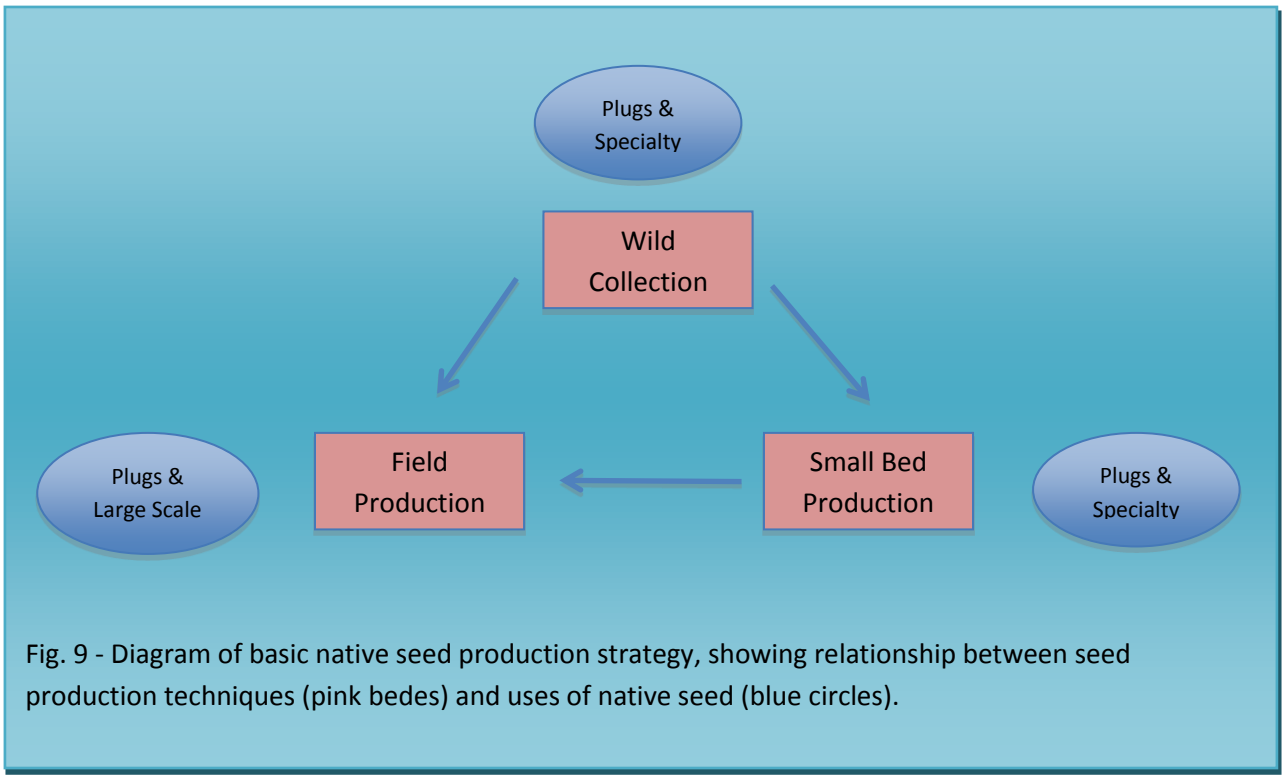

Fig. 9 - Diagram of basic native seed production strategy, showing relationship between seed production techniques (pink bedes) and uses of native seed (blue circles).

A Case Study: Production of *Potentilla gracilis* and *Gallardia aristata*

Seed production strategies for two species illustrate how the basic strategy integrates production techniques and matches those techniques to eventual use. *Potentilla gracilis* and *Gallardia aristata* are both perennial forbs, and showy members of the prairie community. *Potentilla* though is much more common and is one of two-dozen core species for restoration. In contrast, *Gallardia* is infrequent on the prairie, and while it is a very showy and beautiful species it typifies a specialized species. Species which there certainly is a desire to increase, but is not part of current large-scale restoration efforts.

Seed production for both species started with collection from wild populations. *Potentilla* can be gathered from a wide range of locations, while *Gallardia* is limited to only a few wild populations. Additionally, *Potentilla* has been grown to plant plugs for restoration for multiple years, so plugs could be transplanted into seed beds to easily produce sufficient seed for field production. Once this level of seed was obtained then field production of *Potentilla* could be

Fig. 10. The showy *Potentilla gracilis*

initiated either directly from seed or from plant plugs. Direct seeding is the easiest, yet when this was tried in 2010, an unfortunately wet and cold spring precluded germination and field production was set back by a year.

Gallardia production was also initiated with wild collection. The few seeds that were collected were grown into plugs that then were used to start small bed production. Those plants now have grown well and are producing seed used for production of additional plugs or direct seeding out onto specific prairie locations. With the beauty and the potential widespread ecological usage of *Gallardia* by pollinators it will be intriguing to see if the restoration needs for *Gallardia* increase to large-scale levels.

Fig. 11. *Gallardia aristata* seedlings

Summary

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 the larger field production, while scaling upwards to that field production is critical for the core prairie species that will be used to restore or enhance thousands of acres in the South Sound region. 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 – an advantage as prairie restorationists and biologists continue to learn more about desired target communities and the habitat needs of rare animal species.

3 Estimating Seed Production Needs

The scale of restoration and enhancement efforts on South Sound Prairies has increased dramatically over the last few years. Where a hundred thousand plugs met restoration needs a few years ago, now conservationists desire enhancement of hundreds of acres each year. This increase has been fueled by the continuing success in controlling habitat altering pest plants, especially Scotch broom, and by a dramatically increased controlled fire program. These advances in restoration and management have made available hundreds to thousands of acres that are limited by their native plant community prevalence or diversity. Getting these areas restored to a high-level of ecological functioning is critical to maximize the use of protected prairie locations and to recover rare plant and animal species.

Table 2. Factors affecting seed production needs.

Factor	Annual Variation/Degree of Certainty
Field Factors	
Restoration Acreage	Medium / Medium
Intensity of restoration needed	Low / Medium
Site preparation	Medium / Medium
Ecological Target	Low / Medium
Establishment Rate	Medium-High / Low
Production Factors	
Seed Production Rate	Medium / Medium
Plant Density	Low / High
Cultural Practices	Low / Medium
Seed Harvest Efficiency	Low / Medium
Seed Cleaning Efficiency	Low / High

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.

Practically, many of the basic parameters are variable from year to year or are currently being measured. For instance, seed germination and establishment rates for species under field restoration conditions vary with site-preparation methodology and yearly weather. Even fundamentally critical parameters such as the ecological target for restoration are still in flux. While the conservation community continues to collect and integrate the data required to refine the parameters needed to predict seed production, initial seed production efforts need to move forward in the meantime.

Other practical considerations could limit the amount of seed production below any estimated optimal level. First and foremost is funding. Seed production is a multiple-year effort and without continuing funding previous years' efforts can become wasted. This is especially true for slow-growing perennials, such as balsamroot. This species requires several years for plants to gain sufficient size to produce seeds. Similarly, the amount of field space available can limit field production. This is especially true in South Sound, where leased agricultural land is at a premium, with many local growers lacking long-term secured fields.

Table 3. Estimating long-term targets for seed production

Even in the face of uncertainty in estimating seed production needs, a long-term annual production target is useful to direct long-term planning. This will be adjusted as more information on ideal seed mix and establishment success becomes available.

Number of acres to be seeded annually	Forb (80%) and grass (20%) seeds /acre (lbs)	Total seed required (lbs) annually
200	30	6,000

Despite these concerns, seed production needs to proceed even to produce sufficient seed to make better estimates of seeding and establishment rates using large-scale techniques. A practical method is to identify a core set of plant species that are key to long-term ecological functioning and restoration and evaluate the suitability to different production techniques, especially field production. In addition, important specialty species should be identified and evaluated to determine best methods for production. Once these species are cultured and field production and restoration parameters for each species can be measured, then the amount of species under production can be refined.

Evaluation of individual species for their suitability for production under the three basic techniques – wild collection, small bed and field production – involves prioritizing their need for restoration along with the ability and ease of propagation. A generalized rating can identify those species that are best candidates for field propagation and for use in large-scale restoration efforts.

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

This illustrates the potential wide range of estimates for seed use, even when parameters are fairly well known and not extremely variable.

Core Species for Restoration

South Sound conservation partners have identified a set of core species for prairie restoration. This set includes the most prevalent native species, along with several species that are critical for rare butterflies (Table 4). Establishment of new habitat with these species will prove very productive to conservation efforts.

Most of the core species are suitable for field production techniques. They are sufficiently easy to propagate and the restoration needs are large. Some such as Camas and Balsamroot take a longer period for plants to mature sufficiently to produce seed. These are, therefore, more difficult to maintain in a field setting. Other species, such as the violets, have indeterminate flowering and seed production strategies. This necessitates some extra care in the field and novel methodologies to efficiently harvest their seeds. That said, these are critical restoration species, especially for prairie butterflies, and the restoration need overrules any increased propagation efforts. Currently the majority of these species are being raised through field production, see below for summary of current seed production.

Fig. 12. *Microsteris*, a core restoration species.

Table 4. Core species for restoration of South Sound prairies – estimated ease of propagation and estimated need for restoration.

Species	Ease of propag-ation	Need for restor-ation	Species	Ease of propag-ation	Need for restor-ation
Armeria maritima	High	High	*Lupinus albicaulis*	Med	High
Balsamorhiza deltoidea	Low	High	*Lupinus bicolor*	High	Med
Camassia quamash	Low	Med	*Lupinus lepidus*	Med	Med
Campanula rotundifolia	High	Med	*Microseris laciniata*	High	High
Castilleja hispida	Med	High	*Plectritis congesta*	High	High
Collinsia parviflora	High	High	*Potentilla glandulosa*	Low	Med
Danthonia californica	High	Med	*Potentilla gracilis*	High	High
Delphinium nuttallii	High	Med	*Sisyrinchium idahoense*	Med	Med
Erigeron speciosus	Med	High	*Solidago canadensis*	High	Med
Eriophylum lanatum	High	High	*Solidago missouriensis*	High	High
Festuca romerii	High	High	*Solidago simplex*	High	High
Fritillaria affinis	Low	Med	*Viola adunca*	Med	High
Koeleria macrantha	Med	Med	*Viola praemorsa*	Med	Med
Lomatium triternatum	Med	Med	*Zigadenus venenosus*	Low	Med
Lomatiium utriculatum	High	High			

Specialty Species for Restoration

Specialty species can fit into three main categories, see Table 5. Species in category one are currently in, or in the process of establishing, small scale production. These 36 species produce enough seed to meet restoration needs with current production levels. Species in category two have limited wild populations for initial collection and production must be ramped up to a level necessary to move production forward. These 63 species generally begin as native plugs until production parameters are determined. The third category of specialty species is rare or sensitive species as determined by the Washington Natural Heritage Program (WNHP). Currently seven species in production are considered rare or sensitive. Only small amounts of seed are needed to supplement wild populations.

Table 5. Categories of specialty species for small scale production.

Category 1	Category 2		Category 3
Allium amplectens	*Agoseris grandiflora*	*Lomatium dissectum*	*Castilleja levisecta*
Apocynum androsaemifolium	*Anemone lyallii*	*Lonicera hispidula*	*Nuttallantus texanus*
Aquilegia formosa	*Arenaria stricta*	*Lotus nevadensis*	*Packera macounii*
Arabis glabra	*Barbarea orthoceras*	*Lotus unifoliolatus*	*Silene scouleri*
Arabis hirsuta	*Bromus carinatus*	*Madia exigua*	*Symphyotrichum hallii*
Brodiaea coronaria	*Bromus sitchensis*	*Marah oreganus*	*Trillium parviflorum*
Calandrinia ciliata	*Cardamine nuttallii*	*Montia linearis*	*Wyethia angustifolia*
Camassia leichtlinii	*Carex pachystachya*	*Nemophila parviflora*	
Campanula rotundifolia	*Carex tumulicola*	*Nuttallanthus canadensis*	
Cerastium arvense	*Cirsium edule*	*Orobanche uniflora*	
Clarkia amoena	*Cirsium remotifolium*	*Phacelia linearis*	
Collomia grandiflora	*Claytonia parviflora*	*Piperia elegans*	
Delphinium nuttallii	*Claytonia perfoliata*	*Plagiobothrys scouleri*	
Dichelostemma congestum	*Delphinium menziesii*	*Plantago patagonica*	
Dodecatheon hendersonii	*Delphinium trollifolium*	*Poa secunda*	
Elymus glaucus	*Deschampsia cespitosa*	*Prunella vulgaris*	
Fritillaria affinis	*Dichanthelium acuminatum*	*Psilocarphus elatior*	
Gaillardia aristata	*Dichanthelium oligosanthes*	*Ranunculus orthorhynchus*	
Gilia capitata	*Dodecatheon pulchellum*	*Rhinanthus minor*	
Heuchera chlorantha	*Elymus trachycaulus*	*Rorippa curvisiliqua*	
Hieracium cynoglossoides	*Erigeron philadelphicus*	*Rupertia physodes*	
Leptosiphon bicolor	*Erythronium oregonum*	*Sanicula crassicaulis*	
Ligusticum apiifolium	*Galium boreale*	*Spiranthes romanzoffiana*	
Microsteris gracilis	*Geranium bicknellii*	*Synthyris reniformis*	
Navarretia intertexta	*Geranium carolinianum*	*Trifolium microcephalum*	
Navarretia squarrosa	*Hypericum scouleri*	*Trillium chloropetalum*	
Perideridia gairdneri	*Iris tenax*	*Triteleia grandiflora*	
Plagiobothrys figuratus	*Juncus tenuis*	*Viburnum ellipticum*	
Sanicula graveolens	*Lathyrus nevadensis*	*Viola howellii*	
Saxifraga integrifolia	*Lilium columbianum*	*Vulpia microstachys*	
Silene douglasii	*Lupinus polycarpus*	*Vulpia octoflora*	
Sisyrinchium idahoense	*Lithophragma parviflorum*		
Symphyotrichum eatonii			
Trifolium willdenovii			
Triodanis biflora			
Triteleia hyacinthina			
Vicia americana			
Viola glabella			

4 Current Seed Production Efforts

Fig. 13. *Plectritis congestis* seed beds at Shotwell's Landing

Production Locations

Shotwell's Landing Native Plant 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. Occasionally, wild collected seed is only used for plug production to augment wild populations.

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. Appendix 3 is an overview of species currently in production at Shotwell's Landing. Small beds often times have multiple species per bed or remain empty waiting for native plugs from greenhouse production. Each species is identified in production by the four letter code of the first two letters of genus and species. For example, *Castilleja levisecta* is coded as "CALE".

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

Table 6. Shotwell's Landing Production over time

Year	Lbs produced annually	# Species in production	% Rare species	% Restoration species	Notes
2008	35	40	20	80	
2009	50	50	25	75	
2010	53	56	50	50	
2011	45	60	60	40	Shift bulk producing species to Webster's Production
2012	40	65	70	30	Projected #'s

such as *Lupinus albicaulis* will be phased out at small bed production in favor of larger scale grow-out.
Additionally Shotwell's Landing functions as the regional seed processing and storage facility. Regional plant materials are organized, processed, distributed and stored at this facility. Regional plant materials are coordinated here including information on population genetics and establishment methods.

Webster's Nursery

Webster's Nursery serves as the main field production site at this time. The production site is divided into three areas and will continue to expand its role in regional seed production until all areas are in production. In 2007 staff from The Nature Conservancy plugged one acre with native forbs and grasses at Webster's block 24. This initial area (AI) serves as the research and development area with two acres or 85,000 sq. ft. outlined for pilot studies in field production. Cropping methodologies, irrigation options, yield potentials and labor costs are being examined in this section of production which will maintain service options including irrigation. Plugs will continue to be used for crop establishment in this area as well research into methodologies such as sowing species into tarped rows.

In 2010 Area II (the remaining 4.2 acres of Block 24) was directed seeded using a Kasco No-till drill. Area II is divided into annual forb, perennial forb and perennial grasses. This area uses fewer irrigation options and is harvested using appropriately-sized machinery. Specific methodologies for field production that are being identified include the following:

- Seed Collection - the use of tarped beds, vacuums, and costs associated with various machinery.
- Labor Costs - weeding contracts and the workability of large scale intensive hand-weeding.
- Irrigation - survivorship and economy of winter annuals sown out of season with and without irrigation; as well as those sown in season with and without irrigation.
- Crop establishment via sown seed and appropriate equipment.
- Monitoring presence and diversity of pollinators.
- Monitoring soil nutrient and water-holding capacity.

Another top priority over the next five years at Webster's will be to help meet the most pressing goals of the regional core mix. As described earlier the species and amounts of this mix are evolving as observation and inquiry the direct restoration materials that are needed. Appendix 4 indicates the species sown at Webster's based on the original core species mix and the 2010 expansion of additional rows or additional species. This also includes the seed produced in 2010 and the projected amounts of seed to be produced based on other growers' information.

The next five years in Webster's Area II will springboard from a model of that of Heritage Nurseries in the Willamette Valley to a specific cropping plan to satisfy regional need and that fits the production site. Soil moisture levels, site drainage, weedy tree species infestation, seed pests and individual species' harvesting needs are a few of the site-specific cropping plan that are currently being evaluated.

Additional private production facilities have also been explored such as Fourth Corner Nursery in Bellingham, Washington. Fourth Corner currently produces the majority of fescue for South Sound prairie use. The use of private facilities could be a valuable resource as expansion in production of certain species is needed.

Seed Harvesting

Section 2 discusses the three ways in which seed is produced – wild collection, seed bed production and field production.

Prioritizing species collection

Prioritization of species, sites available for collection, collection times and amount of seed needed is identified by professional staff from participating conservation partners and complied for each collection season (Appendix 5). Priority one species require the largest amount of collections from a variety of sites if available. These species indicated for restoration benefits that are currently not in production or production is insufficient for need. Every attempt should be made to record actual or potential collection areas by taking GPS coordinates of populations.

Priority two species are mostly in small production beds that need to be supplemented or in plug production but more seed are needed to adequately establish them. Some species in this category have yet to be established but have been identified as desirable for restoration, albeit not to the extent of species in priority one.

Priority three species are generally already in production and therefore only need supplementary seed, and also include species that have yet to be established in production and have less of a restoration benefit than the other priorities.

In 2011, 129 species were identified for potential collection. 31 of the 42 species indicated as priority one were collected, 23 of the 58 species indicated as priority two were collected and 5 of the 26 species indicated as priority three were collected.

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 or cleaned using a suite of equipment.

Fig. 14. Seed drying hoophouse.

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. 15. A hammermill chops large amounts of plant material.

Fig. 16. 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 pappus's 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. 17. 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. 18. The well-used air screen separator (laboratory version).

Fig. 19. Large Eclipse air screen separator.

Air Column Separator

Fig. 20. 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.

Storage

After seed is cleaned, the majority is allocated out to sites within the region based on considerations such as butterfly need and restoration requirements. The seed is distributed on-site via broadcast sowing or with a no-till seed drill which deposits seed into the ground and provides for soil contact. If seed is not needed for immediate use at restoration sites, it is stored in a temperature- and humidity-controlled room. Since information is not available on specific species temperature and humidity needs for storage, it is currently stored at 40 degrees and 40% relative humidity.

Additional Considerations

Several additional considerations are important to long-term successful seed production. These are: documentation associated with seed production, development of production methods and genetic considerations. Each area has important ramifications for overall success of a seed production program, yet each also has areas where the optimum and practical considerations could be in conflict. Providing sufficient balance between protecting the program from potential miscues or making additional improvements and the cost to conduct that work needs to be periodically evaluated by the production manager, end-users and funders.

Seed production documentation – The source, handling, quality and eventual fate of every lot of seed collected or produced can critical towards understanding patterns of restoration success or failures. The importance of such documentation was illustrated early on in the

restoration efforts in South Sound prairies, when seed from a commercial grower proved to be red fescue rather than the desired, and purchased, Roemers fescue. While this substitution proved to have only minor impacts on the ground, it did set back seed production efforts, and as a consequence restoration efforts, by multiple years. What could have been a minor problem proved more difficult when the records of the commercial grower were inadequate concerning the source of the seed.

Fig 21. Label used to document source information for wild collected seed.

Yet tracking and recording the fate of every lot of seed entering and exiting the seed production process can be overwhelming. For wild collected seed, every location, collector and date could be segregated to help identify if there is a varied response between these lots in viability, phenology or other characteristics. Similarly, the genetic source for lots produced in field production is important, as is recording the plant culture, harvest and seed cleaning techniques used to process the seed. When the total number of different collected and produced lots is considered, and the effort needed to segregate and document these lots, the administrative effort is significant.

Balance between adequate documentation and expense needs to be maintained. Optimally this balance is refined based on the number of problems encountered in the use of the seed. Are differences between individual collectors at the same site significant? What are the genetic purity requirements of end-users, and is documentation, and handling, sufficient to maintain the needed segregation? These types of questions could be answered in the most conservative way, but the costs associated with that level of safety can be tremendous.

Related to this degree of balance is the amount of separate testing on seed lots. Viability, germination or genetic tests can all be important. Yet again, a balance between the most rigorous, conservative set of tests and costs of such tests is needed, weighing the costs with associated return and safety. The balance can be informed by the number of problems encountered in the production and restoration efforts, with testing reduced as a positive production track record is maintained. Some baseline level of testing should continue even when production has been successful; this type of information is most useful once a problem surfaces, which is necessarily after the fact.

Proper testing is best performed by Association of Official Seed Analysts (AOSA) certified seed labs operated by universities such as Oregon State University. They can perform a variety of tests that can be valuable for producers such as percent live seed and viability from each seedlot.

Development of production methodology - Improving and refining production methodology to increase seed production levels and efficiency is incorporated into the standard practices of the seed production program. The use of adaptive management principles, where efforts are recorded and outcomes changed as warranted should prove useful. Production at different scales, such as small bed versus field production, could facilitate such development. Plant culture techniques can be tested in a small bed situation much easier than the larger field. The ability to use the smaller beds with formal experimental configurations could facilitate these tests also.

Data and improvements from trials should be formally recorded and distributed to practitioners elsewhere in the region. This practice will help improve seed production elsewhere, enhancing conservation throughout the region. Methods for communication can range from presentations at formal conferences, or in published papers, to informal web-based communications or site visits to other production facilities. If a suite of enhancements are finished then a more formal summary would be appropriate.

Genetic considerations

The genetic make-up of any source population is a concern for propagation and restoration efforts. This is true for both wild collection and seed production. During wild collection a single small population could be targeted on purpose or by chance, or collection could occur on only a single day, eliminating seeds that mature earlier or later. Similarly in field production, the initial source of plants needs to be considered as does the possible selection pressure applied in the field propagation environment.

The significance of these considerations is magnified when seed produced is used to restore large acreages of native habitat. With the establishment of entire parcels from a single source of seed, any genetic constraint will be present for an extended period, if not forever, on the site.

An additional genetic consideration is the issue concerning appropriate source populations for restorations. This is typically thought about in terms of geographic distance from a restoration site, but since the reproductive ecosystems, including pollinators, differ between species, then

generalized recommendations for all species are just that generalized recommendations. Seed zones have been clearly researched and delineated for example, forest trees, but such research is unlikely to be applicable to grassland species. Even within our grassland species, the difference in reproductive systems and population genetics of perennial grasses and perennial or annual forbs is tremendous.

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 the closes source population has been 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.

For common restoration species delineations within the South Sound region have not been made. Seed have been generally sourced from multiple sites and propagation efforts have not distinguished between sources. While a more conservative approach to genetic considerations could be justified, the time and expense associated with segregating sites, let alone unknown populations, is prohibitive. One of the needs for regional restoration is closer documentation of restoration efforts, including the genetic makeup of seed mixtures used for restoration.

Contact details

Questions regarding this Native Seed Production Strategy may be directed to:

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agoodrich@cnlm.org

Further information on prairie conservation in South Puget Sound may be found at www.southsoundprairies.org.

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

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

APPENDIX 2 – Seed Collection Handbook 2011

(updated annually)

PRAIRIE WILD SEED COLLECTION

Why Seed Is Collected

1. To restore Native Shortgrass Prairie populations through the increase of native plant materials.
    a. Plug Production
    b. Seed Production – For the Direct Seeding of Annual and Perennial Forbs and Grasses
        i. Increases Availability of Rare Seed
        ii. Decreases Pressure on Wild Populations
            (a) Refresh Cultivated Genetics

B. Who

1. Roles
    a. Property Managers
        i. Determines species needs for specific restoration sites.
        ii. Provide information on areas to be avoided such as research plots, areas with sensitive plants or animals.
        iii. Provide information on best seed collection areas for specific plants.
        iv. Provide observations about senescing plants, flagged plants, etc.

b. Shotwell's Nursery Manager/South Sound TNC

   i. Compile collection lists by species, site and priority.

   ii. Compute volume of seed to be collected.

   iii. Coordinate with Seed Collection Coordinators on general seed collection schedule.

   iv. Disperse seed collection materials such as special flagging, and reusable envelopes and bags.

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

   vi. Coordinate hand seed cleaning--set 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 Shotwell's 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 the markings such as whiskers, rebar, flags, etc.

(b) Describe collection area boundaries in terms of landmarks

(c) 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.

(d) Discuss the need for seeds to be representative of all the plants--biggest is not necessarily the best.

(e) Spread the collectors out over the entire area from which seed is to be collected.

(f) If on-base have Range Control Authorization in hand and follow phone protocol when arriving and leave a Training Area. See Appendix 9.

C. Where

1. Joint Base Lewis McChord: TNC Contact Sanders Freed, sfreed@tnc.org : JBLM Contact Rod Gilbert, roderick.gilbert1@us.army.mil

a. Range Control Authorization--must have on person
   i. Johnson
   ii. Weir--Upper, Lower, South
   iii. TA7S
   iv. TA14 and TA15 (Pacemaker)

b. Restricted Areas
   i. Ft. Lewis/TNC Cleared Staff only

2. TNC Managed Areas: Sanders Freed, sfreed@tnc.org
    a. Cavness
    b. Glacial Heritage Preserve
    c. Sergeant Road*
    d. Tenalquot
    e. Wolf Haven

3. Washington Department of Natural Resources: David Wilderman, david.wilderman@dnr.wa.gov
    a. Bald Hills
    b. Mima Mounds
    c. Rocky Prairie
    d. Bald Hills Seed Beds

4. Washington Department of Fish & Wildlife: Dave Hays, haysdwh@dfw.wa.gov
    a. Scatter Creek--North & South Units
    b. West Rocky

5. Seed Production Sites: Anita Goodrich, agoodrich@tnc.org
    a. Shotwell's Landing Native Plant Nursery
    b. Webster Forest Nursery

6. Plug Production Nurseries: Anita Goodrich, agoodrich@tnc.org
    a. Shotwell's Landing Native Plant Nursery
    b. Stafford Creek Correctional Center (Sustainable Prisons Project)

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 at least tan.

        iii. Hardness

            (a) When pinched between your fingers, capsules should be hardened and dry.

        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.
        i. Tarp or snood these species for maximum collection or revisit throughout the season.
3. Effects of Weather
    a. Bloom time
    b. Pollination/Seed Development
    c. Seed Collection
        i. General Rule: DO NOT COLLECT IN THE RAIN
4. Effects of Elevation and Microclimates
    a. Know your collection area

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, instead collect across the site and several sites if possible. Also collect several times within the collection period to increase genetics of earl versus late flowering plants.
    c. Collect no more than 20% of 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
    b. GPS: Only GPS significant populations of widespread species and individual populations of uncommon species.
    c. Notes: Important for describing multiple locations within one area.
3. Materials
    a. Containers
        i. Paper vs. plastic
            (a) Size appropriate
            (b) Taping seams
            (c) Labels & pencils
        ii. Jars
        iii. Snoods
        iv. Packaging tape samples
4. Stem vs. head/capsule

a. Use family based collection techniques provided below to determine best collection method for each species. Remember whatever goes into the envelope has to be separated from the seed. The smaller the seed the harder to remove from chaff material.

5. Insect control
   a. Avoid plants with known infestations, look to collection leaders for assistance on identification.
   b. Drop seed at Nursery ASAP for quick insect removal.
6. Aftercare
   a. Drop-off at Nursery ASAP: If you are unable to do so within the day, take plant material to a cool area away from direct light and spread out to dry. Take care to keep species separate to avoid contamination.
      i. Frequency=ASAP
      ii. Drop-off location
         (a) Drop box located on the north side of Seed Processing Building
      iii. Drop-off log
         (a) ALWAYS fill out information in the seed drop off binder, follow provided directions.

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! See *Fescue Taxonomy*--Appendix 5. 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 maritime;* 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 out

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. See Appendix 6 -- Natural Selection for a Fruit Dimorphism in *Plectritis Congesta;* Ganders, Carey, & Griffiths

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 abut 4 large brown seeds.

R. Saxifrage (Saxifragaceae): Grassland Saxifrage--*Saxifraga integrifoli;* 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 [not included here for space reasons]

1. Seed Collection Overview
2. Field Crib Sheet
3. 2010 Master Plant List
4. Grasses
    a. Prairie Grasses Spreadsheets by Dunwiddie
    b. Fescue Taxonomy by Dunwiddie
5. Natural Selection for a Fruit Dimorphism in *Plectritis Congesta* by Ganders, Carey, & Griffiths
6. Driving Directions & Maps
7. List of Seed Collection Leaders Kit of Goodies
8. Sample of Range Control Authorization
9. CDs
    a. Photos--Blooming, Senesced , Seed
    b. Label format -- 14 per sheet
    c. Master List of Plants
    d. Prairie Species Information

APPENDIX 3 – Plants currently in production at Shotwell's Landing

(as of October 2011)

1. Ligusticum aplifolium (LIAM)
2. Camassia quamash (CAQU)
3. Perideridia gairdneri (PEGA)
4. Camassia quamash (CAQU)
5. Aster hallii (ASHA)
6. Potentilla glandulosa (POGL
7. Trillium parviflora (TRPA)
8. Danthonia californica (DACA)
9. Solidago missourensis (SOMI)
10. Lomatium triternatum (LOTR)
11. Koeleria macranthes (KOMA)
12. Sisirynchium idahoense (SIID) and Cearastium arvense (CEAR)
13. Silene douglasi (SIDO)
14. Microseris laciniata (MILA)
15. Lupinus albicaulis (LUAL)
16. Castilleja hispida (CAHI) and Eriophyllum lanatum (ERLA)
17. Lomatium bradshawii (LOBR)
18. Alium amplictens (ALAM)
19. Perideridia gairdneri (PEGA)
20. Saxifraga integrifolia (SAIN) and Silene scouleri (SISC)
21. Lomatium nudicaule (LONU)
22. Delphinium nutallii (DENU)
23. Empty
24. Empty
25. Arabis glabra (ARGL)
26. Ranunculus occidentalis (RAOC)
27. Plantago lancelota (PLLA) and Sidalcea nelsonianna (SINE)
28. Balsamorizha deltoidia (BADE)
29. Eriophyllum lanatum (ERLA) and Castilleja hispida (CAHI)
30. Empty
31. Plectritis congesta (PLCO)
32. Potentilla glandulosa (POGL)
33. Zigadenus (ZIVE)
34. Collinsia parviflora (COPA)
35. Collinsia grandiflora (COGR)
36. Empty and Tritelia hyanthacina (TRHY) and Empty
37. Microseris laciniata (MILA) and Eriophyllum lanatum (ERLA)
38. Aquilega Formosa (AQFO)

39. Lomatium utriculatum (LOUT)
40. Carex inops (CAIN)
41. Heuchera chlorantha (HECH)
42. Naveretta intertexta (NAIN)
43. Viola praemorsa (VIPR)
44. Camassia quamash (CAQU)
45. Naveretta squarosa (NASQ)
46. Empty
47. Empty with Dodcatheon hendersonii (DOHE)
48. Frageria virginiana (FRVI)
49. Empty
50. Empty
51. Festuca romerii (FERO)
52. Empty
53. Gallardia aristata (GAAR)
54. Sisyrinchium idahoense (SIID)
55. Camassia leichlini (CALEI)
56. Empty
57. Empty
58. Gilia capitata (GICA)
59. Empty
60. Gila capitata (GICA) and BADE and VIPR
61. Erigeron specious (ERSP)
62. Festuca romerii (FERO)

APPENDIX 4 – Plants sown at Webster's Nursery

Websters Species (Established in 2009-2010)	Scale (sq. ft.)	Acreage	2010 Yields (lbs)	lb/ac Yr 2 Yield (Boyer)	2011 Expected Yield (lbs)	lb/ac Yr 3 Yield (Boyer)	2012 Expected Yield (lbs)	2013 Expected Yield (lbs)
Achillea millefolium	3000	0.07	3	287	19.76584	335	23.0716253	
Aster hallii	1500	0.03	1.5	40	1.3774105	80	2.75482094	
Balsamorhiza deltoidea	3000	0.07	0	0.4	0.0275482	91	6.26721763	6.2672176
Camassia quamash	3000	0.07	0	0	0	45	3.09917355	3.1
Castilleja hispida	3000	0.07	1.3	60	4.1322314	80	5.50964187	
Clarkia amoena	3000	0.07	10					
Collinsia parviflora	3000	0.07	6.2					
Danthonia californica	9000	0.21	0	263	54.338843	180	37.1900826	
Eriophyllum lanatum	3000	0.07	17.8	350	24.104683	430	29.6143251	
Festuca roemeri	6000	0.14	0	218	30.027548	600	27.5	
Koeleria macrantha	3000	0.07	0	150	10.330579	200	13.8	
Lomatium triternatum	6000	0.14	2.6	Unknown	Unknown	Unknown	Unknown	Unknown
Lomatium utriculatum	3000	0.07	6.4	572	39.393939	507	34.9	
Lupinus albicaulis	9000	0.21	16.3	295	60.950413	275	56.8	
Lupinus bicolor	3000	0.07	12.5	Unknown	Unknown	Unknown	Unknown	Unknown
Lupinus lepidus	3000	0.07	1.2	Unknown	Unknown	Unknown	Unknown	Unknown
Microseris laciniata	3000	0.07	8.1	248	17.07989	250	17.2	
Plagiobothrys figuratus	3000	0.07	3.5					
Plectritis congesta	1600	0.04	5.7					
Ranunculus occidentalis	6000	0.14	0	156	21.487603	150	20.661157	
Solidago missouriensis			Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Websters Species (Established in 2010-2011)								
Apocynum androsaemifolium	1600	0.04	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown

s

Balsamorhiza deltoidea	6000	0.14		0.4		91	0.05509642	12.534435
Camassia quamash	3000	0.07		0	0	45	3.09917355	3.0991736
Campanula rotundifolia	1600	0.04	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Clarkia amoena	6000	0.14	10		39.944904			
Collinsia grandiflora	3000	0.07	8		13.636364			
Collinsia parviflora	9000	0.21	8		16.528926			
Dodecatheon hendersonii	1600	0.04	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Delphinium nuttalli	3000	0.07	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Elymus glaucus	3000	0.07	200	300	20.661157	180	20.661157	12.396694
Erigeron speciosus	3000	0.07	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Eriophyllum lanatum	3000	0.07	20	350	1.584022	430	24.1046832	29.614325
Hieracium cynoglossoides	1600	0.04	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Lupinus bicolor	6000	0.14	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Lupinus lepidus	5000	0.11	15	Unknown	28.696051			
Microsteris gracilis	1600	0.04	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Plagiobothrys figuratus	1600	0.04	5		3.9669421			
Plectritis congesta	9000	0.21	10		16.942149			
Potentilla gracillis	3000	0.07		102		415	7.02479339	28.581267
Sericocarpus rigidus	9000	0.21	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Solidago simplex	3000	0.07	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Websters Species (Plugged in 2010-2011)								
Armeria martima	5000	0.11						
Viola adunca	1600	0.04						
Potentilla gracillis	1000	0.02						
Frageria virginiana	1500	0.03						

APPENDIX 5 – Seed collection priority table for 2011

H=High Priority Species; M=Medium Priority species

Species Information				Collection Locations				Add. Information	
Code	Botanical Name	Common Name	Family	JBLM Location	JBLM	Off Base Locations	S.S.	Previous Names	Oak spp.
Priority 1									
APAN	Apocynum androsaemifolium	Spreading Dogbane	*Apocynaceae*	Anywhere	M		H		
AQFO	Aquilegia formosa	Red Columbine	*Ranunculaceae*	R76, Johnson	H	SL	M		X
BADE	Balsamorhiza deltoidea	Puget Balsamroot	*Compositae*	7S, R76, Johnson	H	SL			
BRCO	Brodiaea coronaria	Harvest Brodiaea	*Liliaceae*	TA 7s	H		M		X
CAIN	Carex inops	Long-stoloned Sedge	*Cyperaceae*			SL	H		
CALE	Castilleja levisecta	Golden Paintbrush	*Scrophulariaceae*			WB, RP, HRD, NEK, SJI	H		
CALEV	Camassia leichtlinii*	Great Camas	*Liliaceae*	AIA	H		M		X
CANU	Cardamine nuttallii	Oak Toothwork, Slender Toothwort	*Brassicaceae*	UW	H	GH	H	Cardamine pulcherrima var. tenella (CAPU)	X
CEAR	Cerastium arvense	Field Chickweed	*Caryophyllaceae*	Seed Plot, TA 7s, Anywhere	H	SL	H		
DENU	Delphinium nuttallii*	Nuttall's Larkspur, Upland Larkspur	*Ranunculaceae*	TA 13, 15	H	SL, GH, WH			
DICO	Dichelostemma congestum*	Ookow or Cluster Lily	*Liliaceae*	Edge AIA	H		H	Brodiaea congesta (BRCON)	X
DOHE	Dodecatheon hendersonii*	Broad-leaved Shooting Star	*Primulaceae*	MP1, UW	H	SL, GH	M		

s

DOPU	Dodecatheon pulchellum*	Few-flowered Shooting Staf	*Primulaceae*	TA 14	H		M		
ERPH	Erigeron philadelphicus	Philadelphia Fleabane	*Compositae*	Seed Plot	H	RP?	M		
FRAF	Fritillaria affinis	Chocolate Lily	*Liliaceae*	Anywhere, TA 7S, R76	M	GH	M	Fritillaria lanceolata (FRLA)	X
GEBI	Geranium bicknellii*	Bicknell's Cranesbill	*Geraniaceae*	AIA	H		M		X
HECH	Heuchera chlorantha*	Tall Alumroot	*Saxifragaceae*	Cantonement TA 4B	H	SL	M		X
HICY	Hieracium cynoglossoides	Hound's Tongue Hawkweed	*Compositae*	R 76 Anywhere	H	GH,			
IRTE	Iris tenax *	Oregon iris	*Iridaceae*			Case rd,	H		X
LIPA	Lithophragma parviflorum*	Small-flowered Woodland Star	*Saxifragaceae*	R 50, MP13	H		H		X
LOTR	Lomatium triternatum	Nine-leaved Lomatium	*Umbelliferae*	TA 7s	M	SL, WB, GH	M		
LOUT	Lomatium utriculatum	Spring Gold	*Umbelliferae*	TA 7S, Johnson, Seed plot	H	SL, WB, GH	M		
LULE	Lupinus lepidus	Prairie Lupine	*Leguminosae*	Anywhere	M	SL, WB, GH	M		
PAMA	Packera macounii	Macouni's Groundsel	*Asteraceae*	Rod GPS Points	H		H	Senecio macounii (SEMA)	X
PEGA	Perideridia gairdneri	Gairdner's Yampah	*Umbelliferae*	TA 13, 14, 15, Span Lk	H	SL, GH	H		X
PLCO	Plectritis congesta	Sea Blush	*Valerianaceae*			WB	H		
PLFI	Plagiobothrys figuratus	Fragrant Popcorn Flower	*Boraginaceae*	Seed Plot	M	WB, SC, SL	M		
RAOC	Ranunculus occidentalis	Western Buttercup	*Ranunculaceae*		H	All prairies, SL, WB	M		
RUPH	Rupertia physodes*	Forest Scrufpea	*Fabaceae*	AIA, Marion,	H		H	Psoralea physodes (PSPH)	X
SAGR	Sanicula graveolens*	Sierra Sanicle	*Umbelliferae*	7S, UW, R76	H		H		X
SISC	Silene scouleri *	Scouler's Campion or Catchfly	*Caryophyllaceae*	TA6, U/LW	H	SL,	M		X

SYEA	Symphyotrichum eatonii*	Eaton's Aster	*Asteraceae*	TA 14, 15, 7S, Marion	H			Aster eatonii (ASEA)	
SYHA	Symphyotrichum hallii	Hall's Aster	*Asteraceae*	Seed Plot	H			Aster hallii (ASHA)	
TRBI	Triodanis biflora *	Venus' Looking Glass	*Campanulaceae*		H	SL	M	Triodanis perfoliata (TRPE)	X
TRGR	Triteleia grandiflora *	Howel's Brodiaea	*Liliaceae*	R76	H	GH		Brodiaea howellii (BRHO)	
TRHY	Triteleia hyacinthina*	Fools Onion	*Liliaceae*	R50, TA 15	H		H	Brodiaea hyacinthina (BRHY)	X
TRWI	Trifolium willdenovii *	Sand Clover	*Leguminosae*	AIA	H	SL	H	Trifolium tridentatum (TRTR)	
VIAD	Viola adunca	Early Blue Violet	*Violaceae*		H	WB	M		
VIAM	Vicia americana *	Wooly Vetch	*Leguminosae*	R 76 Anywhere	H		M	Vicia americana v. villosa	
VIHO	Viola howellii*			Cantonement	H		H		X
VIPR	Viola praemorsa*	Yellow Montane Violet, Canary Violet	*Violaceae*	TA 13, 14, 15 Anywhere	H	SL	H	Viola nuttallii (VINU)	
WYAN	Wyethia angustifolia*	Mule's Ears	*Asteraceae*		M		H		
Priority 2									
AGGR	Agoseris grandiflora *	Large-flowered Agoseris	*Compositae*	Seed Plot	L		H		X
ALAM	Allium amplectens *	narrowleaf wild onion	*Liliaceae*				H		X
ANLY	Anemone lyallii *	Ranunculaceae	*Lyall's anemone*				H		X
ARMA	Armeria maritima	Sea Pink, Thrift	*Plumbaginaceae*	Pacemaker, R76, seed plot	H		L		
ARST	Arenaria stricta *			R 76	H				
BAOR	Barbarea orthoceras *	American Winter Cress	*Brassicaceae*	TA 13, 15	H				
CACI	Calandrinia ciliata	Red Maid or Desert Rock Purslane	*Portulacaceae*	Shotwells	H				

CAHI	Castilleja hispida	Harsh Paintbrush	*Scrophulariaceae*	Pacemaker, TA7s, R50	H		M		
CAQU	Camassia quamash	Common Camas	*Liliaceae*	TA 15	M				
CARO	Campanula rotundifolia	Harebell	*Campanulaceae*	7s Pacemaker	H		L		
CATU	Carex tumulicola *	Foothill sedge	*Cyperaceae*				H		X
CIED	Cirsium edule *	edible thistle	*Asteraceae*				H		X
CIRE	Cirsium remotifolium *		*Asteraceae*				H		X
CLAM	Clarkia amoena	Farewell-to-spring	*Onagraceae*	Seed Plot	M		L		
COGR	Collinsia grandiflora	Large-flowered Blue-eyed Mary	*Scrophulariaceae*		M		M		
COGRX	Collomia grandiflora*	Grand Collomia	*Polemoniacae*				H		X
COPA	Collinsia parviflora	Small-flowered Blue-eyed Mary	*Scrophulariaceae*				H		
DECE	Deschampsia cespitosa*	Tufted Hairgrass	*Poaceae*				M	Deschampsia caespitosa (DECA)	
DEME	Delphinium menziesii*	Mensies' Larkspur	*Ranunculaceae*				H		X
DETR	Delphinium trollifolium*	Ranunculaceae					H		X
DIAC	Dichanthelium acuminatum *	Western Panicum	*Poaceae*	Anywhere	H			Panicum occidentale (PAOC)	
DIOL	Dichanthelium oligosanthes *	Few-flowered Panicum, Scribner's rosette grass	*Poaceae*	Anywhere	H			Panicum scribnerianum (PASC)	
ERLA	Eriophyllum lanatum	Oregon Sunshine	*Compositae*	Anywhere, seed plot	H		M		
EROR	Erythronium oregonum*	Fawn Lily	*Liliaceae*	Unknown	L		H		X
GAAR	Gaillardia aristata*	Blanket Flower	*Compositae*	Seed plot, Pacemaker, TA 6	M				
GABO	Galium boreale *		*Rubiaceae*				M		X

LEBI	Leptosiphon bicolor *	True Babystars	*Polemoniaceae*	Johnson, R76	H			Linanthus bicolor v. bicolor (LIBI)	
LIAP	Ligusticum apiifolium*	celery leaved lovage	*Apiaceae*				M		X
LICO	Lilium columbianum*	Columbia Lily, Western Tiger Lily	*Liliaceae*	TBD	H				
LODI	*Lomatium dissectum**	Fern leaved lomatium	*Apiaceae*				M		X
LONE	Lotus nevadensis*	Douglas' Bird's-foot Trefoil	*Leguminosae*	TA 14, Marion	H				
LOUN	Lotus unifoliolatus *	American Bird's-foot Trefoil	*Leguminosae*	TA 15 Mck Crk	H			Lotus purshiana (LOPU)	
LUAL	Lupinus albicaulis	Sicklekeel Lupine	*Leguminosae*	TA 14	H		L		
LUBI	Lupinus bicolor	Bicolor Lupine	*Leguminosae*	Anywhere	H		L		
LUPOC	Lupinus polycarpus *	Small-flowered Lupine	*Leguminosae*	R 76	H			Lupinus micranthus (LUMI)	
MAEX	*Madia exigua *		*Asteraceae*				H		X
MIGR	Microsteris gracilis*	Pink Microsteris	*Polemoniaceae*				H		
MOLI	Montia linearis*	Narrow-leaved Montia	*Portulacaceae*	TA 13, 15	H			Claytonia linearis (CLLI)	
NAIN	Navarretia intertexta *	Needleleaf Navarretia	*Polemoniaceae*	TA 15, MP 13, TA 6	H				
NASQ	Navarretia squarrosa*	Skunkbush	*Polemoniaceae*	TA 15, MP 13, TA 6	H				
NUCA	Nuttallanthus canadensis *	Blue Toadflax	*Scrophulariaceae*	Seed Plot	H			Linaria canadensis (LICA)	
NUTE	Nuttallantus texanus*	Blue Toadflax	*Scrophulariaceae*				M	Linaria canadensis v. texana (LICA)	
ORUN	Orobanche uniflora*	Naked Broomrape	*Orobanchaceae*		M				
PLPA	Plantago patagonica*			Johnson	H				
PLSC	Plagiobothrys scouleri*	Scouler's Popcorn Flower	*Boraginaceae*	TA 13, 15	H				
POSE	Poa secunda*	Sandberg Bluegrass	*Poaceae*	AIA	H			Poa sandbergii (POSA)	
PRVU	Prunella vulgaris *			Anywhere, TA 6	H				

PSEL	Psilocarphus elatior*			TA 15	L				
RAOR	Ranunculus orthorhynchus*	Straight-beaked Buttercup	*Ranunculaceae*				H		
RHMI	Rhinanthus minor *	Little Yellow Rattle	*Scrophulariaceae*	TA 12,	H			Rhinanthus crista-galli (RHCR)	
SACR	Sanicula crassicaulis*	Pacific Sanicle	*Umbelliferae*				M		X
SAIN	Saxifraga integrifolia	Grassland Saxifrage	*Saxifragaceae*	AIA	H				
SIDO	Silene douglasii *	Douglas' Campion or Catchfly	*Caryophyllaceae*	Shotwells, AIA	H				
SIID	Sisyrinchium idahoense	Blue-eyed Grass	*Iridaceae*	AIA	M			Sisyrinchium angustifolium (SIAN)	
SOCA	Solidago canadensis	Canadian Goldenrod	*Compositae*	Anywhere	L		M		
SPRO	Spiranthes romanzoffiana *	Ladies' Tresses	*Orchidaceae*				M		
SYRE	Synthyris reniformis*	Snow queen	*Scrophulariaceae*				M		X
TRMI	Trifolium microcephalum*	Small-headed Clover	*Leguminosae*	AIA, TA 15	H				
TRPA	Trillium parviflorum*	Small-flowered Trillium	*Liliaceae*				H		X
VIEL	*Viburnum ellipticum	Oval-leaved Viburnum	*Caprifoliaceae*	Cutting TA 18	L		H		
VIGL	Viola glabella*	Stream Violet, Yellow Wood Violet	*Violaceae*				M		
Priority 3									
ARGL	Arabis glabra	Tower Mustard	*Brassicaceae*	Seed Plot	L				
ARHI	Arabis hirsuta	Hairy Rockcress	*Brassicaceae*	Seed Plot	L				
BRCA	Bromus carinatus*			AIA, Johnson	L				
BRSI	Bromus sitchensis*	Alaska Brome	*Poaceae*				L		X
CAPA	Carex pachystachya *	thick headed sedge	*Cyperaceae*				L		X
CLPA	Claytonia parviflora *	Small flowered miner's lettuce	*Portulacaceae*				L		X
CLPE	Claytonia perfoliata *	miner's lettuce	*Portulacaceae*				L		X

DACA	Danthonia californica	California Oatgrass	*Poaceae*				L	Danthonia americana (DAAM)	
DASP	Danthonia spicata	Poverty Oatgrass	*Poaceae*				L		
ELTR	Elymus trachycaulus *	Slender Wheatgrass	*Poaceae*	AIA	L			Agropyron caninum (AGCA)	
ERSP	Erigeron speciosus	Showy Fleabane	*Compositae*	Seed Plot	L		L		
FERO	Festuca roemeri	Roemer's Fescue	*Poaceae*	Anywhere	L				
GECA	Geranium carolinianum*	Carolina Geranium	*Geraniaceae*				L		
GICA	Gilia capitata*	Blue Gilia	*Polemoniaceae*		M		L		
HYSC	Hypericum scouleri *	Western St. John's wort	*Clusiaceae*				M		X
JUTE	Juncus tenuis *	Poverty rush	*Juncaceae*				L		X
KOMA	Koeleria macrantha	June Grass	*Poaceae*				M	Koeleria cristata (KOCR)	
LANE	Lathyrus nevadensis *		*Fabaceae*				L		X
LOHI	Lonicera hispidula *	Hairy honeysuckle	*Caprifoliaceae*				L		X
MAOR	Marah oreganus*	Manroot	*Cucurbitaceae*				M	Echinocystis oregana	X
MILA	Microseris laciniata	Cutleaf Microseris	*Compositae*	Anywhere, seed plot	L		L		
NEPA	Nemophila parviflora*	Spreading nemophylla	*Hydrophyllaceae*				L		X
PHLI	Phacelia linearis *	narrow leaved phacelia	*Hydrophyllaceae*				L		X
PIEL	Piperia elegans *	Rein Orchard or Elegant Pipera	*Orchidaceae*				L	Habenaria greenei (HAGR)	X
POGL	Potentilla glandulosa*	Sticky Cinquefoil	*Rosaceae*				M		X
POGR	Potentilla gracilis	Graceful Cinquefoil	*Rosaceae*	Anywhere	L		L		
ROCU	Rorippa curvisiliqua*			TA 15, seed plot	L				
SERI	Sericocarpus rigidus	White-topped Aster	*Asteraceae*				M	Aster curtus (ASCU)	
SOMI	Solidago missouriensis	Missouri Goldenrod	*Compositae*			Flag early to ensure posidive ID	L		

SOSI	Solidago simplex	Canadian Goldenrod	*Compositae*			Flag early to ensure posidive ID	L	Solidago spathulata (SOSP)	
TRCH	Trillium chloropetalum*			TA 14	L				
VUMI	Vulpia microstachys*	Small fescue	*Poaceae*				M		X
VUOC	Vulpia octoflora *	Eight flowered fescue	*Poaceae*				M		X
ZIVE	Zigadenus venenosus	Death Camas	*Liliaceae*	Anywhere	L		L		

Site Name	**Code**
South Sound Collection Sites	
Bald Hills	BH
Case Road	CRD
Caveness Property	CP
Chehalis Western Trail	CWT
Glacial Heritage	GH
Lewis County	LC
Mima Mounds NAP	MM
Rocky Prairie	RP
Sargent Road	SRD
Scatter Creek	SC
Scatter Creek--North Unit	SCN
Scatter Creek--South Unit	SCS
Tenalquot	TQ

West Rocky	WR
Wolf Haven	WH
Joint Base Lewis McChord Collection Sites	
Artillery Impact Area	AIA
Johnson Prairie	JP
Lower Weir	LW
Seed Plots on JBLM	SP
South Weir	SW
Training Area 14 (Pacemaker)	TA14
Training Area 15	TA15
Training Area 7S	TA7S
*Same pattern for all TA's	TA**
*Same pattern for any Quadrants	Q'**
Upper Weir	UW
North Sound Collection Sites	
Neukom	NEK
Ft. Casey State Park	FTC
Hill Road (Ebey's Landing)	HRD
Jarisch plus Original Collection Site	J-**
Naas Preserve	NAS
Pacific Rim Insitutue (AuSable)	PRI
Point Disney (Waldron)	WAL
San Juan Island Historic Park	SJI

West Beach	WBH
Production Sites	
Shotwell's Landing	SL
Webster's Nursery	WB
Stafford Creek Corr. Center	SCCC
Bald Hills Nursery Beds (located at Mima)	BH2