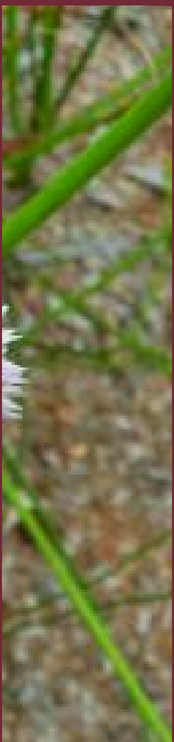

PROVIDING NATIVE PLANT DIVERSITY TO THE WILLAMETTE VALLEY ECOREGION

No-tech, low-tech, and old-tech seed production methods

| **Lynda Boyer**

ABSTRACT

Producing seeds of multiple Willamette Valley prairie forb species is challenging for a grower. Many species do not lend themselves to standard commercial seed production methods. This reality has driven us to find creative, efficient ways to produce seeds of some of the more challenging species. By sharing our results, Heritage Seedlings Inc hopes to provide restoration professionals and native seed buyers with information critical to planning projects and selecting materials.

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KEY WORDS

native Willamette Valley seed, seed harvest, prairie species

NOMENCLATURE

USDA NRCS (2008)

Prior to settlement of the Willamette Valley by Euro-Americans 170 y ago, much of the Willamette Valley comprised open savanna and prairie. Now less than 1% native upland and wet prairie habitat remains (Habeck 1961; Johannessen and others 1971; Towle 1982) so the need to protect and restore this threatened ecosystem is well-established. Native prairie restoration is in its infancy in the Willamette Valley. Wetland prairie restoration began in earnest about 13 y ago, and upland prairie restoration a mere 6 y ago (Smith 2008). Much of the initial focus for seed production was on graminoids and a few common matrix forb species. Recently, however, restoration professionals have emphasized much higher levels of diversity in restoration projects. The preliminary draft Recovery Plan for the Prairie Species of Western Oregon and Southwestern Washington (USFWS, unpublished) notes that habitat quality is linked to the diversity of native plants. This diversity will attract and maintain pollinator populations, which, in turn, helps maintain self-sustaining plant populations.

In 2001, I was facilitating the restoration of oak savanna habitat on a farm owned by Heritage Seedlings. During the planning process, I noted a low diversity of forb seeds from our ecoregion were available on the market, especially for upland prairie. Our need and the need of other restoration professionals in the valley became the impetus for starting our native seed production program. As manager of this fledgling program, identifying the most appropriate species to grow became my first priority.

I started with the prairie species I found in moderate to high abundance on local prairie remnants. Then I tried to add at least 1 to 5 new species per year, and we now grow more than 80 Willamette Valley prairie species for commercial sales. Almost 300 forb species have a high to moderate fidelity to Willamette Valley prairie habitat (Alverson 2008). That's a tall order for a grower. For the USFWS draft recovery plan, Kaye (2008) recently suggested 100 forbs that were good "prairie indicator" species for wet and dry prairie that would aid in quantifying habitat quality and diversity during the recovery process. As it turned out, most species we are growing are the "prairie indicator" species suggested by Kaye. Providing this diversity has proved challenging. Early on it became apparent that some of the species readily lend themselves to commercial seed production methods, whereas others require considerable creativity.

OUR OBJECTIVE: MEET THE DIVERSITY CHALLENGE

Heritage Seedlings is a producer of small plants of woody trees and shrubs for the wholesale ornamental nursery trade. As a result of this focus, in 2001, we were not equipped for starting a seed production program. Since its inception, the main goal of the program has been to keep the species palette diverse and focused on difficult to produce forbs while continually improving our production efficiency. This allows us to increase our suite of species each year and to be agile and flexible (given a small, emergent market) without large inputs of labor and capital. Some of the limitations and challenges we face include finding sources of wild seeds and dealing with the myriad plant characteristics that need to be considered at a commercial level of production.

We are growing our seeds for restoration use, which means it is critically important to provide a broad genetic representation of each species within its collection area. Because prairie remnants are few and frequently degraded, finding multiple population sites that host large patches has proved difficult for some species. Many of our prairie remnants are tucked away on private land, often in areas deemed unsuitable for grazing or crops. Survey work conducted by The Nature Conservancy in the 1980s indicated a few good places to start collecting. As I sought out new sites, I found some landowners very willing to let me collect on their property, but others were hesitant or even hostile to the idea. Many of my collection sites have been county roadsides. These sites are highly vulnerable due to road maintenance or landowner decisions to "clean them up" or to farm to the edge of the road.

Gaining familiarity with plant characteristics plays the most important role in determining our production methods. How to start the plants from seeds is the first step. For each species, we determine if seeds can be sown directly into the field or whether germination requirements are best met by sowing first into plugs and growing in a greenhouse. If field sown, we determine if fall or late-winter sowing is best and if a nurse crop is required to reduce mortality from erosion and frost heaves. For plugs, we determine if any seed treatment is needed such as scarification or stratification, the optimal time for sowing, and germination conditions needed in the greenhouse such as heat or light. To maintain the crop in the field, we often select weed management strategies based on plant type (grass, sedge, or forb; monocot or dicot; annual or perennial; and plant family) and adjust our control method accordingly, be it chemical, manual, or mechanical. For each species, phenology and stature determine how and when to harvest. Last, we determine how much seed and acreage to plant based on germination rates and previously observed seed yields.

MEETING THE CHALLENGE: FROM WILD SEEDS TO INCREASED SEEDS

Easy to Produce

Many of our Willamette Valley prairie plants lend themselves to standard commercial seed production methods. Table 1 is from our seed harvest data compiled between 2003 and 2007 and lists some of the species that we found can be mechanically sown, harvested, and cleaned; have high yields; and have relatively high seed viability as indicated by a tetrazolium (TZ) test.

Seed yields of these "easy" species vary and depend on the growing conditions and, in the case of perennials, when they reach full reproductive size. By my second year of growing native seeds, I was stunned to see that a mere 45 g (0.1 lb) of hard-won wild *Potentilla gracilis* (slender cinquefoil) seeds (Figure 1A) sown on 405 m² (0.1 ac) produced a staggering 20.4 kg (45 lb) of seeds (Figure 1B). Considering the high number of seeds per pound of this species, there could potentially be more than 63 000 000 plants on restoration sites throughout the Willamette Valley from that one lot. The seed yield for second-year *Grindelia integrifolia* (Willa-mette gumweed) was also quite im- pressive producing 48.1 kg (106 lb) on the same acreage. *Grindelia* has fewer seeds per pound, however, than *Potentilla,* so it would produce only a "mere" 14 000 000 plants. I quickly learned that seed yields

TABLE 1

Species that can be mechanically sown, harvested, and cleaned; have high yields; and relatively high seed viability as indicated by a tetrazolium (TZ) test.

Species	**Authority**	**Family**	**Common**	**Annual/ Perennial**	**Seeds/lb^z**	**Yield (lb/ac)^y**	**TZ (%)**
Achillea millefolium L.		Asteraceae	Western yarrow	perennial	1 418 947	300–600	84
Clarkia amoena	(Lehm.) A. Nelson & J.F. Macbr	Onagraceae	Farewell to spring	annual	1 031 818	350–550	94
Clarkia purpurea ssp. *quadrivulnera*	(W. Curtis) A. (Douglas ex Lindl.) Nelson F.H. Lewis & M.E. Lewis & J.F. Macbr.	Onagraceae	Purple godetia	annual	1 890 000	500–700	95
Collomia grandiflora	Douglas ex Lindl.	Polemoniaceae	Large-flowered collomia	annual	121 715	450–750	91
Eriophyllum lanatum	(Pursh) Forbes	Asteraceae	Oregon sunshine	perennial	1 169 047	400	90
Gilia capitata	Sims	Polemoniaceae	Blue filed gilia	annual	1 008 888	700–1000	95
Grindelia integrifolia	DC.	Asteraceae	Willamette gumweed	perennial	127 508	1000	80
Lomatium nudicaule	(Pursh) J.M. Coult. & Rose	Apiaceae	Barestem lomatium	perennial	39 557	1200	85
Potentilla gracilis	Douglas ex Hook.	Rosaceae	Slender cinquefoil	perennial	1 417 469	400–500	85–89
Prunella vulgaris L. var. *lanceolata*	(W. Bartram) Fernald	Lamiaceae	Self-heal	perennial	400 228	400	82

^z seeds/lb x 2.2 = seeds/kg

^y lb/ac x 1.12 = kg/ha

Figure 1. Forty-five g (0.1 lb) of wild *Potentilla gracilis* seed (A) produced 20.4 kg (45 lb) of seeds after 2 y in production (B). Photos by Lynda Boyer

Figure 2. Our International seed drill with every other furrow opener removed. Photo by Lynda Boyer

Figure 3. Funnels made out of chemical jugs placed over the seed pockets distribute the seed and vermiculite mixture to only the desired openers in the seed drill hopper. Photo by Lynda Boyer

can be deceptive if number of seeds per kg (lb) is not considered.

Because we were initially unsure of the market demand, and we wanted to produce numerous species, Heritage Seedlings chose to grow species in small production blocks. To keep costs to a minimum, however, we wanted to ensure most seeds could be mechanically sown and harvested. This meant finding a seed drill that was "just our size," keeping in mind the appropriate-sized swather we would need to cut the small blocks. We chose a 3 m (10 ft) wide drill and a 3.6 m (12 ft) wide swather (Figure 2). To meet our seeding requirements, the seed drill needed some modification. The drill's row spacing was 17.8 cm (7 in); to make certain the plants were well spaced, which would reduce competition for light, we decided to remove every other furrow opener giving us 35.6 cm (14 in) wide row spacing. Next, we had to deal with the open seed bin that would not allow us to target the desired rows, and our need to bulk up the small amount of seeds so that we could distribute them evenly in the desired production block. To bulk up the seeds, we found medium-grade vermiculite worked well and suspended both large and small native seeds. To distribute the seeds, we made funnels out of used chemical jugs and placed them over the seed pockets (Figure 3). The drill was calibrated to sow a known weight of vermiculite for a given distance. The volume of this vermiculite was marked on a 5-gal bucket. Prior to sowing, the seeds were mixed with enough vermiculite to reach the desired volume in the bucket, distributed evenly into 7 containers, placed in the funnels, and away we went!

One of the most rewarding aspects of growing native seeds is learning the life cycles of so many different species. Figure 4 shows *Potentilla gracilis* from newly germinated seedling to fully mature plant. The most critical variable to determine is the "optimal" time to harvest each species. For *Potentilla*, this is when the calyx is brown but still encloses the ripe seed (Figure 4E). Harvesting forb seeds has proved to be much more challenging than sowing. Unlike most grass species, forbs cannot just be cut, left in the field to dry, and then combined in place. Most have a long and uneven seed maturation time so they must be harvested after about one-fourth of the seeds have shattered and the bulk of the seeds are almost mature but not shattered. If left cut in the field, the seeds would just fall on the ground as they ripen and dry. So, it is necessary to cut the material and have it dry on tarps or plastic.

Some Willamette Valley growers cut forbs onto paper that is rolled out under the swather as the plants are cut. The paper and plants are quickly tied down to avoid loss due to the wind. Our sites were too windy for this method. By our third growing season, we made tarps to hang under our swather. As the tarps filled, they were removed, placed in a trailer, and taken to the drying area. This worked well but the harvest was slow and labor intensive. We needed a more labor-saving method of capturing the seeds after they were cut. A solution was found in 2005 when our fabricator designed a conveyor belt that extended from the cutting blade to a trailer pulled behind the swather. This allowed the cut material to be directly dumped into the trailer. We decided to also use this method for our grasses, because the species plots were close together, which excluded the ability to field combine the material. Figure 5 illustrates the harvest of *Bromus carinatus* Hook. & Arn. (Poaceae) (California brome).

Figure 4. The life cycle of *Potentilla gracilis.* Just after germination (A), in May (B), in late June (C), in its third year of production (D), and ripe seeds ready for harvest (E). Photos by Lynda Boyer

Figure 5. Bromus carinatus is cut with the swather blades (A). The material is conveyed (B) into a trailer pulled behind the swather (C). Photos by Lynda Boyer

Drying the material became our next challenge. Because Willamette Valley summers are relatively dry, we decided to dry the cut material on plastic in a field-staging area. If the material was rained on, we realized it was imperative to drain the water immediately and turn the damp material often to ensure that it dried quickly and completely before combining.

Threshing the small lots also proved challenging. We discussed numerous options ranging from using the smallest standard combines currently on the market to small plot combines such as those used by government and university research facilities. Those machines were either too large or cost-prohibitive for our fledgling program. One of our employees thought a small Allis-Chalmers combine (All-Crop®) made in the 1950s would fit our needs perfectly. We now own three of these and they work just great. The All-Crop® is PTO (power take-off) driven, belt-fed, and used as a stationary combine (Figure 6A). The straw is dumped onto a tarp and checked for seeds, and the seeds and small chaff are augured (the combined material is moved by helical flighting) directly into large seed bags to be sent to our cleaning facility (Figure 6B). This method allows for limited seed loss and takes only 2 to 4 labor hours for 0.06-ha (0.15-ac) plots of lighter or smaller plant material and 5 to 10 labor hours for burly plants and grasses. The combine cleans out in less than 30 min and is ready for a new lot.

Figure 6. The plant material is placed on the belt feeder of the combine, then threshed and separated through screens (A). The seeds and small chaff are augured directly into seed bags (B).
Photos by Lynda Boyer

More Difficult to Produce

Seed germination requirements have made fall drilling of some species impossible in the Willamette Valley. This is the case for sedges, rushes, and some tiny-seeded wetland forbs such as saxifrages. Consultation with other growers in our area led me to conclude that when drilled in the fall, those species were not getting three requirements they needed to germinate: heat, light, and adequate soil moisture. All of those requirements are met during early spring in their native wet prairie habitat. Instead of establishing seed blocks of those species by field sowing seeds, we sow seeds in plugs and grow them in a protected, controlled greenhouse that meets all of their germination requirements. The plugs are then outplanted into the seed production blocks and irrigated if necessary to ensure good establishment. Figure 7 shows a *Carex stipata* Muhl. ex Willd. (Cyperaceae) (saw-beaked sedge) plot in June 2007, 2 mo after outplanting. The sedge and rush species can be harvested with our swather and seed yields are expected to be good.

In order to optimize seed yields, some native prairie species need to be hand collected before they can be machine harvested. Species such as *Aquilegia formosa* Fisch. ex DC. (Ranunculaceae) (western columbine), *Camassia leichtlinii* (Baker) S. Watson (Liliaceae) (tall camas), and *Iris tenax* Douglas ex Lindl. (Iridaceae) (Oregon iris) ripen over a long period and the seed heads shatter quite easily. They do, however, have relatively high yields when mature. In these cases, we hand harvest the early-ripening fruits and then machine harvest most of the fruits when they are ripe but not shattering. Figure 8 shows a mature columbine fruit at the fragile shatter stage.

Very Difficult to Produce

Some species have proven extremely difficult to grow for bulk seeds and cannot be harvested mechanically. Plant characteristics such as short stature and long or uneven seed maturation are the biggest obstacles faced by a grower trying to produce diversity of species economically. Species with extremely uneven maturation are *Geranium oreganum* Howell (Geraniaceae) (Oregon geranium), *Viola adunca* Sm. (Violaceae) (early blue violet) and *V. praemorsa* Douglas ex Lindl. (Violaceae) (prairie violet), *Lupinus latifolius* Lindl. ex J. Agardh (Fabaceae) (broadleaf lupine), and *Madia elegans* D. Don ex Lindl. (Asteraceae) (showy tarweed). So far, we have been unsuccessful at producing large amounts of seeds of these species. Our most successful attempt has been with *Madia elegans*. When it first starts to flower in late June, we "flop" the plants over onto plastic with poles and let it flower and set seeds for over 2 mo

Figure 7. Carex stipata seed production block in June, 2 mo after plugs were outplanted. Photo by Lynda Boyer

Figure 8. Mature *Aquilegia formosa* fruit in late June at the shatter stage. Pod is very dry and open at the top. Photo by Lynda Boyer

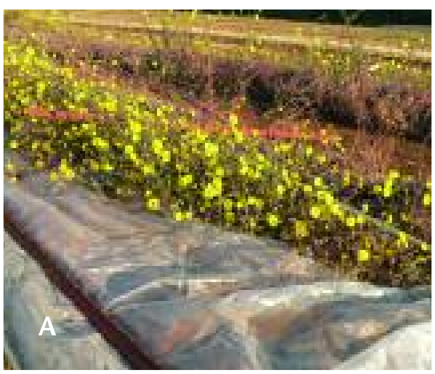

Figure 9. Madia elegans is flopped over during late June onto plastic that is held down by metal bars (A). Two months later it is cut with a weed trimmer and seeds are swept up (B). Photos by Lynda Boyer

(Figure 9A). A 223-m^2 (2400-ft^2) plot produces 6.8 kg (15 lb) of seeds. The best harvest method for these species, I believe, is being used by our USDA Natural Resources Conservation Service Plant Material Center in Corvallis. They are contracted to bulk up seeds of small wild collections. To do this they grow the plants as plugs and plant them into 3.6 m (12 ft) wide ground cloth stapled to the ground with the sides buried. This allows all of the seeds to be swept or vacuumed up after they shatter. Laying the ground cloth and planting the plugs is labor intensive, however, so it would be very difficult to do on a large scale. We are implementing this method for the 2008 *Madia elegans* and *Madia sativa* Molina (Asteraceae) (Chilean tarweed) crops. If successful, we will start small production blocks of other "uncooperative" plants using this method.

CONCLUSION

Our company's desire to provide the diversity of plant material needed to aid in Willamette Valley prairie restoration has had to reckon with the realities of each species' unique characteristics. Diversity is a laudable goal and should be a key component of all restoration plans. By sharing the challenges faced by growers, our hope is that restoration professionals and native seed buyers can better plan their projects and make sound plant choices. One of my favorite "reality checks" came when a colleague working to secure seeds for numerous restoration sites in the valley estimated a need for 150 kg (330 lb) of *Wyethia angustifolia* (DC.) Nutt. (Asteraceae) (California compassplant). I have patiently watched my 223-m^2 (2400-ft^2) plot for the past 5 y. It flowered by the fourth year, but by 2007 it still produced only 1.4 kg (3 lb) of seeds that were painstakingly hand collected (Figure 10). So, to provide my colleague with the desired amount of seeds, we would have had to plant 2.4 ha (6 ac) of


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Figure 10. Five-y-old plot of *Wyethia angustifolia.* Photo by Lynda Boyer

Wyethia 5 y ago with 46.3 kg (102 lb) of wild seeds! I doubt that would be possible, but boy, would it be pretty.

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