TECHNICAL NOTES

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CONSIDERATIONS FOR ESTABLISHING NATIVE GRASSES FROM SEED FOR RESTORATION, REVEGETATION, AND EROSION CONTROL IN WESTERN WASHINGTON AND WESTERN OREGON

INTRODUCTION

Native grasses are increasingly popular and valuable tools for revegetation, erosion control, and wildlife habitat improvement. Many have unique features and benefits that make them advantageous over certain exotic and introduced grasses. In the field of ecological restoration, they are a critical and required component of the target plant community, ecosystem, or natural habitat. A number of native grasses are readily found in the wild, abundant seed producers, vigorous, and easy to establish. Unfortunately, others are slow to establish, low yielding, or have become scarce as a result of land use conversions, noxious weed invasions, or habitat fragmentation. However, they are no less important. This group of native grasses may also lack the ability to compete with invasive, introduced grasses bred for vigor, pest resistance, and high seed yield, let alone the abundance of exotic broadleaf weeds found throughout the landscape. As a result, special care, attention, and patience may be required for such factors as site preparation, weed control, seed source/quality, and initial stand management compared to the less stringent demands of more vigorous and broadly adapted introduced pasture and turf grasses. Unlike perennial ryegrass (*Lolium perenne*) or tall fescue (*Festuca arundinacea*), a successful stand of a slower growing native grass may take two to four years to achieve. Furthermore, risks and costs can be considerably higher. Planning and implementation should begin several years in advance of planting, not just weed control and site preparation practices, but the steps necessary to secure an adequate supply of native grass seed from "local", adapted sources.

The purpose of this paper is to summarize some practical "tried and true" methods for establishing native grasses from seed, as well as to describe less proven, experimental, and emerging technologies or considerations. The difference between the two should be evident. Even the most reliable strategies and alternatives do not always guarantee success because of the highly variable and unpredictable nature of the real world. This document is only a list of ideas for guidance or consideration. It is not a substitute for site or project specific recommendations.

CONSIDERATIONS

1. Preplant and post emergence weed control, including the reduction of weed seeds in the soil bank **is the most critical factor** for establishing native grasses from seed.

   TRADITIONAL METHODS:

   ⇒ Ideally, two years of repeated, shallow tillage, coupled with glyphosate applications (or flaming) should be used to deplete the weed seeds. At least three cycles per year are suggested: twice in the spring and once in the fall. Further reductions can be accomplished when coupled with late spring, summer, and early fall irrigation. This will stimulate additional weed seed germination allowing one to maximize the number of tillage/herbicide cycles within a growing season. Note that simple tillage without herbicides or irrigation during the dry season can be effective at desiccating and destroying perennial plant parts such as rhizomes. However, the effect on the seed bank may be minimal.

   ⇒ An alternative strategy is to use glyphosate, other herbicides, and/or burn treatments that kill the weeds and reduce thatch, followed by drilling the seed with a no-till drill. The advantage to this method is it avoids last minute scarification of the soil surface for seedbed preparation. Disturbance (without further weed control) just prior to sowing invites latent seeds to germinate and opens the ground for further introduction of weeds.

   ⇒ Take advantage of slow native grass seedling emergence or seed dormancy, if any. Kill rapidly emerging weeds with a herbicide between the time the grass seed is sown and the grass seedlings emerge. Species like **California oatgrass** (*Danthonia californica*), **pine bluegrass** (*Poa secunda,* formerly *Poa scabrella*) and **Lemmon's needlegrass** (*Achnatherum lemmonii*, formerly *Stipa lemmonii*), and **rice cutgrass** (*Leersia oryzoides*) have dormant seed requiring fall seeding. They will not germinate for several weeks or many months, providing a long timeframe for easy control of fall and winter weeds. This method will not work with non-dormant, rapidly emerging grasses like **blue wildrye** (*Elymus glaucus*), **slender wheatgrass** (*Agropyron caninum* or *Elymus trachycaulus*), **hairy wildrye**, (*Elymus hirsutus*), **Sitka brome** (*Bromus sitchensis*), **California brome** (*Bromus carinatus*), **meadow barley** (*Hordeum brachyantherum*), and **annual hairgrass** (*Deschampsia danthoniodies*).

   ⇒ After emergence of the grass (usually after the three leaf stage), consider broadcast applications of selective herbicides for broadleaf weed control, mowing or herbicide wicking (if the weeds are tall and the native grass is short), spot spraying, or hand weeding/hoeing if necessary. Livestock grazing for weed management may be appropriate in unique or experimental cases.

   ⇒ All herbicides must be applied according to label instructions and all applicable laws. Utilize knowledgeable, licensed applicators whenever possible or required.

⇒ Field burning should only be conducted by and under the authority of appropriately trained staff, agencies, farmers or organizations with all the required permits and necessary safeguards in place.

SOIL SOLARIZATION:

⇒ Pre-plant weed control using soil solarization to kill latent seeds merits consideration, but the process is expensive and results have been mixed. Soil solarization involves the use of clear plastic (polyethylene film) laid over the soil surface or a seedbed that is moist, clean, and smooth. The plastic creates passive solar heating that destroys or reduces populations of certain soil borne plant pathogens and weed seeds within the top 5 cm of soil (sometimes deeper). Both seeds and perennial plant parts such as tubers and rhizomes can be killed. Research from California has shown that at least 30 common weeds may be controlled by this method. The practice is most effective in growing climes with high solar radiation and warm summer temperatures, but some weed control has been achieved under cooler coastal conditions. Plastic mulches are usually applied for only 4-6 weeks. Periods longer than seven weeks may result in deterioration of the tarp, making pick up and disposal more difficult. Black plastics have been tried, but the soil temperatures are lower and therefore less effective. Others have experimented with the injection of chemical additives like Metham (metham-sodium) that increase effectiveness for disease control. Chemical supplements are usually aimed at replacing methyl bromide (which is being phased out and banned by 2005) in the process known as "soil fumigation".

[The latest concept being tested is "biofumigation". It makes use of plastic film in combination with organic products such as composted chicken manure or residues from plants in the mustard family which are incorporated into the soil for fungicidal activity. Effect on weed seed is unknown].

2. Tailor the species to the site. Soil type, hydrology (drainage, flood inundation), climate, weeds, shade, aspect, slope (topography), adjacent crops, associated land uses, and objectives (restoration versus erosion control, revegetation, wildlife food and cover, etc.) should be considered for species selection.

3. Shallow seeding depths (maximum of 1/8 to 1/2 inch of coverage depending on seed size) coupled with good mineral soil contact (and/or a thin layer of mulch) is a must. Surface sowing almost never works, except on continuously moist mud flats, immediate shorelines, or subirrigated areas, assuming the seed doesn't wash or float away or is consumed. Many grasses require light for germination along with adequate moisture. Both are usually best achieved with a thin soil layer, alone or in combination with mulch coverage.

   ⇒ "Clean" seedbed preparation and sowing techniques similar to those for turf and pasture/hayland plantings are still among the best methods for successful seeding of native grasses. The seedbed should be weed free and compacted so adult footprints are barely visible. However, reduced tillage and no-till drill methods have worked under the right conditions.

4. Mulches are almost always a good idea and worth the additional budget requirements. Mulches reduce seed movement, mortality and predation, retain soil moisture and fertilizers, and reduce erosion. Many modern erosion mats and blankets serve these purposes and will eventually biodegrade by design. However, even those with organic fibers, especially those made of coconut fiber ("coir fabric") may last several years longer than advertised and can actually hinder annual reemergence of wide leafed perennials, including Liliaceous species. In all cases, the mulch layer or mat must be thin enough to prevent smothering and allow adequate light penetration. Recent advances in hydromulches and other hydraulically applied materials (like bonded fiber matrices), combine a number of useful characteristics into one product, including avoidance of "tenting", environmental compatibility, and adherence to nearly any soil surface.

   ⇒ Consider the use of straw bales from native grass seed crops as mulch. These could be bales created from same seed field (same species and genetic material) as the purchased or contract grown seed source if details are worked out in advance with the grower. The mulch will already contain good seed, but if the production field was weedy, one will be introducing new weed seed to the revegetation site. Oregon does not certify straw bales. However, if the grass seed field is in the pre-varietal or varietal seed certification program, the fields are inspected 7-14 days prior to cutting and a weed list is recorded. This list could be used by the grower as a reasonable representation of what weed seeds might be present in the straw bales.

5. Choose the right equipment for the job. Site characteristics, such as soil moisture, surface residues, remoteness, soil texture, soil quality, type of site preparation, and slope severity will dictate the type of equipment that can be used.

   ⇒ Drilling requires less seed compared to broadcasting, but the rows can initially create an unnatural appearance. This appearance can diminish over time. To avoid the problem, try cross-drilling in multiple, irregular directions, with the same and different species. Some people prefer drilled rows of single species to aid in early seedling identification.

   ⇒ Steep banks and inaccessible sites will require the use of manual cyclone seeders (such as belly-grinders) or hydroseeders. However for some practitioners, hydroseeding certain native grasses has not shown good results so far. Seedlings or container grown plugs should also be considered in these areas.

   ⇒ Always calibrate equipment ahead of time to achieve correct seeding rates.

   ⇒ If the seed is to be drilled, look for a drill equipped with depth bands attached to the double disk furrow openers. The bands prevent the seed from being buried too deeply in the ground. Special drills designed for seeding native grasses will usually have these.

⇒ If accessible, broadcast seeding is best achieved with equipment that relies on a seed box with a metered feed and a trailing cultipacker to press the seed into the ground and firm the soil. Fertilizer spreaders or other devices that rely strictly on gravity flow are hard to accurately calibrate for sowing grass and require additional harrowing or rolling afterwards to cover the seed. Other broadcast seeding options include motorized cyclone seeders mounted on an ATV or the 3 point hitch of a tractor. Another alternative is the use of high volume seed blowers, but if different size and density of seeds are mixed, separation will occur. Aircraft application is reserved for large scale forest and range seedings.

6. Pay close attention to seed quality and condition because it further affects equipment choice. Trashy seed with stems and other materials will not flow well through most seeding equipment. Also, many native grass seeds have awns (like **blue wildrye**) or pubescence [such the fine hairs on **tufted hairgrass** (*Deschampsia caespitosa*) seed] that will "bridge" inside the seed box or plug up a standard grain drill or hydroseeder. In such cases, one has three choices:

   ⇒ (1) Special order or purchase seed that has been further conditioned to remove these appendages so it will flow smoothly through standard seeding equipment. The seed will cost more however.

   ⇒ (2) Find someone who has a seed drill specifically designed to handle these types of "chaffy" grasses. The seed boxes have fluted feeds that actually pull the seed downward out of the bin and large drop tubes that prevent the seed mass from hanging up inside.

   ⇒ (3) For small projects, throw the seed out by hand or purchase a cloth lined rubbing board to rub off the awns or hairs so a belly grinder can be used.

7. To fertilize or not to fertilize? Nitrogen fertilization will often favor the growth of exotic grasses and broadleaf weeds over native grasses. Most restoration projects using drilled or broadcast native seed do not specify standard granular fertilizers because of this. However, if it appears weeds are not a going to be a significant problem, the soil has low fertility (subsoils, cut and fill slopes for example), the site is small, runoff will be low or minimized by mulching, silt fences, etc., then a slow release fertilizer can be beneficial. Avoid the use of manure. Composted leaf and lawn litter or other organic fertilizers may have application in special cases. Low to moderate rates of both starter and maintenance fertilizers in the standard granular form may be more appropriate for pasture, hayland, cover crop, and low maintenance turf areas utilizing native grasses. (See also seed coating).

   ⇒ Consider a seed mix with an easy to establish native legume (native lupine, trefoil, vetch, clover) to provide natural fertility. Use of a native forb in the mix will preclude the use of post emergence, selective broadleaf weed control herbicides. Preferably, the grass and legume should be compatible in terms of germination rate, seedling vigor, and rate of early growth.

⇒ Prairie restoration and revegetation with native grasses may actually benefit by incorporating organic materials with high carbon to nitrogen ratios into the soil, thereby rendering soil nitrate nitrogen less available to weedy plants. In a process called "Reverse Fertilization", researchers have begun to look at amending the seedbed with raw sawdust, wood chips, and even sucrose in order to tie up soil nitrogen, theoretically favoring native species over certain non-native grasses and weeds. This is not yet a recommended practice because the ideal rate, regularity, timing, and quality of sawdust or other carbon source material is yet to be determined. For example, soil type, natural levels of soil fertility, and pulses of nitrogen from flood events affect initial and repeat application rates. However, restoration ecologists already make good use of sawdust or fine wood chips as a thin layer of mulch applied after seeding.

8. Seed coating grass seed is an option under experimental conditions. Various types of seed coatings, including prilling with lime or phosphatic fertilizers and pelleting with inert materials, have improved establishment of forage grasses in some cases and may have application to native grass establishment. Other compounds can be added to the coating, including nitrogen, potash, trace elements, stabilizers for "slow release", and in the case of legumes, inoculants for bacterial nitrogen fixation. Coating of native grass seed may have application on extremely infertile sites. Besides providing nutrients primarily to the grass (and not weeds), seed predation may decrease because rodents and birds may no longer recognize it as food. Also, the seed becomes easier to sow because of its higher weight that improves equipment calibration, placement, and ballistics.

   [An experimental idea that needs research is the potential application of seed coats containing dormancy inducing hormones, temperature sensitive polymers, or inert materials that might actually delay germination until better conditions exist for establishment. Moreover, further delay can allow for the use of nonselective herbicides after sowing. This "artificial" dormancy may create a new window for post-emergent weed control similar to the recommendation for native seeds with natural dormancy described earlier].

9. Mixes or monotypic stands? The choice depends in large part on the overall objective of the seeding, scale of the project, and site variability, but there are other important considerations and many unknowns. For example, there is a lack of scientific and anecdotal information on native grass seeding mixes in western Washington and western Oregon, especially when one considers that almost every site is unique and many natives are only now coming into use. As a result, almost every seeding mix involves guesswork and some wishful thinking. With mixes, invariability it is hard to predict stand composition the first season, let alone what the plant community will look like in the 5^{th} or 10^{th} year. Monotypic stands are inherently much simpler to establish and manage with more predictable results. However, properly designed seed mixes can have advantages over single species plantings in certain situations, particularly on uniform upland soils or wetlands with significant micro-relief.

SEEDING MIXES:

⇒ It is common practice to include at least one fast growing, short-lived grass in a mixture to provide immediate cover and erosion control. However, overloading the mixture with rapid establishing native grasses (**California brome, Sitka brome, blue wildrye, slender wheatgrass, meadow barley**), or even slower developing but competitive ones like **tufted hairgrass** will inhibit establishment of other shorter, less competitive, or slower growing (and usually more expensive), long-lived grasses in the mix. One suggestion is that the competitive, "quick cover" grass component should not exceed 5-10% of the mixture by weight, but this is speculative. The concept applies more predictably with introduced turf grass and erosion control mixtures. Another idea that needs evaluation is to combine a quick cover "pioneer" grass with a slightly more shade tolerant understory grass that will not succumb to light reduction caused by the taller grass.

⇒ A popular native grass for some restoration ecologists to use as initial cover in the region is **slender hairgrass** (*Deschampsia elongata*). It is relatively quick to establish and broadly adapted yet short-lived, smaller in stature, and probably less competitive with other native species in a seed mix compared to the aforementioned species.

⇒ Mixes should be simple (2-3 grass species at most) and targeted toward the correct soils, hydrology, and habitat inclusions (such as vernal pools within a wet prairie or shaded areas within an oak savanna). "Sculptured Seeding" is the coined term. Using the "one mix fits all" concept across the entire terrain with the hope that each species will find its own ecological niche can be extremely wasteful and costly when dealing with expensive native grass seed.

⇒ The practicality of using one or more mixtures (or patches of single species) is often a matter of scale and position in the landscape. A single mixture approach is best applied to upland sites with very uniform growing conditions over large areas. It is also a good alternative over multiple mixtures or single species plantings where habitat variation occurs at the microsite scale. For example, in most wetlands, even minor undulations (micro-relief) in the soil surface of only a few inches can have a major impact on what species gets established. Where the ground is too uneven, it is impractical to target different mixes or individual species to areas only a few square feet or meters in size. A single mix allows the species to sort themselves out according microhabitat, particularly by moisture regime. In contrast, multiple seed mixtures may be desirable in order to mimic the concentric rings of simple, uniform plant communities that typically surround natural wetlands formed in or around large depressions. Mixtures can be designed and sown to re-create these drastic differences in plant composition that normally occur over very minor changes in elevation. Unlike wetlands, micro-relief is usually much less significant in terms of plant adaptation on well-drained soils and uplands.

⇒ Until more is known or unless one has personal experience, generally do not mix native grass with native perennial forb seed because of the unpredictable results. Some native perennial forb seeds can be more costly than even the most expensive native grass seed. They can be easily out competed by the grasses in the mix. An exception is a competitive native grass with a competitive native perennial or annual forb. Examples might be using **blue wildrye** for erosion control with **riverbank lupine** (*Lupinus rivularis*) for natural fertility, **slender wheatgrass** with annual forbs like **Clarkia** (*Clarkia* sp.) for upland restoration sites, and **meadow barley** with **tarweed** (*Madia* sp.) or select **fireweeds** (*Epilobium* spp.) for wetland prairie seedings. Noncompetitive forbs may be best established as small monocultures from seed, or from plugs and other container stock.

⇒ Generally, do not mix species with low or no seed dormancy with those that have moderate to high seed dormancy (unless the seed has been cold, moist stratified). For example, both **California oatgrass** and **Lemmon's needlegrass** have high physiological seed dormancy requiring fall sowing (or indoor, refrigerated, moist stratification) to germinate. Predictably, those species without dormant seed will germinate and occupy the site first, swamping the site and potentially excluding establishment of this kind of native grass. In short, species like oatgrasses and needlegrasses are at a distinct disadvantage, especially when one considers they are also known for slow development even after their seed dormancy has been overcome.

⇒ There is a case when non-dormant seed of one species might be mixed with dormant seed of another. Early fall sowing of a rapidly germinating, diminutive (less competitive) annual forb or grass (like **annual hairgrass** or **slender hairgrass** with a perennial (like **California oatgrass**) can provide quick cover and erosion control until the dormant grass seed finally germinates in late winter or early spring. Sometimes this is referred to as a type of "Nurse Crop". Consider a low rate of the annual (max. 1/2 to 2 lbs/acre depending on seed size) with a high rate of the perennial.

⇒ Generally, do not mix warm season grasses with cool season grasses. Logically, the cool season grasses will germinate sooner in the spring when the soils are still cool, precluding growing space for the warm season grasses. In the fall, only the cool season grasses will germinate at all. The three most common native warm season grasses in our area are **rice cutgrass**, **western witchgrass** (*Panicum occidentale*), and **annual witchgrass** (*Panicum capillaire*). All three are primarily associated with wetlands but the latter two may occur elsewhere as well.

⇒ Consider mixing grasses with similar management requirements in order to maintain the presence of each species within the plant community, if so desired. Management that favors one species or groups of species over another may also be a goal, such as accelerating natural plant succession.

MATRIX SPECIES AND MONOCULTURES:

⇒ A more predictable and potentially more manageable strategy to achieve species diversity is to use a progressive system of monoculture seedings, starting with the establishment of a dominant matrix species. This grass should be quick and easy to establish, comparatively less expense, and competitive with any residual weeds. Examples are **slender wheatgrass** for xeric uplands, **blue wildrye, hairy wildrye,** and **slender wheatgrass** for mesic uplands, and **meadow barley** for seasonal wetlands. Once established, irregular patches within the field could be sprayed with a herbicide, flamed, or very closely mowed in spring (to kill the tall matrix grass), and tilled/raked to create new seedbeds. In the second or third year, use these new bare areas for sowing new monocultures of slower establishing, longer-lived, and more expensive native grasses. By planting monotypic stands, initial weed control and management for establishment of subplots is simplified and the results more certain. The theory is that these stands of grasses will slowly intermingle and diversify over time to achieve a more natural appearance.

⇒ Planting the bare patches with grass plugs could supplement or replace the seedings. Grass plugs are a more expensive, but more reliable means of establishment for certain "difficult" species.

⇒ The final step (year 3, 4 or 5) would be to create further openings and plant or sow patches of native forbs and wildflowers.

⇒ Another advantage to this method is that the small monotypic stands within the larger unit can serve as easy sites to harvest or recollect native grass seed for future work and expansion.

⇒ Monoculture seedings can have disadvantages over mixes. As discussed earlier, they may be impractical in certain wetlands where minor undulations over short distances (micro-relief) can substantially affect establishment. In such cases, a single mixture of wetland, vernal pool and marsh grasses may be the best way to insure full coverage of the site. In addition, the number of years and amount of follow up activity to achieve desired results (a "natural look") can be substantially greater for single species than with a mix, especially on uplands. Furthermore, the initial management of multiple, single species subplots may, in some cases, end up being as much or more work than the management of a single large unit comprised of a complex of species. Finally, the general concept of seeding a succession of monocultures is not well tested, but neither are native seed mixes.

10. Consider the possibility that a valuable native seed bank may already be present in the soil under special circumstances. In a limited number of revegetation projects, primarily those associated with select wetland enhancements, little if any overseeding has been needed because of a high pre-existing level of desirable species in the seed bank. Investigate if local experience under nearly identical conditions has resulted in successful stands of native wetland vegetation without seeding. In other cases, sowing only a light stand of a short-lived, quick establishing grass may be enough. Examples

include **annual hairgrass**, **slender hairgrass**, or **meadow barley**. The native grass provides initial cover and protection until other natives establish from the seed bank.

⇒ If little is known about the wetland seed bank, consider creating small, bare test strips or random plots at least two years ahead of site or seedbed preparation. Use treatments that mimic one or more methods of large scale site work then observe what naturally volunteers before choosing a final plan of action. In fortunate cases, native species have returned with time and patience.

⇒ Another option is to collect samples of topsoil from the site and conduct "growouts" in a greenhouse or sheltered outdoor site for at least a year and a half. Place the soil in shallow pots or flats and observe what germinates and grows to help assess the contents of the seed bank. Make sure the samples go through at least one fall and winter outdoors in order to "stratify" any dormant seed and allow for their germination. Sample more deeply (6-18 inches) to scout for beneficial bulbs and tubers in the soil.

11. **CAUTION:** Some native grasses are weeds in other crops and must be used with care or only under special circumstances.

⇒ **California brome** and possibly **Sitka brome** are weeds in certain Willamette Valley grass seed fields. California brome is even listed in "Weeds of the West". It may be wise to avoid using them along roadsides or other areas adjacent to grass seed production fields. However, because of their competitive nature, they may be a good choice for areas where tall fescue, tall oatgrass, and velvet grass or noxious broadleaf weeds are becoming invasive. California and Sitka bromes could be used as both competitors with exotics or as a buffers or barriers to their further encroachment.

⇒ Other native grasses sometimes considered weedy in ryegrass or other introduced grasses grown for seed on hydric soils are **western mannagrass** (*Glyceria occidentalis*), **western sloughgrass** (*Beckmannia syzagachne*), and **water foxtail (***Alopecuris geniculatus***)**. Water foxtail is not considered native by some experts but is by others. In California, **spike bentgrass** (*Agrostis exarata*) is considered weedy by some individuals. Alternative native species to consider using near seed production or other sensitive crop fields on hydric soils include **slimheaded mannagrass** (*Glyceria leptostachya*) for western mannagrass, **annual hairgrass** for western sloughgrass (in wet depressions), and **short-awned foxtail** (*Alopecuris aequalis*) for water foxtail.

12. Timing is a critical factor even when irrigation is available, especially on clay textured, hydric soils. The smallest window of opportunity for seedbed preparation and sowing exists on seasonally wet, heavy clay soils like the Bashaw and Waldo series in the Willamette Valley. For wetlands or floodplains with available irrigation, species that lack seed dormancy should be spring seeded, assuming the seedbed was prepared and the weeds controlled the prior year. Irrigation during the summer ensures establishment and eliminates the danger of poor fall germination and washouts.

⇒ Late summer or early fall may be the only opportunity to sow wetlands if the site is too muddy in spring and summer irrigation is unavailable. However, risks from flood damage are much greater in fall. If fall seeding must be done on an annual floodplain or stream terrace, irrigate (if available) immediately after sowing, or hope for early fall rains to germinate the seed. Unfortunately, ungerminated seed (and soil) will easily float or wash away with the advent of winter floods, unless securely anchored by mulches or mats.

⇒ Fall seeding is absolutely required for seeds with moderate to high levels of physiological dormancy. However, small amounts of dormant seed can be moist, cold stratified (moist chilled) in containers in a refrigerator over winter and then seeded by hand or with a belt seeder in spring.

13. Before making a final seed purchase, request a **TZ (tetrazolium) test** (unless there already is one) from the seed laboratory or vendor for determining viability of native grass seed lots when seed dormancy is present or unknown for the species. A TZ test indicates if the seed is alive and not whether it will immediately germinate. However, it provides a more accurate picture for seeding rate calculations. A standard germination test will give a "false negative" when dormancy is high. Standard germination tests are still suitable for native grasses where physiological dormancy is lacking or readily overcome using standardized, short-term treatments, such as 7-14 days of "pre-chilling" and soaking in KNO_3 (potassium nitrate) solutions.

14. Only purchase native grass seed with a current (less than 12 month old) seed test showing high purity, low or no weed seed content, low inert matter, and good germination or viability. Carefully examine the list of weed seeds, even if they are "legal" by state law. When it comes to restoration projects in particular, the highest standards should be applied to weed content. However, because native grasses are not bred and viability from wild collections and harvests are naturally quite variable, a percent germination or percent TZ viability as low as 50% may be acceptable. Adjust bulk seeding rates accordingly.

15. What seeding rate should be used? As with mixture composition, there is a lack of hard data to firmly support seeding rate recommendations for many if not most native grasses in western Oregon and western Washington. General guidelines for a few native grasses are listed in the in the Seeding Guide for Oregon and Washington, fact sheets, and technical notes. A target seeding rate for moderate to high precipitation zones is 50 pure live seeds (PLS) per square foot. However, this can be low for erosion prone critical areas, cover crops, low maintenance lawns, sites with known weed problems, or species that are slow or difficult to establish. In the high precipitation areas (35 inches or more per year) of western Oregon and western Washington, seeding rates as high as 300 PLS/sq. ft. are not out of line for such applications in conjunction with single species or compatible, simple seed mixtures. If germination is high, competition and natural thinning often causes plant density to quickly decline and level off after two to four years. Seeding rates that are much higher are probably a waste of good, expensive seed. Given the tremendous variability and frequent unpredictability of natural systems including planting sites, high seeding rates do not necessarily guarantee good stands, and

low seeding rates can result in excellent stands if conditions are nearly ideal. Recommended seeding rates can very from 1/2 to 60+ pounds per acre depending on a multitude of factors.

A "typical" seeding rate for grasses may in the range of 5-15 pounds per acre which is then doubled for broadcast seedings or critical areas.

⇒ To calculate a PLS seeding rate in pounds per acre, choose a target PLS rate per square foot and calculate the rate as follows:

$$\frac{\text{Target \# of seeds}}{\text{1 Sq. Ft.}} \times \frac{\text{43,560 S.q. Ft.}}{\text{1 Acre}} \times \frac{\text{1 Lb.}}{\text{known \# of seeds per Lb.}} = \frac{\text{PLS Lbs.}}{\text{Acre}}$$

⇒ To convert a seeding rate in PLS Lbs/acre to the actual or bulk Lbs/acre rate, simply divide the PLS rate by both percent purity and percent germination (or viability from TZ test), expressed as a decimal fraction.

16. Know the natural origin of your seed and choose the most local seed possible and/or a proven seed source recommended for your area or ecoregion by a reputable organization. For nearly all native grasses in western Oregon and western Washington there is a lack of documentation about their population genetics and adaptive variation (the new term is "restoration genetics"), but this should not preclude their important uses. While the term "local" is subjective and highly debatable, a reasonable approach without species specific data is to use ecoregions or floristic provenances as "Seed Zones". One of the better approaches is to apply Omernick's Level III "Ecoregions of Western Washington and Oregon" (by D.E. Pater, et. al. 1998, published by the USGS, Denver, CO) as a reasonable, temporary facsimile of seed zones. [In western Oregon and western Washington, these approximate NRCS Major Land Resource Areas (MLRAs).] Others may wish to subdivide ecoregions with a wide range of elevations into low, medium and high elevation seed zone bands. It should be noted that the use of ecoregions as temporary seed zones is not official NRCS policy.

⇒ Many cultivars of native grasses released by the NRCS were not bred or hybridized and therefore still approximate a subset of the wild population from which they were derived. Examples include **'Elkton'** and **'Arlington' blue wildryes**. They are valuable in revegetation and erosion control within their recommended zones because they are proven and well adapted for the intended use. Native cultivars are often more genetically uniform than wild populations, which can be a disadvantage in terms of long term pest resistance and other factors. However, for a highly self-pollinated species such as blue wildrye, genetic composition may actually be similar to the original stand.

⇒ For pure restoration purposes, cultivars are not necessarily meant to replace local or onsite seed sources of native grasses. Such decisions must be made carefully on a case by case basis for each environment and ecosystem.

⇒ Certified "tested class", "selected class", and "source identified class" seed sources of native grasses should be favored over uncertified materials whenever possible. Examples included certified seed of selected class, pre-varietal NRCS releases such as Baskett Slough Germplasm California oatgrass, Tillamook Germplasm tufted hairgrass, and Willamette Germplasm tufted hairgrass.

17. For large projects with large budgets and long lead times (the "perfect world"), consider a 3-5 year plan and time frame to collect local native grass seed and contract grow seed or plugs with a reputable seed producer or nursery grower. Several years may be needed because seed production in the wild can be low and erratic and slowly developing native grasses with a strong vernalization requirement may not produce much seed until the third growing season. During the same time period, preparation of the restoration site, especially weed control and reduction of the weed seed in the soil bank can be accomplished to a high degree of effectiveness.

18. Learn to sight ID the most common native grasses in your area and scout or record potential collection sites (populations) during the course of other work activities and site visits. Obtain landowner permission to collect or "harvest" in advance, then once a project comes along that could use native grass seed, one may have a small but ready made source for a small project. Small, mechanical hand held harvesters modified from "weed eaters" have been developed, but they generally work well only in pure stands or those without exotic weeds and introduced grasses of similar height.

19. If collecting seeds from wild stands, sample from as broad a cross section of plants and from as many as specimens within the population as possible. For most revegetation projects, but especially those emphasizing true ecological restoration, capturing genetic diversity, if present, is potentially advantageous for disease resistance, fecundity, long-term adaptation, and other ecological principles. For highly cross-pollinated species such as **Roemers fescue** and **tufted hairgrass**, variation in physical traits may be readily apparent. For example, a person could observe and collect for differences in leafiness, leaf width (texture), flowering period (by visiting the site more than once to collect), stem or leaf color, pubescence (hairiness), disease signs and symptoms, and other characteristics. Typical recommendations are to collect seed from no less than 50 to 100 individuals to start a new population.

    ⇒ In contrast to cross-pollinated species, wild populations of highly self-pollinated species like **blue wildrye** and **slender wheatgrass** tend to be much more homogeneous. Therefore, genetic diversity within a population can often be captured by sampling seed from far fewer individuals.

20. For many revegetation and restoration projects, a target objective might be 75% native species on a percent cover basis without the presence of noxious or invasive weeds. Unfortunately exotic shrubs, introduced grasses and broadleaf weeds are here to stay and a pure native stand of grasses or grasses and forbs is unrealistic. Different cost shared conservation programs may have their own requirements. For restoration projects, visit known reference sites and protected habitats to visualize a target plant community.

21. Long term monitoring, maintenance, and adaptive management are requirements most of the time. Some re-invasion or encroachment of exotic weeds seems inevitable. Consult the NRCS Technical Guide, National Range and Pasture Handbook, Agronomy Manual, and other literature for guidance.

22. Finally, if time and finances permit and the risks are low, be experimental. Trial and error demonstrations can provide valuable learning experiences. Consider simple trials using different seeding rates, mixtures, site preparation treatments, soil amendments, and weed control methods that are legal and within the guidelines of the USDA or state administered conservation program. Such trials will have more legitimacy if one consults beforehand with Extension, NRCS Plant Materials, University, or private sector researchers for incorporation of replicated, randomized, well designed plots. Contact the Plant Materials Center for the availability of native grass seed for field plantings.

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