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Planning and Implementing a Seeding in Sage-Grouse Country

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This Technical Note is based on a webinar created by the Western Plant Materials Consortium for the NRCS and partner staff working on sage-grouse conservation. It is intended to provide information for planners and practitioners to make the best decisions possible when restoring or rehabilitating sagebrush ecosystems, while acknowledging the real-world compromises that are often encountered.

Introduction

The sagebrush steppe represents one of the largest ecosystems in North America. Significant efforts are underway across the west to conserve and restore sagebrush steppe, especially to reverse long-term declines in habitat quantity and quality for obligate wildlife species like sage-grouse. Restoration actions often involve seeding desired plant species to achieve resource objectives. However, seeding in arid rangeland settings like the sagebrush steppe can be a daunting task because of challenges with site limitations, species selection/availability, costs and risks. Conservationists need to be equipped with the best available information throughout the seeding process to set expectations appropriately and increase the likelihood of success wherever possible.

Planning should follow the old carpentry adage, "measure twice, cut once", or in other words, make sure the project is well thought out and all contingencies well planned before executing the seeding. It is not uncommon for planners to want to select species and procure seeds prematurely, but as will be described, species selection depends on many factors, not the least of which is commercial availability and cost. Considering information about the landscape context and site conditions will be necessary to improve the likelihood of achieving desired outcomes.

Time restraints, limited capability for adequate field preparation and weed control, and the availability and cost of native seed, hinder our abilities to rehabilitate sagebrush steppe. Invasive annuals like cheatgrass have significantly altered the environment, making traditional restoration approaches insufficient. Achieving optimal habitat from a heavily degraded site often requires multiple intermediate steps over several years. This Technical Note conveys key considerations, tools and resources to help practitioners plan and implement seedings, in light of these real world constraints, to maximize the likelihood of seeding success.

I. Planning

Landscape context is a primary consideration when planning seedings to benefit wildlife species like sage-grouse. We often spend a lot of time measuring and managing for habitat conditions at the site scale since that's where we work. However, we first need to pick our heads up and look around to understand the type of landscape the project site is set in.

Sage-grouse are considered a "landscape species" which means they require vast areas, often multiple watersheds in size, to fulfill their life history requirements. A prerequisite to supporting healthy sage-grouse populations is having large and intact areas supporting sagebrush rangelands instead of other land uses/cover types (e.g., cropland, annual grasslands, and juniper woodlands). As a general rule, birds do best in landscapes where >2/3 of the area is in sagebrush rangeland but have trouble persisting with <1/3 of the landscape in sagebrush communities.

This is relevant to seeding decisions because significant investments can be made in restoration of a really high quality patch, but if it's set in a fragmented landscape, it may not generate the desired outcomes for grouse. Planners should utilize available spatial data and local wildlife agency expertise to gauge the relative likelihood that site-scale restoration efforts will meet

project goals and objectives. If an evaluation of the landscape context reveals site level restoration would be beneficial, the next step is to begin to understand the ecology of the site.

Think about the ideal sagebrush ecosystem. What do you see? Most of us probably envision a sagebrush stand that's not too dense, with abundant forbs and grasses. But the sagebrush ecosystem is incredibly diverse and occurs across broad environmental gradients (Figure 1). Figuring out where the site you're working with falls along this gradient is pivotal to understanding the inherent site potential, limitations and risks.

Figure 1. The idealized vision of a sagebrush ecosystem.

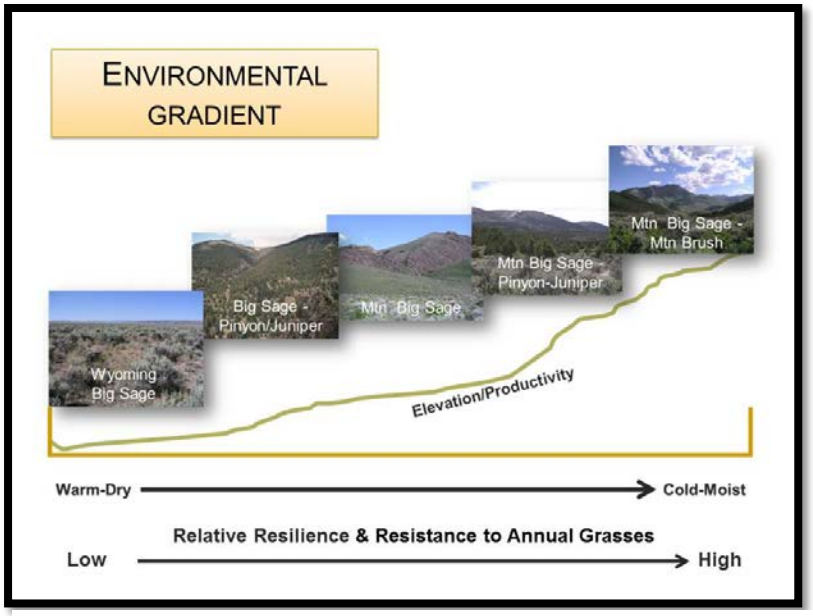


Figure 2. Sagebrush ecosystems are diverse and occur over a broad environmental gradient (modified from Chambers and others, In Press). Restoration risks and options vary considerably across ecosystem types.

Along this gradient, many defined ecological sites exist (Figure 2). An ecological site is a distinctive kind of land with specific physical characteristics that differs from other kinds of land in its ability to produce a distinctive kind and amount of vegetation. Ecological Site Descriptions (ESDs) provide a wealth of information about the site needed to make informed restoration decisions.

Once we know the type of site we're dealing with, we can gain a better understanding of vegetation dynamics through the state-and-transition model (STM). State-and-transition models are important conceptual tools that provide information on possible plant community states and phases, expected response to disturbances, and what pathways for recovery exist. Figure 3 shows one generic STM example with four possible states: reference, invaded, annual, and seeded states. Within each state are plant community phases that can shift back and forth. Each has its own

risks, recovery potential, and ability to support sage-grouse. Determining which state best characterizes your site will help you determine the appropriate role of seeding.

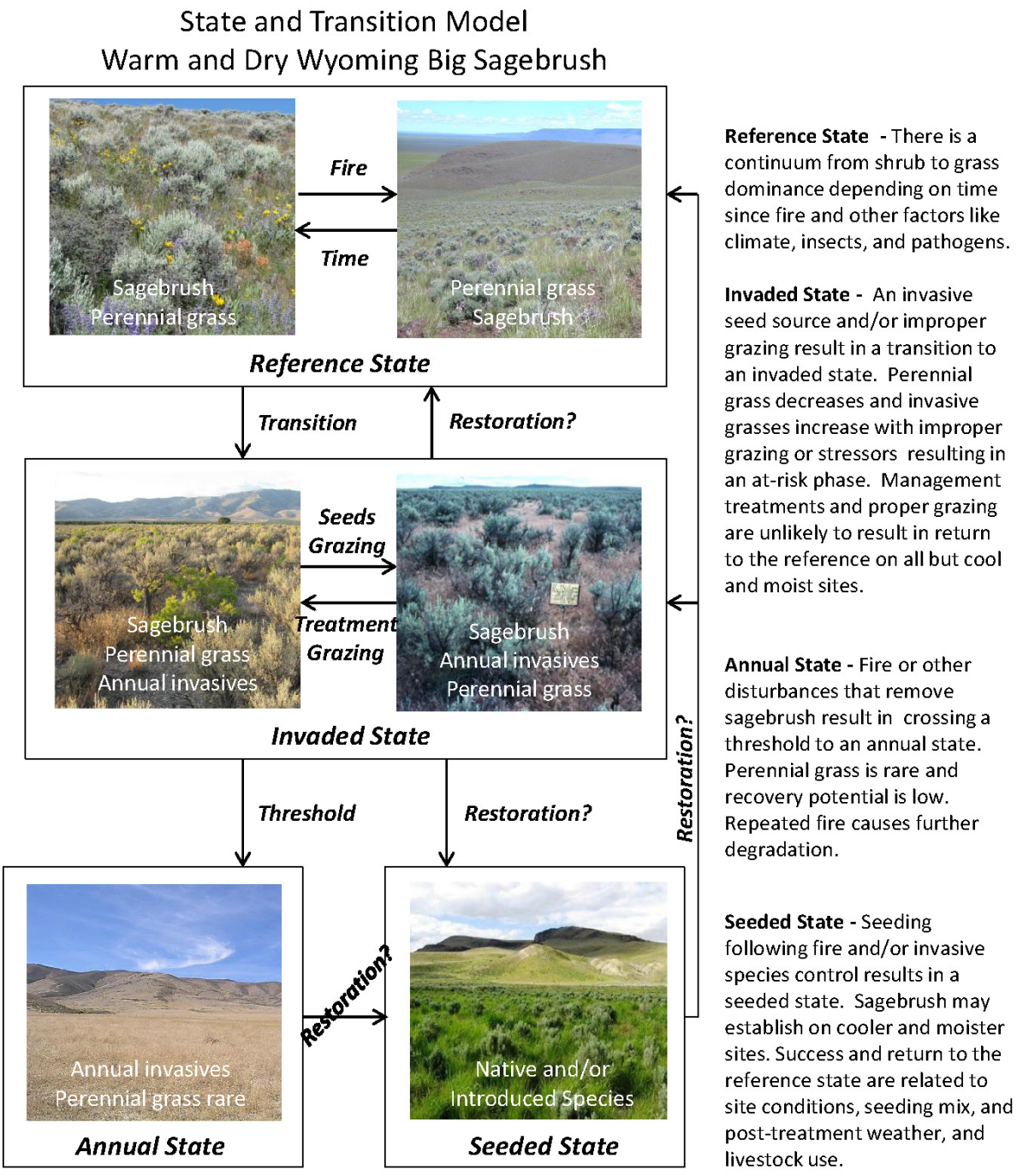


Figure 3. A generalized state and transition model that illustrates vegetation dynamics and restoration pathways for the warm and dry Wyoming big sagebrush ecological type (Chambers and others, In Press).

One of the first questions to be answered when looking at a site that needs vegetative improvement is: *"what is the best approach: re-seeding or better managing what exists on the*

site?" Seeding can be a risky proposition and may not be the best answer. For example, it might be preferable to manage the site to allow natural recovery to occur, especially if adequate amounts of desired species are present (e.g., desired species >25% of the total vegetative composition). (See Table 1).

In the Intermountain West, a large portion of non-irrigated plantings fail for one reason or another, with sites receiving fewer than 10 inches annual precipitation having the highest failure rates. A recent study examining 101 post-wildfire seedings in sagebrush steppe found that restoration actions did not increase the probability of burned areas meeting sage-grouse habitat guidelines, and that sage-grouse were found to be unlikely to use many burned areas within 20 years of fire regardless of treatment (Arkle and others 2014). Furthermore, seed and site preparation costs are high, which make multiple interventions unpalatable even when they may be needed.

It's important to keep in mind there are circumstances when seeding is not the best conservation solution, and can actually make an existing problem worse if the seeding fails! Plantings using complicated seed mixes occurring in areas of low annual precipitation, and sites with a heavy weed infestation are particularly prone to failure, thus requiring extra care. Inter-seeding into existing vegetation is seldom successful, which makes habitat enhancement projects especially difficult.

Regardless of your decision, planting or managing, it is important to spend adequate time evaluating landscape and site-scale information to determine the best course of action.

Table 1. To seed or not to seed? Ask yourself…

- Where is the site along the elevational /temperature/moisture gradient? Higher elevation, cooler and moister sagebrush sites often do not require re-seeding after disturbance.
- What is the current composition of desired plants? If desired species represent less than 25% of the existing on-site plants, then consider re-seeding
- What is the risk of invasive species? If current pressure from cheatgrass or other invasives is high, seeding desired perennials may be needed to stabilize the site.

Site and Resource Inventory

Once the decision has been made that seeding is warranted, it can be easy to get ahead of oneself in planning a seeding and to jump to species selection. Selecting the right plant species, deciding if the planting should consist of all native species, all introduced species, or a combination of both, and which cultivars or selections should be specified, will all be influenced by the site conditions as well as planting goals. A good site inventory is the first step towards a successful project.

Climate

Once it is determined that simply managing the site will not provide the desired results and that a new planting is needed, one of the first tasks is to complete a site inventory (Figure 1). This information will help you select the right plants, prepare the site properly and plant at the best time. One of the first things you should obtain is basic climate data. You want the most localized

information possible. You will want to know growing season length as determined by average first and last frost free dates. This helps identify which plants will be used as well as when you will be doing the seeding. You will want to note the monthly average high and low temperatures which again effects which plants are selected and when they are planted. And, most importantly, determine the total amount of precipitation received each year as well as its seasonal distribution.

Figure 4. A post-burn site in Hailey, Idaho. Before attempting any seeding, planners should properly understand the climatic and soil properties of the site. Photo by Derek Tilley, NRCS.

Soils

Understanding the soil properties can help you select the correct plants as well as find out if the site has characteristics that could impact planting installation or survivability of the seedlings. Soil chemistry including salinity and pH are important in determining well adapted species. Determine the site's predominant soil texture and the general lay of the land, as this greatly influences which species should be grown. Is your land on a slope (i.e., it drains well) or is it at the bottom (where water puddles)? A soil with a high clay content will tend to retain water. Sandy, gravelly and rocky soils will tend to drain quickly. If the site has low water holding capacity, is sandy or gravelly, the plants will become drought stressed fairly easily, and drought tolerant species should be selected. Species that have good tolerance for wet conditions should be selected for poorly drained sites.

Specific plant species characteristics and adaptations should be matched to soil and climatic conditions, as well as intended use of the planting.

Weeds

Proper control of weeds cannot be understated, as planting failure resulting from weed competition is common. It is crucial to understand the weeds present at a site, their abundance or density and the likelihood of an underground seed bank.

Cheatgrass and medusahead wildrye are perhaps the most common and most problematic weeds in sage-grouse habitat restoration (Figure 5). Both are winter annuals, germinating considerably earlier than most native species. This gives the weeds a significant tactical advantage in

Figure 5. Introduced annuals like cheatgrass compete against seeded species for moisture and nutrients. Weeds need to be controlled for seedings to be successful. Photo by Cassondra Skinner @ USDA-NRCS PLANTS Database

the fight for spring moisture and available soil nutrients.

Obtaining adequate weed control takes time and effort. In some cases two years of tillage and/or chemical fallow is necessary to significantly reduce long term competition. In the planning phase it is important to consider how much will be required to control the current competition as well as weed seed bank implications. One should also consider the possible secondary effects of weed control such as residual herbicide activity and increased erosion. Post seeding herbicide treatment options are limited, especially where forbs and shrubs are planted. University Extension weed control specialists are an excellent resource for herbicide questions.

Equipment

Once the soil properties and plant competition levels of a site are understood you can determine what type of equipment is needed for site preparation and planting. Drill seeding is far more effective at establishing grasses than broadcast seeding methods and is strongly recommended when feasible. Aerial seeding is often used for large areas of land, but the resulting seed-to-soil contact is poor and establishment rates may be significantly reduced.

Availability and cost of the necessary equipment are often a major factor, and conservationists are forced to use the best option at hand. A lack of availability of certain equipment may also limit your species options and may make seeding a particular site very difficult if not impossible. Consult with your state Plant Materials support staff to explore options.

Species Selection

In addition to many climatic and environmental considerations when selecting plants, there are numerous plant characteristics that need to be taken into account. These might include the species' competitive ability with weeds and other vegetation, their longevity or lifespan, i.e., are they annuals, short lived perennials, or long lived perennials, and are there distinctive growth habits of the species (bunch grass or sod-forming)?

Table 2. Native or Introduced?

Native
- (+) Well adapted to environmental extremes
- (+) Function well as part of native plant community
- (-) May not compete well with introduced weeds
- (-) May be difficult or slow to establish, especially where noxious weeds are prevalent

Introduced
- (+) Well adapted to environmental extremes
- (+) May compete well with introduced weeds
- (+) Typically easy/quick to establish
- (-) May form monocultures with limited diversity
- (-) Concerns about spreading into non-target areas

When properly applied, both native and introduced plant species serve a function in resource conservation. One of the major factors determining whether a seeding succeeds or fails is the weather during the first year of establishment. Natural weather patterns allow for recruitment from native stands only periodically. In low precipitation years the seed is preserved in the soil seed bank waiting for the right conditions in which to germinate. However, cheatgrass and other annual weeds can germinate and thrive under droughty conditions and create a landscape in which native species compete very poorly. Although not preferred for sage-grouse habitat, introduced perennial species can be useful in quickly stabilizing sites at risk of invasive species conversion and help prepare a site for future improvements.

Table 2 gives some of the pros and cons associated with the two types of conservation plants. The appropriate choice depends on many factors, but the most important are: what is the planner's objective and what is the environment into which the planting is going to be made? If the site is heavily infested with cheatgrass, especially at lower precipitation zones, use of introduced species capable of competing with the cheatgrass may be a better option than currently available native plant cultivars. Converting a site from cheatgrass directly to a diverse native community is highly unlikely.

Intermediate steps such as the establishment of introduced perennial species to restore ecosystem function may be required before a native species mix can be successfully introduced. There may be times when both may be appropriate to use, for instance, using natives in island type plantings, while seeding the open heavily weed infested areas with competitive introduced species.

Site Preparation

Site preparation is a critical and often overlooked step in the restoration process. How it is approached depends on variables such as topography, project scope, site disturbance considerations, likelihood of weed invasion, and of course, cost. Site preparation for most sage-grouse habitat projects, given their typically large scale, will generally fall into the first category, involving litter removal or dispersal, followed by chemical weed control and then dormant fall seeding.

On smaller, more intensively managed landscapes, conventional agronomic site preparation such as disking or even plowing may be possible. Use of seed drills (planters) may also be feasible if the site is level and accessible. Site preparation measures such as these will improve seed to soil contact and may improve stand establishment, although the cost may be relatively high.

Typical Protocols for Preparing a Seedbed Currently in Perennial Vegetation

1) Shred or burn existing litter		1) Plow 1st spring
2) Apply herbicides 1st spring, again in fall if green-up occurs		2) Disk 1st fall
		3) Disk 2nd spring
3) Apply herbicides 2nd spring, again in fall if green-up occurs	OR	4) Disk 2nd fall and mechanically prepare final seedbed
4) Plant new seed mixture as a dormant planting		5) Plant new seed mixture as a dormant planting

It is important to remember that these are starting recommendations. Each site is different and may require variations to this starter recommendation. The bottom-line message is that competition needs to be controlled and the seedbed must be in the best condition possible to facilitate seed germination and establishment.

Weed Control

The presence of weeds (especially noxious weeds) will also determine the methods used to prepare a good seedbed and to have a successful seeding (Figure 6). For successful establishment, seeding fields with significant weed populations must be delayed until weeds are controlled. Refer to the Pacific Northwest Weed Management Handbook and Montana-Utah-Wyoming Weed Management handbooks for information on herbicides that can be used for weed control during seedbed preparation and establishment.

Figure 6. When feasible, herbicide treatments can be an effective means of controlling weeds or eliminating competition from established introduced perennials. Photo by Loren St. John, NRCS.

Other sources of information include extension specialists, county weed control supervisors and chemical dealers. Guidelines for Integrated Pest Management are available in the electronic Field Office Technical Guide (EFOTG) section IV, Practice Standards. Always read and follow label instructions when applying herbicides.

II. Common Scenarios

To illustrate the variety of conditions encountered in Intermountain Western rangelands, we highlight four scenarios and discuss possible treatment options. Keep in mind though, all sites are unique and should be approached with an open mind.

Figure 7. N-sulate floating row cover is laid over small islands seeded to forbs and shrubs. Photo from UDWR.

Scenario 1: Low precipitation/ mostly native grasses/ poor cover/ few forbs

In this scenario the site is in a low precipitation area receiving less than 12 inches precipitation annually. The cover is predominantly native species but could use an increased forb component as well as increased sagebrush cover.

In general, sites like this are probably best left alone to allow nature to take its course. Any ground disturbance like tillage or herbicide treatments to prepare for a seeding has the potential to allow undesirable weeds to establish. If the ground has already been disturbed by wildfire, this

site would be a good candidate for a diverse native seed mix. Interseeding (planting directly into existing cover), though tempting, has been proven to be largely ineffective and is not recommended. It may be possible to clear isolated areas for the establishment of small pockets or islands of forbs and shrubs using seed or nursery developed materials. In the picture, forb islands are being covered with a floating row cover commonly used in vegetable production to improve soil moisture by reducing evaporation (Figure 7).

Scenario 2: Low precipitation/ introduced perennials or annual weeds dominate

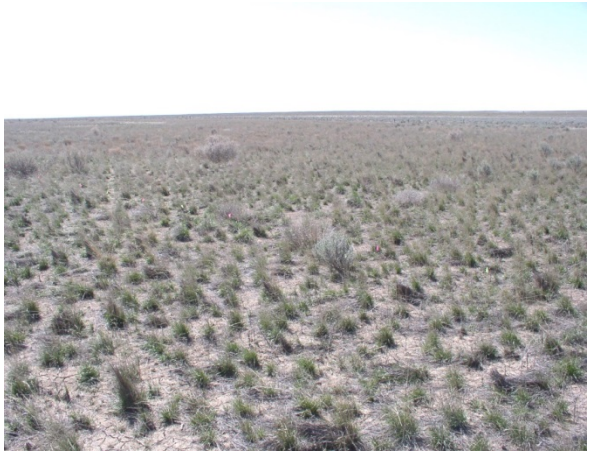


Figure 8. Scenario 2, a low precipitation site dominated by introduced perennials. Sites like these typically require a significant amount of preparation before a native seeding mixture can be successful. Photo by Derek Tilley, NRCS.

The second site is also a low precipitation area but is dominated by introduced species (Figure 5). A post-fire seeding of natives on a site like this without further site preparation is likely to fail. Introduced perennials like crested wheatgrass and intermediate wheatgrass are extremely competitive and are not typically reduced significantly from a single fire event. Additionally new seedlings from introduced perennials as well as cheatgrass and other annuals are more vigorous and can out-compete the majority of our available natives. Multiple site preparation treatments of tillage or chemical fallow are required to kill the existing stand and reduce the seed bank to a degree where natives will establish and persist. If site preparation treatments are not an option, consider improving ecosystem function by seeding a more diverse mixture of introduced species.

Scenario 3: Higher precipitation/ strong native plant community

The third site may be a location that receives 14 or more inches mean annual precipitation. There is a strong native plant community mostly consisting of perennial grasses. If there is little threat from weeds, then patience may be the best option. The site is likely recovering from a burn in the recent past and could be naturally moving towards the desired plant community. Again, forb or shrub islands and mother plants may be an option to hasten the process. If this is a post-fire seeding then a diverse native mix is recommended.

Scenario 4: Higher precipitation/ high weed pressure

The final site is a higher precipitation area but has a well-established community of invasive weeds. The most important thing to do here is control the weed population. A post-fire seeding may be initially successful, but the weeds will return if not properly treated. If the site is dominated by broadleaf weeds such as knapweed or yellow star thistle, it may be advisable to establish perennial grasses to allow for subsequent treatments of selective broadleaf herbicides. A more diverse native species mixture can be introduced at a later time when conditions are more favorable.

III. Developing Seed Mixes

Often the greatest technical challenge for planners and land managers when developing a seeding mix is choosing the species, determining their relative percentages in the seeding mixture, and then making the appropriate seeding rate calculations. In the following section we show how to develop a site specific seed mixture that is adapted to the local conditions and approximates the reference state plant community.

What Do I Need to Figure Out?
The answer depends on how much information is available, the complexity of the seeding mixture, the need for specialized carriers and equipment, the species selected, and the severity of the site disturbance. In almost all cases, planners will need to know how much seed (number or weight of live seeds) to apply per unit area. Adjustments will need to be made based on Pure Live Seed versus bulk seed, the quality of the seed lot used, if the seeding is broadcast sown versus drilled, if the site is a critical area planting or not, and if seed carriers are needed**.**

Since most seedings in sage-grouse country will involve relatively large acreages of rangeland, we show how to develop a mix for a broadcast seeding as well as a drill seeded mix. Both "good" sites, as well as "critical" or highly disturbed sites will be addressed. It is important to note that most seeding rate recommendations are based on "good" sites and the use of specialized planters; therefore, seeding rates must be adjusted accordingly when they are broadcast or the site is considered highly disturbed.

Which Species and Relative Amounts in the Mix? – Begin with Ecological Site Descriptions (ESDs)

Without experience, choosing the plant species to use and determining their relative percentages in a seed mix can be pretty intimidating. For sage-grouse habitat restoration in rangeland, an excellent starting place is the Ecological Site Description or ESD. These inventories provide a wealth of important information regarding site conditions and the types of plant species you might expect growing there.

The plant species are organized by life form (grasses, forbs, and woody plants), and their estimated anticipated annual production in the plant community. Although a relatively crude extrapolation, this information can be used to estimate the relative percentages to include in a mix, although availability and cost will certainly influence the final composition of the seed mix.

In this example from MLRA 25 in southwestern Idaho, grasses make up approximately 55% of the annual production on the site, while forbs account for approximately 15% and shrubs make up the final 30%.

Site name: **LOAMY 10-13 ARTRW8/PSSPS**
/ Artemisia tridentata ssp. wyomingensis / Pseudoroegneria spicata
(/ Wyoming big sagebrush / bluebunch wheatgrass)
Site type: Rangeland
Site ID: R025XY019ID
Major land resource area (MLRA): 025-Owyhee High Plateau

	Annual Production (lbs per ac)	
1 -Grass/Grasslike	220	600
2 -Forb	55	170
3 -Shrub	125	330

The species composition tables provide additional production estimates of the dominant species in the plant community. The table below shows the composition of the grass and grasslike species at the site (Table 3). We would certainly want to include a substantial percentage of bluebunch wheatgrass in a seed mixture. We might also want to include a small portion of some of the other grasses concentrating primarily on the bunch grasses. If a particular species is not commercially available, choose species which are functionally or structurally similar. The same steps should be followed to decide on forb and shrub composition in the seed mix.

Table 3. Annual production estimates of grass/grasslike plants at LOAMY 10-13 ARTRW8/PSSPS

		Annual Production (lbs per ac)	
Common name	Scientific name	Low	High
		220	600
Indian ricegrass	*Achnatherum hymenoides*	5	20
Thurber's needlegrass	*Achnatherum thurberianum*	10	30
bottlebrush squirreltail	*Elymus elymoides*	10	30
thickspike wheatgrass	*Elymus lanceolatus*	1	15
Nevada bluegrass	*Poa nevadensis (syn)*	1	10
Sandberg bluegrass	*Poa secunda*	10	30
bluebunch wheatgrass	*Pseudoroegneria spicata* ssp. *spicata*	160	440

The final seeding mixture will reflect what is commercially available and within project budget. The NRCS Plant Materials Program has numerous well-adapted selections and can help planners decide which selection, if any, is best suited for the site and for enhancing or restoring sage-grouse habitat.

Forbs for sage-grouse habitat are particularly challenging as there are many fewer selections of native forbs available on the commercial market than grasses, and they are often very expensive. Many native forbs utilized by sage-grouse are poor seed producers or do not lend themselves to

mechanized seed production. There are currently no cultivars or tested plant materials available for any of the forbs or shrubs from this example ESD (Table 4). Wildland collected seed may be available, but it is likely to be expensive and its performance is unknown. Choosing related or similarly functioning species is often a real world compromise when selecting forbs for the seed mix.

Table 4. Annual production estimates of forbs at LOAMY 10-13 ARTRW8/PSSPS

		Annual Production (lbs per ac)	
Common name	Scientific name	Low	High
		55	170
pussytoes	*Antennaria*	1	5
aster	*Aster*	5	15
milkvetch	*Astragalus*	1	10
Hooker's balsamroot	*Balsamorhiza hookeri*	0	10
arrowleaf balsamroot	*Balsamorhiza sagittata*	10	30
tapertip hawksbeard	*Crepis acuminata*	10	20
larkspur, tall larkspur	*Delphinium*	1	5
erigenia	*Erigenia*	5	15
biscuitroot	*Lomatium*	1	5
lupine	*Lupinus*	5	15
Hoods phlox	*Phlox hoodii*	10	20
longleaf phlox	*Phlox longifolia*	10	20

As with forbs, shrubs are also less available and harder to establish than grasses. Success with shrub seeding is often much lower than grasses or even forbs, especially in low annual precipitation zones. Seeding or planting of seedlings in island plantings could be considered to establish woody plants in rangeland sites, although this too is far from guaranteed success.

Table 5. Annual production estimates of shrubs at LOAMY 10-13 ARTRW8/PSSPS

		Annual Production (lbs per ac)	
Common name	Scientific name	Low	High
		125	330
Wyoming big sagebrush	*Artemisia tridentata* ssp. *wyomingensis*	100	275
green rabbitbrush	*Chrysothamnus viscidiflorus*	10	30
buckwheat	*Eriogonum*	5	15

Sagebrush species and subspecies have narrow parameters of adaptation. Proper identification of species and subspecies is critical for the long-term restoration of sagebrush ecosystems. There is also increasing evidence supporting the importance of locality with regards to sagebrush establishment and persistence. Whenever possible, sagebrush seed should originate from the same Major Land Resource Area as the intended planting site. Additionally, sagebrush has small, relatively short-lived seed. It can easily be planted too deeply, and seems to establish better when properly broadcast than drilled.

Table 6. Possible sources for plant composition when ESD not available

- Major Land Resource Areas (MLRAs)
- Soil Survey information
- Habitat types
- Botanical surveys
- Study results
- Stand-alone publications
- Local experts

Ecological Site Description Not Available?

So what do you do if an ESD on your proposed project site is not available? There are many other sources of information that can be used to provide clues into site conditions and potentially adapted species (Table 6).

Remember, nothing is better than an on-site survey of the project site prior to seed mixture development. If the site has been recently disturbed, attempt to find undisturbed plant communities in close proximity or in a similar environment. An often overlooked resource is a local land manager, professional or private, that has knowledge of the site and climate in the restoration area. Such individuals provide invaluable plant community insight, and may save precious time and monetary resources when consulted early in the planning process.

Plant Materials Selections and Other Seed Sources for Sage-grouse Habitat Restoration
It's important to keep in mind that many native plant species may not be commercially available or are currently prohibitively expensive. To address these issues, the NRCS Plant Materials Program has developed a brochure titled, "*Improving Sage-grouse Habitat Through Revegetation and Rangeland Management*", providing lists of plant selections that may be used in seed mixes for enhancing or restoring sage-grouse habitat. This brochure lists plant selections from Plant Materials and other programs that should meet the functional requirements of each species and life form when attempting to establish a plant community capable of supporting sage-grouse habitat.

The Plant Materials Program has also developed some excellent resources regarding plant species characteristics and seeding installation. Visit your state NRCS Plant Materials Center website for these and other publications.

Plant Materials Tech Note 10 "Pasture and Range Seedings Planning-Installation-Evaluation and Management" provides information on planning, implementing and evaluating seeding projects.

Montana Plant Materials Tech Note 46 "Seeding Rates for Conservation Seedings" and Idaho Plant Materials Tech Note 24 "Conservation Plant Species for the Intermountain West" have detailed information on most conservation species.

Seed Mixture Considerations
Some general rules of thumb should be applied for developing seed mixtures. For dryland situations, choose 6 to 10 species including grasses, forbs and shrubs. Adding additional species generally increases cost but does little to increase overall diversity. Be mindful of compatibility issues. For example, will one species crowd out other species. You should also be aware of recommended seeding depths for each species. When using a seeding drill, deep seeded species and shallow seeded species should be planted separately, if possible. If separate seeding is not feasible, then the shallower depth should be used.

Extra consideration should be used when combining native and introduced species together. This practice is generally not recommended, as introduced species are very competitive and may out-compete native plants. However, introduced forbs such as alfalfa, blue flax and small burnet can be successfully established with native grasses.

When developing a seed mix one should consider the expected life span of the species. Some species have relatively short life spans, such as slender wheatgrass and, usually, should not make

up more than a fraction of the mix. These species are often fast at establishing and including them will help get a stand established while the slower and longer lived species develop.

Another thing to consider is whether or not the seed needs a pre-treatment. Many, if not most, native forbs require a cold stratification period in order to germinate. These species are typically planted in the fall rather than the spring to allow for natural stratification. Additionally, legume seed should be inoculated with the proper rhizobacteria prior to planting. Legume seed often has a hard seed coat which may need to be mechanically or chemically scarified to allow immediate germination. This is most often handled by the seed vendor and should be specified when purchasing the seed.

Example Seed Mix

Using the species composition from the ESD on page 10, one can determine relative percentages of grasses, forbs and shrubs at the site and develop a mixture approximating those proportions (Table 6). The information found in ID Tech Note-24, MT-46, Plant Guides and other sources can be used to select species not on the ESD suitable to the site, and guide decision making regarding cultivars or releases.

This sample mix includes a high percentage of bluebunch wheatgrass, a small component of Nevada bluegrass and Indian ricegrass, and a minimal amount of the sod forming grass, thickspike wheatgrass (Table 7). Also included is a low percentage of slender wheatgrass, a vigorous but short-lived perennial bunchgrass used to provide immediate cover and site stabilization. The forbs Lewis flax, yarrow and Palmer penstemon make up a relatively small amount of the overall mix reflecting the abundance of forbs in the ESD, as do the shrubs winterfat and Wyoming big sagebrush. Though the mix is not made of the exact species from the ESD, the species chosen are known to be commercially available and perform similar ecological functions to those in the reference state.

Table 7. Sample mix developed for LOAMY 10-13 ARTRW8/PSSPS

Species	Recommended Percentage in Mix
Bluebunch wheatgrass	40
Indian ricegrass	10
Nevada bluegrass	5
Thickspike wheatgrass	5
Slender wheatgrass	5
Lewis flax	5
Yarrow	5
Palmer penstemon	5
Winterfat	10
Wyoming big sagebrush	10

IV. Seed Quality: Not All Seed is the Same!

The quality of the seed of each lot in the mix is extremely important. When possible, always attempt to procure certified seed which has been inspected and is held to quality standards for germination, weeds, other crops and inert material. If certified seed is not available, make sure to request a full laboratory analysis (not just a seed tag) so that you know exactly which species of Other Crops and Weeds are in the sample. It will also be important to know how processed (how well cleaned) the seed is, as this characteristic will greatly influence mixing and seed flow through equipment. If you have questions about seed quality you can call a Plant Materials Center or seed certification office for advice. Montana Tech Note 67 is an excellent reference for this subject.

Seed Classes

It can be important in some cases to consider the different seed characteristics of each release class since the amount of testing, and therefore the anticipated performance, is reflected by the Release Class (Table 8). Source Identified seed has had no performance testing, but may have originated from a site nearer the intended seeding. Selected and Tested Class seed has undergone limited evaluations at a Plant Materials Center or similar facility and has documented performance. Cultivars have been tested extensively for multiple generations and in numerous locations; however, selection of certain traits may have narrowed the genetic diversity of the seed. Wildland and some common seed have virtually no performance pedigree, and are rarely certified, but may be the only materials available for use.

Table 8. Comparison of seed releases classes.

Source Identified	Selected/Tested Class	Cultivar
(-) No performance testing	(+) Some performance testing	(+) Performance known and tested in multiple environments
(-) Seed quality tests may be lacking	(+) Limited plant selection, so genetics little altered	(+) Usually establishes readily
(+) Seed can come from similar area or wildland collected from area to be planted with appropriate lead times	(+) Selection often grouping of better performing lines from within an ecological region	(+) Certified seed available
(-) Certified seed often not available	(+) Certified seed often available	(+) Seed relatively inexpensive
(-) Seed often expensive	(-) Level of testing not as thorough as cultivars	(-) Concerns by some that genetics have been narrowed which may affect performance and persistence

Certified seed

Certified seed insures the quality of the product and protects the buyer. It provides third party verification for seed collectors and growers. An independent certification agency verifies seed origin and generation, inspects production fields to verify isolation distances and control of weeds, and seed cleaning facilities are also inspected. If all the standards are met, then the seed lot can be tagged with Certification labels.

Certified seed is highly recommended for conservation seedings. Use of certified seed insures quality, which improves the chances of a successful planting. Some NRCS states actually require the use of Certified seed for cost-shared practices. Be sure to check your state standards.

Common seed

If you cannot obtain Certified seed, you may be able to purchase common class seed, but buyer beware. You may not be getting what you think you are or what you were willing to pay for. It may be a named variety but not grown under certification program or it may not have met certification requirements. Remember, you still must be provided a seed tag, and it is especially important to ask for a seed analysis report when the seed lot is not certified.

Figure 9. Seed purity and viability determine the quality and value of the seed. Photo by Derek Tilley, NRCS.

Pure Live Seed

All NRCS seeding recommendations are based on Pure Live Seed (PLS) rates. This value indicates the number of actual live seeds in a sample, and takes into account the viability of the seed lot, as well as the amount of other crop seeds, weed seeds, and inert (plant stems, broken seed, etc.) material (Figure 9). Percent PLS is calculated by multiplying the percent purity of the lot by the percent germination or viability of the lot. This information is found on some seed labels and on seed laboratory analyses. Bulk seed, on the other hand, includes live seeds plus all other seeds and inert material. You may need to calculate the bulk seed value when weighing or purchasing seed.

Purity is the actual amount of pure seed of the species in the lot. A higher purity percentage reflects a better quality of seed lot. Purity and inert matter will vary by species. Most commonly cultivated grasses should have purities approaching or exceeding 90 %. Some native grasses may only have purities of 50-60 % due to awns or long seed appendages. Forb and shrub seed is difficult to clean and may have very low purities; sagebrush for example is commonly sold with purities as low as 20%. This “trashiness” presents handling problems and may limit how the material can be planted. Seed that has a lot of trash in it (inert matter, other crop seed and damaged seed) can be difficult to run through a seed drill.

Viability

Seed calculations and procurement requests should always be conducted on a Pure Live Seed basis. Working with PLS means that we are always describing actual, live seeds placed on the ground. Live seeds are measured in different ways. “Germination” describes seeds that are likely to grow given favorable conditions in a certain amount of time, although some seed that does not germinate is often “alive”. “Total Viable Seed” describes all seed that will germinate, as well as other seeds that have hard seed coats and/or dormancy mechanisms that will not allow the germination until appropriate conditions are met. The tetrazolium, or TZ test, is used to identify if non-germinating seeds are alive or not, and provides an indication of how many seeds are

alive, even though some or all may not immediately germinate given favorable growing conditions.

High germination percentages suggest the seeds will germinate and grow given favorable conditions of temperature, moisture, etc. In contrast, seeds with a high percentage of hard or dormant seed will not germinate readily, and may need to be scarified or planted in the fall to overcome dormancy mechanisms.

As noted, NRCS conservation seedings should be based on Pure Live Seed (PLS). PLS is the percent purity times percent germination (or TZ) divided by 100 and is determined for each separate seed lot. For example, a seed lot with 99.5% purity is multiplied with 90 % germination and divided by 100. The resultant PLS is 89.56%.

- Germination
  - % normal seedlings likely under favorable conditions
- Total Viable Seed
  - % germination + % hard and/or dormant seed
  - Tetrazolium chloride test (TZ)
- % Purity + inert matter + weed seed + other crop seed = 100%
- PLS= % purity X % viable / 100

In general, most grasses should have germination rates above 80%. Be cautious buying grass seed with less than 60% germination, as it may have lower seedling vigor and thus poor establishment ability. In comparison, Source Identified class grasses, native forbs and shrubs often have lower germination rates.

Germination decreases with age, so older lots of seed should be avoided. Some species can lose viability rapidly. For example, winterfat and sagebrush are known to lose viability quickly after only two years of storage in typical conditions. The best way to avoid problems and insure the best quality of seed is to request a current germination or TZ test (within last 12 months).

Comparing Seed Cost

PLS is also a good tool to compare the relative value of a lot of seed. Bulk seed offers no consistency in terms of composition from lot to lot. Table 9 shows a simple comparison of two seed lots with different PLS values that both cost $1.00 per bulk pound. At first glance without doing the calculation you might not really notice much difference in seed quality. The % purity is not much different between Lot A and Lot B, but there is a huge difference in % germination, which translates into large differences in PLS. As a result,

Table 9. Comparison of the relative value of two lots of seed based on % PLS

	Lot A	**Lot B**
Purity (%)	99.5	93.0
Germination (%)	90.0	60.0
PLS (%)	89.56	55.8
$/lb PLS	**$1.12**	**$1.79**

lot A is a much better value per pound of Pure Live Seed.

Bulk seed

There are times when it may be necessary to know the bulk weight of seed, such as when weighing out prior to planting. In order to apply the recommended PLS rate during seeding, the bulk seeding rate needs to be determined from the PLS information on the seed tag. The recommended PLS seeding rate per acre is divided by the % PLS of the seed to determine the bulk seeding rate.

For example if Goldar bluebunch wheatgrass is being seeded at 8 pounds PLS/A and the PLS of the lot is 89.56%, then 8 pounds PLS divided by 0.8956 equals 8.9 pounds of bulk seed needed per acre.

It can be easy to get confused but all you need to remember is that the bulk seeding rate is **larger** than the recommended PLS seeding rate. If you mistakenly multiply the PLS seeding rate by the % PLS, the bulk rate will be smaller.

Seed Tags

The seed tag is an incredibly valuable piece of information. Everything listed on the tag is shown below (Table 10). This information includes the lot number, origin, and the name of the seller, should a problem arise. One key item missing on seed tags is which species make up the Other Crops and Weeds categories. You must request a laboratory analysis for that information.

Table 10. Items found on a seed tag

1) Variety and kind (Species and Common name)
2) Lot number
3) Origin
4) Net weight
5) Percent pure seed
6) Percent germination (and date of test)
7) Percent inert matter
8) Percent other crop seed
9) Percent weed seeds
10) Name of restricted noxious seed
11) **Prohibited noxious seeds are not allowed.**
12) Name and address of company responsible for analysis (seller)

Every state has a list of prohibited and restricted noxious weeds. It's not so important to know all the weeds on the noxious weed lists for your state, but it is important for the seed seller.

Table 11. Weed Seed Designations

- Prohibited Weeds:
  - No prohibited or restricted weed seed allowed in certified seed
- Restricted Weeds:
  - Allowed in "common seed"
    - Amount restricted up to limits established by law
    - Name and number of seeds per pound must be listed
- Common weeds:
  - Should not total more than 5% by weight
  - Obtain seed analysis report to view specific weeds

Prohibited noxious weeds are not allowed in either common or Certified seed. **Restricted** noxious weeds however are allowed in common seed but are restricted to certain limits allowed by law, while Certified seed may not contain any restricted noxious weed seed. Restricted weed species and number of seeds per pound must be listed on the tag. Common weeds should be no more than 5% by weight, but a standard tag won't specify what weeds these are (Table 11).

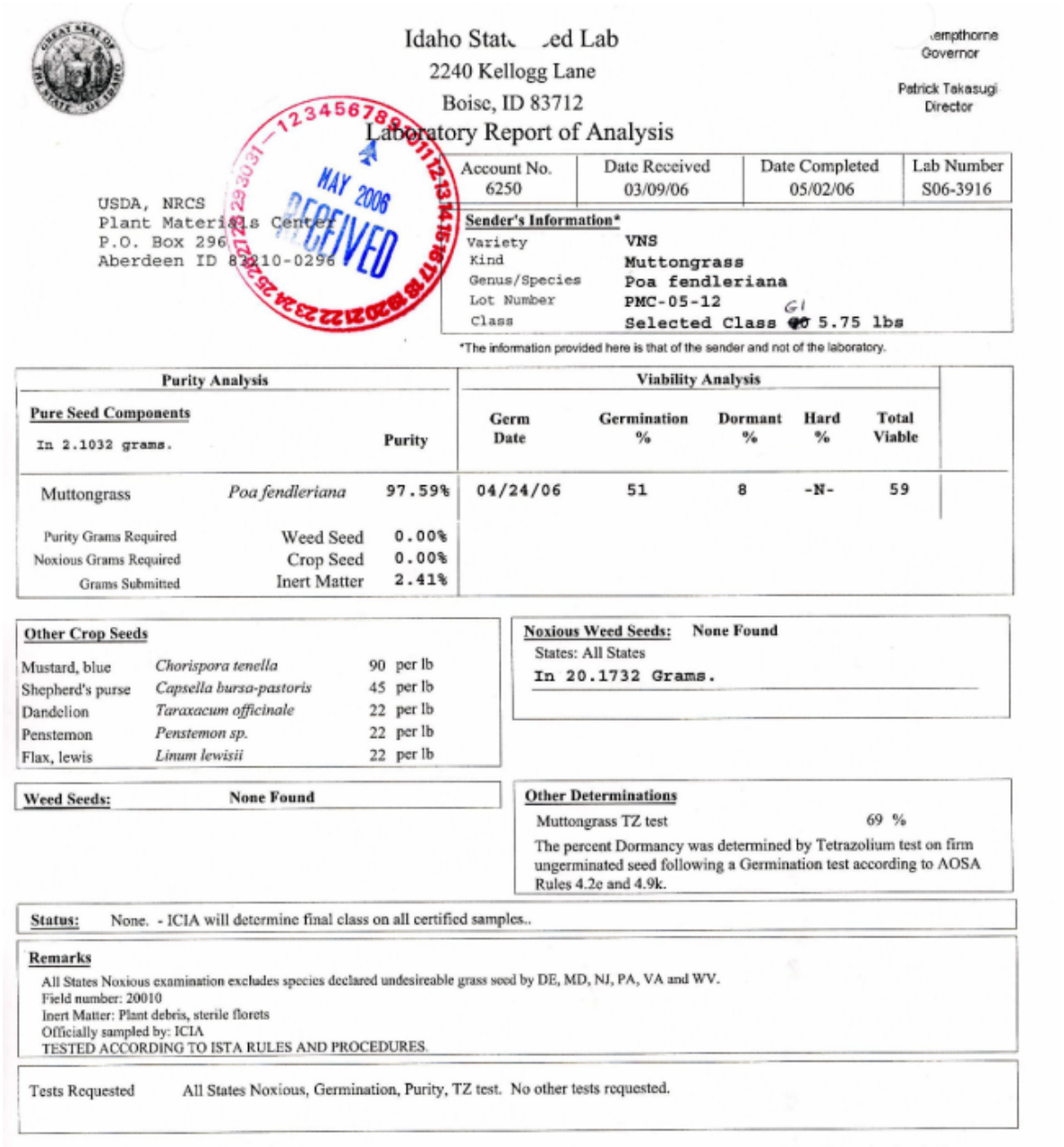
Seed grown in one state and purchased for use in another state must comply with the laws of both states. Even though each state has their own noxious weed list (and not all lists are the same from state to state), seed produced in Montana and shipped to Idaho must be free of the noxious weeds in Idaho as well as Montana. Basically it's the responsibility of the seed seller to make sure they are not importing weed seed to any state they ship to.

Seed Analysis Report

The seed analysis report is another valuable piece of paper. You should ask for a copy when you purchase seed. The seed seller is obligated by law to provide it upon request. Be wary of a seed vendor that won't provide the seed analysis report. You will be better off dealing with a company that does.

The seed analysis report has more detail than what can fit on a seed tag. It lists the crop seed by species (you may consider some "crops" weeds) and number per pound and weed seeds and their number per pound. It will also state whether or not the seed meets Certification standards. It is signed by the lab that did the test and is a valuable legal document if issues arise.

In the example, sender's information includes variety, kind, genus/species, lot number and class of seed (Figure 10). Purity analysis includes purity of the sample material, weed seed, crop seed, and inert matter. The viability section includes % germination, % dormant and the total viable seed. Other crop seeds are listed including weeds (blue mustard, shepherd's purse and dandelion) and other crops (penstemon and flax). The noxious weeds section states the lot is free of noxious weeds, and in the other determination section we see that a TZ test was conducted with resultant 69% viability.



Idaho State Seed Lab
2240 Kellogg Lane
Boise, ID 83712

...mpthorne
Governor

Patrick Takasugi
Director

Laboratory Report of Analysis

MAY 2006 RECEIVED

USDA, NRCS
Plant Materials Center
P.O. Box 296
Aberdeen ID 83210-0296

Account No.	Date Received	Date Completed	Lab Number
6250	03/09/06	05/02/06	S06-3916

Sender's Information*

Variety	VNS
Kind	Muttongrass
Genus/Species	Poa fendleriana
Lot Number	PMC-05-12 G1
Class	Selected Class 5.75 lbs

*The information provided here is that of the sender and not of the laboratory.

Purity Analysis

Pure Seed Components In 2.1032 grams.		Purity
Muttongrass	*Poa fendleriana*	97.59%
Purity Grams Required	Weed Seed	0.00%
Noxious Grams Required	Crop Seed	0.00%
Grams Submitted	Inert Matter	2.41%

Viability Analysis

Germ Date	Germination %	Dormant %	Hard %	Total Viable
04/24/06	51	8	-N-	59

Other Crop Seeds

Mustard, blue	*Chorispora tenella*	90 per lb
Shepherd's purse	*Capsella bursa-pastoris*	45 per lb
Dandelion	*Taraxacum officinale*	22 per lb
Penstemon	*Penstemon sp.*	22 per lb
Flax, lewis	*Linum lewisii*	22 per lb

Noxious Weed Seeds: None Found
States: All States
In 20.1732 Grams.

Weed Seeds: None Found

Other Determinations
Muttongrass TZ test 69 %
The percent Dormancy was determined by Tetrazolium test on firm ungerminated seed following a Germination test according to AOSA Rules 4.2e and 4.9k.

Status: None. - ICIA will determine final class on all certified samples..

Remarks
All States Noxious examination excludes species declared undesireable grass seed by DE, MD, NJ, PA, VA and WV.
Field number: 20010
Inert Matter: Plant debris, sterile florets
Officially sampled by: ICIA
TESTED ACCORDING TO ISTA RULES AND PROCEDURES.

Tests Requested All States Noxious, Germination, Purity, TZ test. No other tests requested.

Figure 10. Sample seed analysis report. This document provides information on seed purity, viability and detailed description of weed species found in the seed lot.

V. Calculations

In this section we cover the calculations commonly associated with developing a seed mixture. Careful attention to these calculations will ensure that the appropriate amount of seed of each species is planted for best chance of a good stand in an economically efficient manner.

Percentages of Each Species in the Seeding Mix (developed from ESD)
In this example, an experienced planner has suggested the relative percentages of each species in a mix (Table 12). These percentages can be multiplied by the full stand seeding rate to determine lbs PLS per acre of each component of the mix.

Table 12. Sample mix developed for LOAMY 10-13 ARTRW8/PSSPS

Species	Recommended Percentage in Mix
Bluebunch wheatgrass	40
Indian ricegrass	10
Nevada bluegrass	5
Thickspike wheatgrass	5
Slender wheatgrass	5
Lewis flax	5
Yarrow	5
Palmer penstemon	5
Winterfat	10
Wyoming big sagebrush	10

Determine Full Stand Seeding Rates (good site using a planter or drill)
The section of table below from ID TN-24 shows the recommended full stand seeding rate in PLS pounds per acre, when using a drill, on a non-critical area site, for several native grasses used in vegetative conservation practices in Montana (Table 13). The *full stand seeding rate* is the rate you would use if you were to seed a solid stand (100%) of a single species. It is based on a 12-inch, between-row spacing. In these cases, the rate is based on sowing 20 to 25 Pure Live Seeds per square foot. This number range is based on research results and observational experience on successful stand establishment in semi-arid environments, and also reflects the seed size of the individual species. On the table you can see that bluebunch wheatgrass is recommended at a full stand seeding rate of 8 lbs PLS per acre.

Table 13. Excerpt from ID Technical Note 24 showing tabular listing of seed information including the recommended full stand seeding rate (highlighted).

Grass seeding information				
Common Name	**Scientific name**	**Seeds/lb**	**Drill lb/ac**	**Seeding depth**
Wheatgrass, bluebunch	*Pseudoroegneria spicata*	139,000	8	1/4-1/2
Wheatgrass, crested	*Agropyron cristatum*	175,000	5	1/4-1/2
Wheatgrass, crested X	*Agropyron cristatum X*	165,000	5	1/4-1/2
Wheatgrass, crested	*Agropyron desertorum*	165,000	5	1/4-1/2
Wheatgrass, intermediate/pubescent	*Thinopyrum intermedium*	80,000	10	1/4-1/2
Wheatgrass, RS hybrid	*Elymus hoffmanii*	139,000	8	1/4-1/2
Wheatgrass, Siberian	*Agropyron fragile*	160,000	6	1/4-1/2
Wheatgrass, slender	*Elymus trachycaulus*	135,000	8	1/2-3/4

What If I Don't Have Full Stand Seeding Rate Information?

For many native species not commonly or historically used or available for conservation practices, it may be hard to find full stand seeding rates. In such cases, you can find and use the number of seeds per pound for that species, look up the target number of seeds per foot recommended for that size of seed, and work backwards to calculate the number of PLS pounds per acre to plant given our seeds per pound and target number of seeds.

Determine Seeding Rate for each Species in the Mixture

The next step in the equation is to calculate the seeding rate for each species in the mixture (Table 14). This is done simply by multiplying the full stand seeding rate times the desired percentage in the mix (in decimal format). For example bluebunch wheatgrass has a full stand seeding rate of 8 lbs/ac and is recommended to compose 40% of the total mixture. Multiplying 8 X 0.4 equals 3.2 lbs PLS per acre of bluebunch in the mix. The same calculation is done for each component.

Remember, these seeding rates are based on 12-inch between-row widths. We would need to makes adjustments to the PLS pounds per acre if row width increases above 12 inches. For example, at 24-inch row spacing, half as many linear feet are seeded than at 12-inch spacing. Thus the seed rate would need to be decreased by 50% to achieve the same number of seeds per foot of row.

Table 14. The desired percentage is multiplied by the full stand seeding rate to find the drill seeding rate for each component in the mix.

Species	Recommended Percentage in Mix	Drilled Full Stand Seeding Rate	Drilled Good Site Mix Seeding Rate
	%	*PLS lbs.*	*PLS lbs.*
Bluebunch wheatgrass	0.4	8	3.2
Nevada Sandberg bluegrass	0.05	2	0.1
Thickspike wheatgrass	0.05	8	0.4
Slender wheatgrass	0.1	8	0.8
Lewis flax	0.1	5	0.5
Yarrow	0.1	0.5	0.05
Winterfat	0.1	2	0.2
Wyoming big sagebrush	0.1	0.5	0.05
		Total:	**5.3**

Broadcast Seeded and Good Site

Seedling establishment tends to be lower when using broadcast seeding instead of using a planter or drill. To compensate for this decrease in seedling establishment, we increase the number of sown seeds by 1.5 to 2.0 times the standard drilled seeding rate (Table 15). In some instances, this increase in seeding rate is reduced (or not even needed) if there is a follow-up cultivation operation, such as rolling or packing after seeding. In the example below, the drilled seed rates are multiplied by two to provide the recommended broadcast seeding rate for each species in the mix.

Table 15. For sites being broadcast seeded, drill seed rates are multiplied by 2 to find the appropriate broadcast seeding rates.

Species	Recommended Percentage in Mix	Drilled Full Stand Seeding Rate	Drilled Good Site Mix Seeding Rate	Broadcast Good Site Mix Seeding Rate
	%	*PLS lbs.*	*PLS lbs.*	*PLS lbs.*
Bluebunch wheatgrass	0.4	8	3.2	6.4
Nevada Sandberg bluegrass	0.05	2	0.1	0.2
Thickspike wheatgrass	0.05	8	0.4	0.8
Slender wheatgrass	0.1	8	0.8	1.6
Lewis flax	0.1	5	0.5	1.0
Yarrow	0.1	0.5	0.05	0.1
Winterfat	0.1	2	0.2	0.4
Wyoming big sagebrush	0.1	0.5	0.05	0.1
			Total:	**10.6**

Critical Area and Broadcast Seeded

Much as a broadcast seeding requires planting additional seed per unit area, so often does a critical area planting. What constitutes a 'critical area' depends on the site conditions and risks, but includes where rapid establishment is desired to prevent degradation, such as areas prone to severe erosion. The amount of additional seed recommended varies with the specific type of critical planting, standards and specifications by state, as well as other factors. A rate of 1.5 to 2 times the rate for broadcasting on a good site, and therefore 3 to 4 times the drill seeded rate on a critical area is not uncommon (Table 16). This example uses the 2 times the broadcast rate approach. You can see how much seed is required, and can anticipate the relatively high seed cost.

Table 16. For seedings in critical areas, the broadcast seed rate is doubled.

			Drilled	Broadcast	Broadcast
		Drilled	Good Site	Good Site	Critical Area
	Recommended	Full Stand	Mix	Mix	Mix
	Percentage	Seeding	Seeding	Seeding	Seeding
Species	in Mix	Rate	Rate	Rate	Rate
	%	*PLS lbs.*	*PLS lbs.*	*PLS lbs.*	*PLS lbs.*
Bluebunch wheatgrass	0.4	8	3.2	6.4	12.8
Nevada Sandberg bluegrass	0.05	2	0.1	0.2	0.4
Thickspike wheatgrass	0.05	8	0.4	0.8	1.6
Slender wheatgrass	0.1	8	0.8	1.6	3.2
Lewis flax	0.1	5	0.5	1.0	2.0
Yarrow	0.1	0.5	0.05	0.1	0.2
Winterfat	0.1	2	0.2	0.4	0.8
Wyoming big sagebrush	0.1	0.5	0.05	0.1	0.2
			Total:		**21.2**

Calculating Bulk Seed per Acre

Remember, after we calculate how much pure live seed we want of each species, we'll need to convert that number to a bulk value because that is actually what we weigh out when mixing the various lots. The bulk weight is determined by dividing the PLS lbs/acre needed by the actual PLS % from the seed label or analysis to give us the bulk value (Table 17). The bulk value is always greater than the PLS value since it usually includes inert material and non-viable seeds.

In the example shown, the broadcast-critical area seed rate of each component is multiplied by the % PLS from the seed tag or seed analysis. For bluebunch wheatgrass 12.8 lb PLS/acre is divided by 0.9781 to obtain a bulk seeding rate of 13.09 lb/ac. If you were using a seed drill or seeding on a non-critical area site, you would divide those seed rates by the % PLS.

Table 17. PLS information from the seed tag is multiplied by the calculated seed rate to determine the amount of bulk seed needed per acre.

Species	Recommended Percentage in Mix	Drilled Full Stand Seeding Rate	Drilled Good Site Mix Seeding Rate	Broadcast Good Site Mix Seeding Rate	Broadcast Critical Area Mix Seeding Rate	Pure Live Seed	Bulk Seed Needed
	%	*PLS lbs.*	*PLS lbs.*	*PLS lbs.*	*PLS lbs.*	*%*	*Lbs./A*
Bluebunch wheatgrass	0.4	8	3.2	6.4	12.8	.9781	13.09
Nevada Sandberg bluegrass	0.05	2	0.1	0.2	0.4	.9357	0.43
Thickspike wheatgrass	0.05	8	0.4	0.8	1.6	.9976	1.60
Slender wheatgrass	0.1	8	0.8	1.6	3.2	.9724	3.29
Lewis flax	0.1	5	0.5	1.0	2.0	.9258	2.16
Yarrow	0.1	0.5	0.05	0.1	0.2	.9921	0.20
Winterfat	0.1	2	0.2	0.4	0.8	.9167	0.87
Wyoming big sagebrush	0.1	0.5	0.05	0.1	0.2	.8993	0.22

Rice Hulls or Other Carriers

Additional seeding calculations are required when using carriers such as rice hulls (Figure 11). Rice hulls are a preferred carrier for seed mixes containing different sized seeds. Rice hulls prevent separation while planting and effectively keep the seed in the mix from settling or bridging in the seeding equipment. Many types of carriers are available but rice hulls are effective, relatively inexpensive, are compatible with conventional grain drills and are easy to calibrate. See Idaho Tech Note 7 for more information and for an online interactive rice hull calculator.

Figure 11. The Aberdeen PMC farm crew calibrates a rangeland drill. Photo by Derek Tilley.

Calibrating Seeding Equipment

Whatever seeding equipment is used, it will have to be calibrated to deliver the desired amounts of seed per acre. See Idaho Tech Note 7 for more information on how this is done.

VI. Installation and Beyond

In this final section we discuss some of the remaining considerations involved in rangeland seedings. We also look at potential impediments to success and reasons why plantings may fail.

Proper Seeding Dates

On light sandy to loamy soils, dormant fall planting is recommended. On heavy to medium textured soils that tend to form soil crusts over winter, early spring planting should be considered. In general, spring dryland plantings should be completed early in the spring as soon as equipment can get on the field to take advantage of spring moisture. Hopefully, seedings will have at least 30-45 days of adequate soil moisture to reach a 3-5 leaf stage. Dormant seedings may be completed any time after measured soil temperatures are below 40-45º F. Most states have seeding date specifications based on MLRA. Be sure to follow your state's specifications on seeding dates.

Seedbed Preparation

In the western United States, inspection of hundreds of plantings in the past 65 to 70 years have shown the most common cause of conservation seeding failures is from poor seedbed preparation. Seedbed deficiencies include soil looseness, dryness near the surface and excessive weed competition. The ideal seedbed is uniformly firm, has soil moisture near the surface, is free from competing vegetation and is well-packed underneath with small surface clods or a light mulch of residue to prevent erosion (Figure 12).

Figure 12. A firm seed bed (top) leaves a boot print approximately ½ inch deep, while a loose seed bed (bottom) leaves a much deeper print and needs additional firming with a packing implement. Photos by Derek Tilley, NRCS.

Some factors such as weather, disease/pest outbreaks are out of our control, but if we do everything in our power to provide as ideal a seedbed as possible, the chances of having a good stand establish increases and may compensate for the negative factors beyond our control.

Seeding Into Existing Stands

Many planners want "instant" results and try to interseed into existing plant communities. Numerous studies have shown interseeding into existing plant communities almost always fails due to competition for water and nutrients from existing vegetation. In addition, there may be allelopathic effects from living and decaying vegetation. Plantings where existing vegetation

can be completely killed with herbicides prior to the seeding are much more likely to succeed.

Seeding Equipment
The most successful seedings are those where competition is adequately reduced, either with chemical treatments or tillage. Tillage, however, is often unfeasible over large acreages or on rough terrain. It can also bring new weed seed to the soil surface, and can create a more favorable environment for cheatgrass germination. Rangeland drills eliminate the need for tillage and can be effective on level terrain that is largely free of rock, but no-till drills have some drawbacks. No-till seeders can produce poor seed to soil contact due to lack of seed bed preparation, and they can also be difficult to control seeding depth.

Broadcast seeders are those that randomly scatter seeds over the soil surface. This can be done from the ground or from the air. This is the cheapest and easiest method of seeding, but seed placement is not accurate and seeding rates need to be increased 50- 100%. To obtain adequate seed-to-soil contact, rolling the soil with a cultipacker, dragging a harrow, pulling a roller harrow with the tines up or running a drag over the soil surface after applying the seed is recommended.

Legume Inoculation
Legumes, in a symbiotic relationship with rhizobia bacteria, produce nodules that can fix nitrogen from the air and produce nitrogen needed for plant growth. It is critical that inoculant with the proper strain of rhizobia bacteria be used. Much of the seed being sold today is pre-inoculated. If the seed is not pre-inoculated or if seeding date is beyond the expiration date for the inoculant, the seed should be inoculated with a fresh culture prior to seeding.

Idaho Plant Materials Technical Note 26 “Legume Inoculation” provides information on the benefits and procedures to inoculate seed and also provides a list of manufacturers and distributors of inoculants.

Why Seedings Fail
Before establishing a conservation seeding, it is helpful to know why seedings fail. Losses occur over a long period, from the seeding itself, to early seedling establishment, to growth and development of seedlings into a mature stand. In reality very few of the seeds planted will survive to maturity. Many will die prior to germination from predation or desiccation. Many more may be lost at germination from a lack of soil moisture.

Even after emergence, many seedlings will die. Some of the more common reasons include poor soil conditions; too little water causes drought stress and mortality, especially to seedlings with small root systems. Too much water from poor drainage leaves the plants susceptible to fungal pathogens. Spring frosts can damage leaf tissues. Insects like weevils, grasshoppers, black grass bugs and aphids can attack the young seedlings. Finally, weeds and even other species seeded in the mixture can compete with the seedlings for light, nutrients and moisture.

Many of these factors are actually timing issues. For instance, sagebrush seedings need to be implemented either early enough to capture spring rains or planted fully dormant in the fall after any likelihood of warm temperatures to prevent premature germination and loss to freezing. Seed too late in the spring and you may miss spring moisture; seed too early in the fall and the seed

may germinate and you may lose seedlings to frost. As a result of these issues, dormant fall seedings are often the most practical and successful plantings.

Evaluating Planting Success

It is highly recommended that you read Idaho PMC Tech Notes 10 and 12, available from the Plant Materials website, as they provide good solid advice as well as how-to information relative to this subject. Inspect the planting as soon as possible after emergence; realizing identification of seedlings can be very difficult. Evaluating early may allow the planner to recommend a reseeding if the planting is an obvious failure. Early evaluation and decision making can capitalize on any residual soil moisture and salvage at least a part of the seedbed preparation cost.

However, care must be used in evaluating rangeland seedings since first year results can often be misleading. Planted seed will remain in the seed bank waiting for optimum conditions to germinate and the stand will improve over time. Additionally, good seedling establishment is often masked by heavy weed growth. Many such stands have been plowed up and reseeded when another year of deferment and observation could have allowed the seeded perennials to become fully established and eliminate the weeds through competition. With the exception of a complete seeding failure, it will be best in most cases to look at stand trends over time to determine if the establishment of desirable species is trending in the right direction given the climatic conditions since planting.

Replant or Natural Recruitment?

So you have determined your planting has a poor stand – not a total bust, but certainly not a success. Now you have to decide if the planting can be left as is and provide the desired cover and desired mix of species through natural recruitment, or do you reseed. This is never an easy decision. The rule of thumb is, “you should reseed unless natural succession is judged to result in at least fair condition range after 10 years.”

If you do not reseed, some sites may persist in weeds indefinitely. Successional data indicates that abandoned cropland requires 25-30 years (if ever) to return to a fair condition on its own. In the Columbia Basin, Great Basin, and Snake River Plain, annual grasslands may persist indefinitely unless replaced with perennial species.

Conclusion

Unfortunately, limited time and available resources for adequate field preparation and weed control, and the availability and cost of native seed, hinder our current abilities to reliably restore sagebrush ecosystems and potentially sage-grouse habitat. We are often left with imperfect and unsatisfactory results that, while improve the overall condition of the site, may not meet conditions required by sage-grouse. This Technical Note is intended to provide the information for conservation planners and practitioners to make the best decisions possible to maximize the likelihood of success while acknowledging the real-world compromises and challenges that are often encountered.

Useful Websites
The following are useful websites where NRCS Technical Notes and plant information are located.

National Plant Materials Program:
http://www.nrcs.usda.gov/wps/portal/nrcs/main/plantmaterials/pmc/west/mtpmc/

Bridger Plant Materials Center (Montana NRCS):
http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/mt/plantsanimals/?cid=nrcs144p2_057491

Aberdeen Plant Materials Center (Idaho NRCS):
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/id/technical/?cid=nrcs144p2_047764

IDAHO PMC Rice Hull Calculator:
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/id/technical/?cid=nrcs144p2_047763

PLANTS Database:
http://plants.usda.gov/java/

Pacific Northwest Weed Management Handbook:
http://pnwhandbooks.org/weed/

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St. John, L., Tilley D., Scianna J., Jacobs, J. 2013. Technical Note 7: Mixing Seed with Rice Hulls. USDA-NRCS. Aberdeen, ID and Bridger, MT. 16p.