



Native Grassland Restoration in the Middle Trinity River Basin

Texas 10 Ecoregions

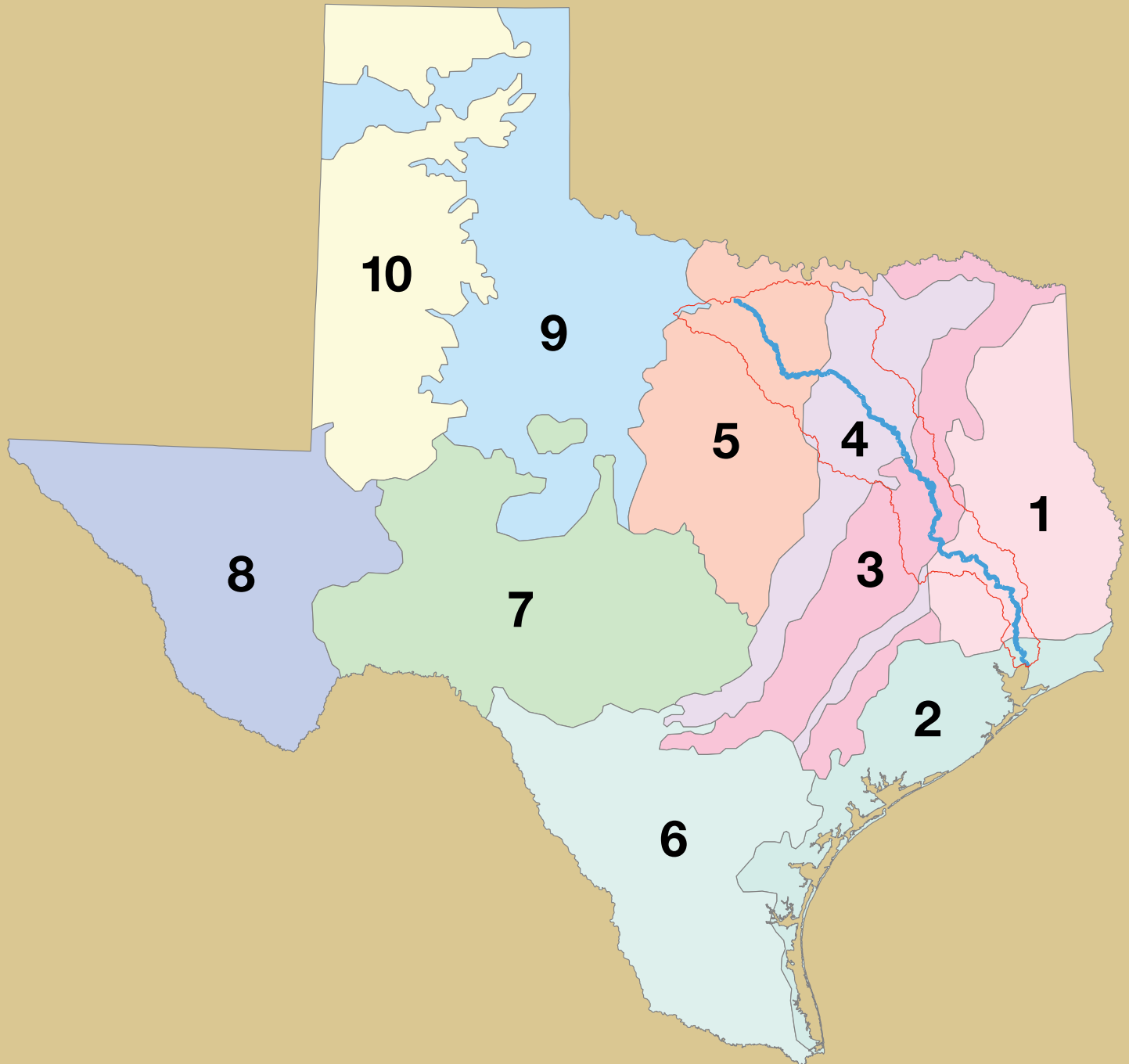


Figure 1. Because of differences in climate, soil types, and communities of plants and animals, 10 natural regions are commonly recognized in Texas: 1) Piney Woods, 2) Gulf Coastal Prairies and Marshes, 3) Post Oak Savannah, 4) Blackland Prairie, 5) Cross Timbers, 6) South Texas Brush Country, 7) Edwards Plateau, 8) Trans-Pecos, 9) Rolling Plains, and 10) High Plains. The Trinity River Basin (red polygon) and Trinity River (blue line) traverses several ecoregions within Texas. (Adapted from Cathey et al. 2007)



Figure 2. Little Bluestem is a perennial tallgrass species native to the Trinity River Basin that provides excellent cover for quail and other grassland birds. (Photo courtesy Dr. Jim Cathey, Texas AgriLife Extension Service)

Native Grassland Restoration in the Middle Trinity River Basin

Introduction

Many landowners in the Trinity River basin have realized that sound land management practices yield multiple benefits to the ecosystem. Mixing wildlife and livestock operations is now commonplace throughout Texas, and many Texans have benefitted from merging the two enterprises. Despite benefits of managing both wildlife and livestock, mixing the two is not an easy task, and therefore compromise is often required to accommodate multiple goals. A useful example is native grassland restoration, which is desirable for numerous wildlife species, but requires different livestock grazing management compared with those commonly used with introduced grass pastures. Introduced grasses are those species not native to Texas and are typically grown as monocultures requiring extensive agronomic inputs such as nutrient and pest management. An example of introduced grass would include all varieties of bermudagrass. In contrast, native grasses are those species that evolved here, are suited to the climatic variations of the region, and persist well if properly managed on the soils of the region. Given the increased costs associated with fuel, fertilizer, and equipment for introduced grass pasture management, the use of native forages may be one way to improve

economic returns to the ranch operation and benefit wildlife management.

Native grasslands have many lasting benefits to landowners, but planning and careful consideration is needed to best achieve restoration goals. Basic principles of native grasslands will be presented in this publication to help private landowners within the middle Trinity River basin between Dallas and Lake Livingston to understand and implement native grassland restoration techniques on their property.

Historical Use and Benefits of Native Grasslands

Much of the original native prairie found in the Trinity River basin of Texas has been converted to introduced grass pastures or to row crop production. Due to the suppression of naturally occurring wildfires, changes in historical grazing regimes, and other environmental effects, some native prairies have become shrub or forest dominated systems. Even though native grasslands (also known as tallgrass prairies and savannahs) are characteristic of the ecoregions present within the middle Trinity River basin, today true native grassland is believed to occupy only 1% of the historical land cover (Allen, 2007; Table 1). Ecoregions

County	Grassland/Pasture 1	Cropland 2	Shrub/Scrub 3	Forest 4	Total Acres
Anderson	133,155	18,227	161	109,725	261,268
Freestone	193,474	28,589	1,192	123,134	346,389
Grimes	50,743	2,999	23	17,397	71,163
Henderson	158,398	8,990	687	83,539	251,614
Hill	98,388	43	57,880	10,230	166,540
Houston	220,378	36,562	1,679	148,622	407,241
Leon	207,070	26,030	351	159,880	393,331
Limestone	43,621	563	2,479	3,474	50,137
Madison	153,184	3,397	348	34,025	190,954
Navarro	358,107	9,287	48,605	55,144	471,143
Trinity	49,182	18,879	32	113,752	181,844
Walker	60,468	19,810	147	108,229	188,654
Total	1,726,167	173,378	113,582	967,151	2,980,278

Table 1. Acreage of upland classes (grassland/pasture, cropland, shrub/scrub, and forest) by county in the middle Trinity River basin, as determined using GIS. (Adapted from Cathey et al. 2011)



Figure 3. Conversion of native grasslands to introduced grasses results in loss of wildlife habitat as these grasses provide little food or cover required by many grassland species, such as quail. (Photo courtesy Blake Alldredge, Texas AgriLife Extension Service)

are areas with similar vegetation and animal communities that reflect soil and climate conditions. Texas has 10 distinct ecoregions, but two dominate the middle Trinity River basin: the Blackland Prairie and Post Oak Savannah (Figure 1; Box 1).

Native bunchgrasses and forbs make ideal habitat for wildlife, as quail and other ground-nesting birds rely on these plants for food and cover (Figure 2 on page 1). The bare ground between bunchgrasses makes excellent travel and feeding areas for grassland

birds, and also allows a variety of native forbs to thrive (Bond et al. 2005). This habitat type is particularly important to 40% of North American bird species, as well as several species of mammals, reptiles, amphibians, and insects native to prairie habitats (Allen, 2007). Conversion of native grasslands to other uses is a dominant factor in the decline of many wildlife populations that depend on these habitats (Figure 3).

Once wide-ranging, native grasslands are highly efficient in providing ecosystem services that benefit humans. These services include flood retention, erosion control, livestock forage, wildlife habitat, water filtration, and soil formation. Native grasslands are important to watershed protection due to the extensive root systems that increase the water holding capacity of the soil, reduce erosion by slowing runoff, and promote groundwater recharge by allowing water to infiltrate soil more efficiently than many introduced grasses, such as bermudagrass (*Cynodon dactylon*; Thurow et al. 1986; Schuster, 2001; Teague et al. 2011). Also, healthy native grasslands more efficiently cycle nutrients and maintain a lower soil temperature than some introduced grasses, such as King Ranch bluestem (*Bothriochloa ischaemum*), dallisgrass (*Paspalum dilatatum*), and kleingrass (*Panicum coloratum*; McLaughlin and Walsh, 1998; Wilsey and Polley, 2006; Teague et al. 2011).

Additionally, when compared to introduced pastures, the cost of maintenance is diminished in native grasslands. Currently, landowners are looking for

ways to reduce input costs for their operations. Introduced pastures often require regular fertilization to produce high quantities of forage and hay. Conversely, many warm-season native grasslands produce sufficient forage with adequate protein during the growing season to meet livestock requirements without expensive fertilization or irrigation. Ideal native grasslands may have 200-300 grass and forb species (Bailey and Martin, 2007). Such a diverse herbaceous mix provides a broad spectrum of plant vigor that can persist through fluctuating climatic conditions, including drought if grazing is managed properly (Wilsey and Polley, 2006).

Inherent ecosystem services provided by native grasslands should be considered as part of a landscape-level conservation practice within the Trinity River basin. Rapidly increasing human population, greater water demand, and widespread urbanization places demands on the Trinity River ecosystem, a resource that is more valuable than ever.

Site Selection

Before starting a restoration project, establish goals and measureable indicators for monitoring that will be used to evaluate project success. It is important to understand the past history of the land and the soil characteristics, as these influence present vegetative communities. Next, assess the composition (grasses, forbs, shrubs, trees) of the vegetative communities by making a few observations and collecting data. County Extension Agents and wildlife biologists from Texas Parks and Wildlife Department (TPWD) and Natural Resources Conservation Service (NRCS) in the area are a valuable resource due to their expertise associated with local conditions (Appendix A).

By assessing composition of vegetative communities, you can determine the extent of undesirable vegetation, or designate areas that may not be ideal for grassland restoration. This can be done by making simple observations as to which species are present and/or collecting vegetative cover data. Vegetative cover is simply the amount of land surface covered by vegetation, whether that is native or introduced grasses, forbs, shrubs, or trees. For detailed descriptions on various techniques used to assess vegetative composition, see McGinty and White (1998), Wright et al. (2005), Hanselka et al. (2006), and Hanselka et al. (2009). Depending on the vegetative species present, a combination of various restoration techniques and the

BOX 1. Blackland Prairie and Post Oak Savannah Ecoregions

The gently rolling Blackland Prairie is named for the deep, fertile black soils that once supported a vast area of native tallgrass prairie species such as little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), switchgrass (*Panicum virgatum*), sideoats grama (*Bouteloua curtipendula*), and indiagrass (*Sorghastrum nutans*). The vast majority of this ecoregion has been replaced by crop farming, pastureland, and cities. The Blackland Prairie covers 11,500,000 acres in bands running northeast to south in north central to central Texas and is the southernmost extension of the true prairies that run from Canada to Texas.

The Post Oak Savannah contains patches of oak woodland within grasslands and is a transition zone between the tallgrass communities of the Blackland Prairie to the west and the pine forests of the Pineywoods to the east. This ecoregion covers approximately 12,500,000 acres and consists of gently rolling to hilly terrain. Dominant vegetation within the Post Oak Savannah includes oak and hickory trees, with tallgrass species such as little bluestem (*Schizachyrium scoparium*), indiagrass (*Sorghastrum nutans*), brownseed paspalum (*Paspalum plicatulum*), and switchgrass (*Panicum virgatum*). Bottomland soils are clay to sandy loam, and upland soils are sandy loam to sand.

order in which they are implemented may differ. For example, an area dominated exclusively by bermudagrass or bahiagrass (*Paspalum notatum*) will require more intensive restoration than would a grassland with a mix of native and introduced grasses.

Establishing goals is vital to a successful restoration because there are many reasons for restoring native grassland, such as creating habitat for quail and other native grassland birds, providing sustainable forage for livestock, or improving water quality. County Extension Agents, TPWD and NRCS wildlife biologists, and NRCS grazingland specialists can work with you to develop goals to best suit your needs. Establishing goals will help determine which activities need to



Figure 4. Powerline right-of-ways can provide a starting point for restoration as they are managed to suppress woody vegetation growth. (Photo courtesy Blake Alldredge, Texas AgriLife Extension Service)

be implemented and identify what will be needed for the project (seed mix, prescribed burning equipment, no-till seed drill, etc.). Some activities, such as introduced plant removal, prescribed burning, and plant establishment should only be conducted during certain times of the year, and if a combination of restoration activities need to be conducted, the sequence in which they are done is important.

Measureable indicators used during the monitoring phase help evaluate the project and determine if additional actions are needed, such as applying herbicide to control introduced grass regrowth. These indicators can be as simple or detailed as time and budget allow. Simple observations can be made to see if native grasses are more abundant than introduced grasses, and if native wildlife species, such as grassland birds, are more numerous than before. Photo points are a good example of monitoring vegetation changes on the landscape over time (McGinty and White, 1998; Wright et al. 2005). More detailed data can also be obtained by collecting vegetative cover data, as discussed before.

When selecting a site for grassland restoration, there are a number of factors to consider, such as

soils, current vegetation types, and other potential restoration areas on the property. The Texas A&M Institute of Renewable Natural Resources developed the Trinity River Information Management System (TRIMS) as a tool to access much of this information. TRIMS was designed for stakeholders within the Trinity River basin to access spatially explicit data for making land use decisions. TRIMS can perform functions much like a Geographic Information System (GIS) directly through an internet browser. TRIMS can be accessed at <http://trims.tamu.edu>. Features that can be accessed through this system include:

- Measurement of areas and lengths (i.e., pasture acreage, fencelines, roads)
- View recent high resolution aerial photographs
- Access conservation planning data (USGS stream gauge, soil, elevation, vegetation)
- Produce printable maps

Using TRIMS, you can select areas with productive soil types for a grassland, determine the best locations for native grassland restoration, view the amount of available acreage, and print a map of the area. For a more thorough discussion of TRIMS, read the

AgriLife Extension publication titled “*Habitat Restoration in the Middle Trinity River Basin*,” available in the AgriLife Bookstore.

Also available to landowners are Ecological Site Descriptions provided by the NRCS (<http://esis.sc.egov.usda.gov>). Ecological sites are defined as “a distinctive kind of land with specific characteristics that differs from other kinds of land in its ability to produce a distinctive kind and amount of vegetation” (NRCS, 2011). Therefore, these descriptions provide information about specific sites on soil types and historic plant communities that were present before settlement. Descriptions also indicate the percentages of each species that were present in past plant communities. This allows landowners to formulate a seed mixture that is specific to their property based on species percentages and a plant community that is well adapted to the soils and climate of the area.

A budget for time and money are needed beforehand to determine how much acreage can be restored. Landowners can use the budget to help determine which of their sites will be given priority. Certain features, such as right-of-ways and fencelines, may pro-

vide a starting point for native prairie restoration since they are typically managed to suppress woody vegetation growth (Figure 4). Restoration can proceed in a piecemeal pattern, such as strips or patches that can be built up over time to form a large tract. Riparian areas along creeks and rivers greatly influence water quality, so they are ideal places to restore grasslands with benefits to both wildlife and water quality (Figure 5). Another cost-effective option is to seed cropland with native grasses and forbs. Since there is very little competing vegetation once the crops have been harvested, the need for herbicide is reduced (Figure 6).

Although grassland birds, such as quail, require large areas of grassland to provide sufficient food and shelter, large-scale restoration may not be feasible for many landowners. The cost of restoring native grassland from introduced grassland is estimated at \$100 to \$200 per acre, depending on the cost of herbicide treatment and seed (Hays et al. 2005). Cost-share assistance is available for landowners through various programs conducted by non-governmental organizations and state and federal agencies (Appendix B).



Figure 5. Native grasses and forbs were planted in this riparian area to reduce bank erosion and improve water quality along this creek. (Photo courtesy Dr. Jim Cathey, Texas AgriLife Extension Service)



Figure 6. Reseeding cropland with native grasses and forbs is cost-effective as there is no cost for herbicide application. (Photo courtesy Gary Price, 77 Ranch)

Site Preparation

In some cases, the first step in restoration is to remove introduced vegetation, such as bermudagrass and bahiagrass. For a pasture dominated exclusively by introduced grasses, stop fertilization and allow growth up to 10-12 inches in preparation for herbicide application. This allows for extensive vegetative coverage when spraying to effectively absorb herbicide (Harper, 2007). In most situations, apply 4 quarts of Glyphosate (RoundUp®, Everris™, Charleston, South Carolina, USA) with 41% active ingredient for sandy soils, or 5 quarts for clay soils. Metsulfuron methyl (Cimarron® Plus, DuPont™, Wilmington, Delaware, USA) can be used exclusively on bahiagrass by applying 3/8 oz/acre. Although herbicides are a proven, cost effective method for grass and weed control, potential risks associated with their use can have unintended consequences in the watershed. Therefore, to help decrease herbicide runoff to ground and surface water and reduce costs through over-application, always follow the recommendations given on the herbicide label and be sure to calibrate the sprayer beforehand to

ensure appropriate application quantities. Suggested reference materials on sprayer calibration, application rate and optimal climatic conditions can be found in the AgriLife Bookstore publications, *Weed Busters: Sprayer Calibration Guide*, and *Reducing Herbicide Entry into Surface Waters*.

The best time for application is from mid-summer until the end of the active growing season (Figure 7). Applying herbicide during this time allows for the greatest herbicide effectiveness as grasses are replenishing carbohydrate reserves, thereby transporting as much herbicide as possible to the lower portions of the plant (Holechek et al. 2003). If the introduced grasses continue to regrow or if there is a mixture of natives and introduced species, more than one application or spot applications of individual plants may be necessary. Treatments during drought conditions are not recommended.

Landowners should consider testing soil fertility before trying to establish native vegetation as nutrient levels may not be high enough to support plants, depending on past management. County Extension



Figure 7. The best time to apply herbicide is from mid-summer until the end of the active growing season (a) to ensure greatest efficacy of herbicide as seen on this introduced pasture (b). (Photo courtesy Tim Siegmund, Texas Parks and Wildlife Department)

offices provide sample bags, sampling instructions and information for mailing samples to the Texas AgriLife Extension Service Soil, Water, and Forage Testing Laboratory (Provin and Pitt, 2009). Soil sample tests cost from \$10-\$74 per sample depending on what is tested. More information about soil sample tests can be found in Provin and Pitt (2009) or online at <http://soiltesting.tamu.edu>. If nutrient levels are low, you can fertilize the area to be restored or establish a cover crop to improve soil fertility before planting.

Establishment of Native Vegetation

Once a site has been prepared for restoration, several factors must be considered that will determine the success and the cost of native grassland establishment. This cost may be direct/monetary, such as the cost of herbicide or seed, or indirect, such as deferment from grazing. One way to reduce direct costs is natural restoration, which relies on the remnant seed bank as a seed source.

The seed bank refers to the seeds in the soil that can germinate given the right conditions (soil moisture, temperature, light). Disturbance to the above ground plant community, such as by fire and disking, helps initiate germination of several plants. The species in the seed bank at each site must be evaluated to make this a feasible option. Sites with a nearby native grass seed source have the potential to hold windblown seeds from adjacent sites, even in wood-

land landscapes (Platt and Weis, 1977). Also, if native grasses and forbs existed on the site prior to modification, there may be a sufficient seed bank present to adopt a passive approach to restoration.

To determine if the seed bank is sufficient for restoration, stop fertilizing the pasture and remove livestock from the area to prevent grazing for a growing season. This will allow plants to mature and enable better identification of plants in order to evaluate which species are present. Once natives have matured, they may be able to outcompete the introduced species, although this passive method may take longer than a more aggressive approach, requiring patience on the part of the land manager. Spot treatments of herbicide may also be useful to eliminate introduced species competing with natives for sunlight and nutrients in the soil. Once natives become dominant on the landscape, periodic maintenance including prescribed burning, rotational grazing, or limited mowing should be done to further enhance and diversify native populations. If introduced grasses continue to exert significant dominance on the land, or if natives remain suppressed, allow growth up to 10 – 12 inches in preparation for herbicide application from mid-summer until the end of the growing season in order to reseed with native grasses and forbs.

The decision to use natural restoration and rely on the native seed bank should be a calculated judgment. Generally, if more than 10% of the vegetation



Figure 8. No-till seed drills plant the seed in the ground rather than placing seed on the soil surface as done by broadcasting. (Photo courtesy Tim Siegmund, Texas Parks and Wildlife Department)

is desirable native species (i.e., little bluestem), a land manager can rely on natural succession (Rector, 2000). A land manager must understand what factors altered the land to its current state in order to conduct a successful restoration. Degrading factors in grasslands such as overgrazing or invasive species must be managed so that native species are allowed to establish. There is no cost for seeds or equipment in natural restoration, but this method may require a longer period of deferred use than may be feasible for a landowner.

Reseeding Methods

Whereas natural restoration depends on native species to reestablish with limited input from the land manager, active restoration drives secondary succession (changes in vegetation that occur after a disturbance) of the plant community by removing introduced vegetation, preparing the seedbed, and planting seed. The two most common methods for planting seeds are drilling and broadcasting.

Drilling with a no-till seed drill is a more reliable method for seedling establishment when compared to broadcasting because it places the seed in full contact with the soil, rather than on the surface (Welch et al. 2001; Figure 8). The no-till seed drill plants seed through existing or dead vegetation by cutting a shallow slit into the soil and depositing the seed directly

into the cut, while still providing proper seed to soil contact needed for germination. By allowing vegetation to remain intact, this seeding method may be desirable for areas that are highly erodible, sites where desirable native species diversity is low but present, or on sites previously dominated by introduced grasses. A no-till seed drill specifically designed for planting the fluffy seed characteristic of native grasses is recommended. Native grass drills should have double disk openers with depth bands and large-diameter drop tubes that prevent seeds from getting caught in the tubes (Welch et al. 2001). Contact your local Soil and Water Conservation Districts, County Extension, TPWD, and NRCS offices as they may have no-till seed drills available for use.

Another seeding technique that can be used is broadcasting. This seeding option is best suited for rough terrain where drills may not be able to go. With broadcast seeding, seeds are spread with larger average distances between individual seeds, with some seed clumping occurring. This variable dispersal method, however, may more closely mimic natural seed dispersal (Rabinowitz and Rapp, 1980). Depending on the type of seed drills readily available in your area, broadcast seeding may be the only option with regard to the availability of necessary equipment. A fertilizer spreader can be used and will cover a 6-ft-wide strip,

or a cone-type spreader can broadcast a wider strip. Other methods of broadcast seeding include hand spreading and rotary spreading with a compressed airstream.

The broadcast method is more effective at seeding the small and slick seeds of forbs rather than the fluffy seed typical of some native grasses. Broadcast seeding is more successful when followed by a method of firming the seed bed to create further seed to soil contact, such as harrowing, chaining, heavy hoof action, rolling, or cultipacking, which will also help reduce soil erosion and seeds washing away. With regard to large acreage plantings, the efficiency and speed of coverage may make broadcast seeding a more efficient option, but may also be more costly as a higher seed rate is usually required due to a lower expected germination rate.

Once reseeded, it will typically take 1-2 years for native grasses to establish as most growth will be directed to the root systems (Welch et al. 2001). Forbs may grow rapidly during this time, so mowing to no less than 4 inches above the ground may be necessary to provide sufficient light to grass seedlings (Dillard, 2000). No matter what reseeding method is used, it is important not to graze livestock in the restored areas for at least 2 growing seasons to allow native grasses to become established.

Seed Selection

Selected seeds should be adapted for the ecoregion and be suited to the specific microhabitat and soil properties (pH, texture) of the site. At a minimum, information should be obtained from the local NRCS or Soil and Water Conservation District office to determine the historic plant community for the area. The Ecological Site Descriptions, as described earlier, will provide substantial information on historic plant communities. Additional information can be obtained from range descriptions from a county soil survey, referencing species compositions of local remnant prairies, or other recognized sources. A species list developed from such sources should serve as an index for seed mixtures. Some desirable species may be unavailable due to problems associated with production and harvest, such as drought.

It is important to understand that while native grasslands are composed of 50 to 90% grasses (Dillard, 2000), they are also associated with a variety of forbs, which may be seasonally co-dominant in the

landscape. Forbs often serve as the basis for much of the species diversity found in native grasslands, and quail and other grassland birds depend on forbs for food, water, and cover. The soil disturbance resulting from site preparation and seeding will promote germination of a number of forbs from the existing seed bank. However, including forbs in a seed mix ensures that this vital component is present in restored native grasslands. The forbs selected should also reflect natural communities that will enhance the landscape by providing food and cover necessary for quail and other grassland birds. Annual forb diversity may increase naturally over time as grassland birds and other species disperse seeds from other areas. Forbs are usually short-lived and are heavily dependent on precipitation events and/or disturbances such as fire, disking, or intensive grazing.

Initial plantings may include as little as four or as many as three dozen different species. Many commercial seed companies will mix seed on request when ordering or already have mixes available depending on the site (Appendix C). If possible, seed sources originating within 300 miles of the area, or no more than 100 miles east or west and 200 miles north or south will improve the chances of successful establishment. This ensures seeds are well adapted to the climatic characteristics of the region. Seed prices are variable and depend on availability, demand, fluctuating fuel prices, and purity. Using certified seed is recommended because the seed has a known identity and meets certified quality standards for purity and germination (Bailey and Martin, 2007). However, if a seed mixture specific to the property cannot be determined, general grass and forb species that can be included in similar proportions in a seed mixture are listed in Box 2.

BOX 2. Common Grasses and Forbs used for Grassland Restoration in the Trinity River Basin

GRASSES:

Little Bluestem, Big Bluestem, Indiangrass, Switchgrass, Eastern Gamagrass, Side-Oats Grama

FORBS:

Illinois Bundlesflower, Maximilian Sunflower, Engleman Daisy, Coneflowers, Partridge Pea, Prairie Clover

Seeding Rate

The seed rate depends on the species and method of seeding and is based on pounds of pure live seed (PLS) per acre. Understand that PLS is the percentage of the bulk seed material that is the species of interest and is live, viable seed (Welch et al. 2001). The higher the PLS, the more species specific seed content per unit of measure, which will equal a higher germination rate. Recommended seeding rates are 20 live seed per square foot (Rector, 2000; Welch et al. 2001). While certain species have seeding rates of 1.2 - 6.0 pounds PLS per acre, available seed mixes containing native grasses and forbs suggest seeding rates that vary between 3-5 pounds PLS per acre, depending on the species included and the percentage of each in the mix.

Seeding Depth

Planting depth is critical because seed germination requires good seed to soil contact with sufficient soil moisture and light to be successful. For most seeds, plant about $\frac{1}{4}$ to $\frac{1}{2}$ an inch deep, but no more than $\frac{3}{4}$ of an inch (Welch et al. 2001). This depth will provide the necessary seed to soil contact and still allow the seedlings to reach the surface.

Timing

For drilling and broadcasting, the best time to plant is late fall to early spring (Welch et al. 2001). This is the period of greatest rainfall for the Trinity River basin and will allow seed to become established before the growing season begins in spring. Seeds need approximately 30 days of sufficient soil moisture and temperature in order to germinate and establish good root systems (Rector, 2000). Therefore, seeding during a drought is not recommended as seedling survival will be reduced.

Using Native Grass Hay As A Seeding Option

Establishment using hay is another seeding option that can provide several benefits over traditional methods. When performed correctly, hay harvested from native grasslands can provide a seed source at a discounted rate when compared to cultivated seed. Spread 40-50 square bales of hay per acre evenly over adequately prepared soil. A suitable seedbed for haying should be stubble free with soil loose enough to promote seed to soil contact. Once distributed, the hay should then be pressed into the bare ground with rollers, cultipackers, or hoof action. A secondary advantage to this method

is that the grass chaff adds organic matter to the soil and acts as mulch, thereby increasing the moisture holding potential of the soil. Such plantings should be done in the fall and winter following the harvest of native seed hay. A bailbuster is a piece of equipment designed to broadcast hay seed when hand spreading is not practical.

The success of the haying method may not be reliable, so land managers should apply only in certain situations, such as test plots, small acreage plantings, or topographically sensitive and erosive sites to see whether it is successful or not. The main limiting factor in this process is the fact that the PLS and amount of seed distributed is unknown. Hay should be harvested at an increased level of maturity to ensure adequate seed set and ripening. However, many species set and ripen seed at different times, making it difficult to harvest hay with multiple species providing ripened seed. The key to successful haying is to minimize seed loss between the time the hay is cut and bailed.

Conclusion

The recommendations provided in this publication should be used as a guideline to help address the many strategies and procedures that can be used in restoring native prairies in the middle Trinity River basin. As each site varies, so do the considerations and approaches to restoration, and thorough examination should be given to alternative methods of restoration, such as passive restoration or broadcasting native hay. A detailed restoration plan is the best tool a landowner has when restoring native prairie. Seek the advice of County Extension Agents, NRCS personnel, and TPWD wildlife biologists when developing the plan, as they have valuable knowledge and experience (Appendix A). A solid and detailed plan will go a long way in supporting the cost, confidence and patience required in restoring native grasslands. Also, many financial assistance programs are available to landowners when establishing native grasslands (Appendix B).

While it is impossible to recreate the native grasslands that once stood in Trinity River basin, time and thoughtful planning can produce an ecosystem with benefits to the landowner and watershed. It is important to note that as plant diversity increases, wildlife diversity will likely increase as well. Therefore, use as many native species as appropriate as site and economic considerations warrant.

Reduced input costs and high quality forage provided by native grasslands provide landowners with a reasonable alternative to traditional introduced grass pastures. Furthermore, improved water resources, wildlife habitat, and ecotourism opportunities, such as wildlife photography, stem from native grasslands which can provide additional revenue for landowners. A successful restoration will provide relatively low maintenance forage and land cover, and proper land management practices will further enhance the productivity of native grasslands. Properly stocking the restored grasslands and developing a grazing

system that affords periods of rest from grazing (i.e., rotational grazing system) is critical to maintaining its long-term health and productivity (Lyons and Machen, 2001). County Extension Agents and NRCS grazing-land specialists can provide forage inventories, stocking rate recommendations and work with landowners to develop grazing management plans following restoration. Additionally, periodic management treatments such as prescribed burning and/or shredding can be implemented to further enhance the quality, diversity, and productivity of the restored grassland.

References:

- Allen, L. 2007. Prairie revival: researchers put restoration to the test. *Science News*. Vol. 172 (24): 376-377.
- Bailey, P., and C. O. Martin. 2007. Regional availability of plants for prairie restoration. EMRRP Technical Notes Collection. ERDC TN-EMRRP-SI-31.
- Bond, B. T., C. D. Baumann, M. W. Lane II, R. E. Thackston, and J. L. Bowman. 2005. Efficacy of herbicides to control bermudagrass for enhancement of north bobwhite habitat. *Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies*. 59:191-199.
- Cathey, J. C., S. L. Locke, A. G. Snelgrove, K. Skow, and T. Snelgrove. 2011. Habitat restoration in the middle Trinity River Basin. *Texas AgriLife Extension Service SP-392*.
- Dillard, J. 2000. Guidelines for Native Grasslands Restoration Projects. *Texas Parks and Wildlife Department PWD RP W7000-1153*.
- Hanselka, C.W., C.R. Hart, and A. McGinty. 2006. Texas rangeland monitoring: Level three. *Texas AgriLife Extension Service L-5455*.
- Hanselka, C.W., C.R. Hart, and A. McGinty. 2009. Texas rangeland monitoring: Level two. *Texas AgriLife Extension Service L-5454*.
- Harper, C. A. 2007. Strategies for managing early succession habitat for wildlife. *Weed Technology*. Vol. 21 (4):932-937.
- Hays, B., M. Wagner, F. Smeins, and R. N. Wilkins. 2005. Restoring native grasslands. *Texas AgriLife Extension Service L-5456*.
- Holechek, J. L., R. D. Pieper, C. H. Herbel. 2003. *Range Management Principles and Practices*. 5th edition. Prentice Hall. Upper Saddle River, NJ.
- Lyons, R.K., and R.V. Machen. 2001. Stocking rate: The key grazing management decision. *Texas AgriLife Extension Service L-5400*.
- McGinty, A., and L. D. White. 1998. Range monitoring with photo points. *Texas AgriLife Extension Service L-5216*.
- McLaughlin, S. B., and M. E. Walsh. 1998. Evaluating environmental consequences of producing herbaceous crops for bioenergy. *Biomass and Bioenergy*. Vol. 14 (4): 317-324.
- Natural Resources Conservation Service (NRCS). "Ecological Site Description." <http://esis.sc.egov.usda.gov>. Updated 05/10/2010. Accessed 12/10/2011.
- Platt, W. J., and I. M. Weis. 1977. Resource partitioning and competition within a guild of fugitive prairie plants. *The American Naturalist*. Vol. 111: 479-513.
- Provin, T., and J.L. Pitt. 2009. Testing your soil: How to collect and send samples. *Texas AgriLife Extension Service E-534*.
- Rabinowitz, D. and J. K. Rapp. 1980. Seed rain in a North American tall grass prairie. *Journal of Applied Ecology*. Vol. 17: 793-802.

- Rector, B. 2000. Rangeland risk management for Texans: seeding rangeland. Texas AgriLife Extension Service E-117.
- Schuster, J. L. 2001. Soil and vegetation management: Keys to water conservation on rangeland. Texas AgriLife Extension Service E-168.
- Teague, W. R., S. L. Dowhower, S. A. Baker, N. Haile, P. B. DeLaune, D. M. Conover. 2011. Grazing management impacts on vegetation, soil biota and soil chemical, physical and hydrological properties in tall grass prairie. *Agriculture, Ecosystems and Environment*. Vol. 141 (3): 310-322.
- Thurow, T. L., W. H. Blackburn, and C. A. Taylor, Jr. 1986. Hydrologic characteristics of vegetation types as affected by livestock grazing systems, Edwards Plateau, Texas. *Journal of Range Management*. Vol. 39 (6): 505-509.
- Welch, T. G., B. S. Rector, and J. S. Alderson. 2001. Seeding rangeland. Texas AgriLife Extension Service E-53.
- Wilsey, B. J., and H. W. Polley. 2006. Aboveground productivity and root-shoot allocation differ between native and introduced grass species. *Oecologia*. 150:300-309.
- Wright, B. D., J. C. Cathey, and R. K. Lyons. 2005. Habitat monitoring for quail on Texas rangelands. Texas AgriLife Extension Service B-6172.

Appendix A. Contact Information for County Extension Agents and Wildlife Biologists.

Texas AgriLife Extension Service County Offices	http://counties.agrilife.org/
Texas Parks and Wildlife Department Wildlife Biologists	http://www.tpwd.state.tx.us/landwater/land/technical_guidance/biologists/
Natural Resources Conservation Service Texas Zones	http://www.tx.nrcs.usda.gov/contact/directory/zones/index.html

Appendix C. Native Seed Vendor Information.

Company	Location	Website	Phone Number
Turner Seed Company	Breckenridge, TX	www.turnerseed.com	254.559.5860
Native American Seed	Junction, TX	www.seedsource.com	1.800.728.4043
Douglas-King Seeds	San Antonio, TX	www.dkseeds.com	1.888.357.3337
East Texas Seed Company	Tyler, TX	http://www.easttexasseedcompany.com	1.800.888.1371
Pogue Agri Partners, Inc.	Kenedy, TX	www.pogueagri.com	830.583.3456
MBS Seed, Ltd.	Denton, TX	http://www.mbsseed.com/	940.387.2701
Justin Seed Company	Justin, TX	http://justinseed.com/	940.648.2751
Bamert Seed Company	Muleshoe, TX	http://www.bamertseed.com/index.php	1.800.262.9892

Appendix B. Federal and State Cost-share Programs Available in Texas. (Adapted from Cathey et al. 2011.)

Program	Cost-Share	Habitat Affected	Ecosystem Benefits	Length of Contract	Website
USDA – NRCS					
Grassland Reserve Program		Grazing Lands	Grazing, Wildlife Habitat		http://www.nrcs.usda.gov/programs/GRP/
– Permanent Easement	100% of fair market value of land			Permanent	
– Rental Contract	Up to 75% of grazing value, not to exceed \$50,000 per year			10, 15, 20 years	
– Restoration Agreement	50% of restoration costs, not to exceed \$50,000 per year				
Conservation of Private Grazing Land	Technical Assistance only	Grazing Lands	Grazing, Wildlife Habitat, Water Quality, Erosion Control		http://www.nrcs.usda.gov/programs/cpgl/
Conservation Stewardship Program	Paid based on conservation performance, not more than \$80,000 per year	Cropland, grassland, prairie land, improved pastureland, rangeland, nonindustrial private forest land, agricultural Tribal land	Soil, water, and air enhancement, Wildlife Habitat	5 years	http://www.nrcs.usda.gov/programs/new_csp/csp.html
Environmental Quality Incentives Program	No more than \$300,000 over 6 year period	Cropland, rangeland, pastureland, private non-industrial forestland, other farm and ranch lands	Soil, water, and air quality, wildlife habitat	Up to 10 years	http://www.nrcs.usda.gov/programs/eqip/
Farm and Ranch Lands Protection Program	50% of fair market easement value of conservation easement	Productive farm and ranchland in agricultural use	Productive Agriculture	3-5 years	http://www.nrcs.usda.gov/programs/frpp/
Wildlife Habitat Incentive Program	\$50,000 per year, or 90% of long term agreements	Upland, wetland, aquatic, and other types of wildlife habitat	Wildlife Habitat	1-10 years or long term agreements lasting 15 years or longer	http://www.nrcs.usda.gov/programs/whip/
USDA Farm Service Agency					
Conservation Reserve Program	50% of conservation practices	Private Lands	Erosion Control, Wildlife Habitat	10,15 years	http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crp
U.S. Fish and Wildlife Service					
Partners for Fish and Wildlife	50% of restoration costs	Private Lands	Wildlife habitat	10 years	http://www.fws.gov/southwest/es/partners/Partners_Main.html
TPWD					
Landowner Incentive Program	Up to 75% of restoration costs	Habitat for rare or at-risk species	Wildlife habitat, water quality	No set length	http://www.tpwd.state.tx.us/landwater/land/private/lip/
TSSWCB					
Water Quality Management Plan Program	Cost-share provided by local SWCD	All	Water Quality, erosion control	Dependent on project	http://www.tsswcb.state.tx.us/wqmp
Texas General Land Office					
Texas Farm and Ranch Lands Conservation Program	Tax Deductions from Conservation Easements	Rural Land	Restricts development	Indefinite	http://www.glo.state.tx.us/res_mgmt/farmranch/
Texas Water Development Board					
Agricultural Water Conservation Grants and Loans	100% for grants, none for lands	All	Water Conservation		http://www.twdb.state.tx.us/financial/programs/
Nature Conservancy, Native Prairies Association of Texas, Texas Agricultural Land Trust, Texas Land Conservancy, Texas Land Trust Council, Forever Land Trust					
Conservation Easement	Tax deductions	All	All	Indefinite	



Authors

Kyle Thigpen

Graduate Student
Department of Wildlife and Fisheries Sciences
Texas A&M University

Blake Alldredge

Extension Associate
Texas AgriLife Extension Service

Jay Whiteside

Technical Guidance Biologist
Texas Parks and Wildlife Department

Dr. Shawn Locke

Extension Program Specialist
Texas AgriLife Extension Service

Dr. Larry Redmon

State Forage Specialist
Texas AgriLife Extension Service

Dr. Megan Dominguez

Extension Range Specialist
Texas AgriLife Extension Service

Dr. James C. Cathey

Extension Wildlife Specialist
Texas AgriLife Extension Service



Disclaimer:

This publication was developed as part of the Building Partnerships for Cooperative Conservation Initiative in the Trinity River Basin, with funding support from the U.S. Environmental Protection Agency through a Clean Water Act §319(h) grant administered by the Texas State Soil and Water Conservation Board. We would like to thank Brian Hays of the Institute of Renewable Natural Resources and Jeff Goodwin of the Natural Resources Conservation Service for their thoughtful review of this publication. Brand names are used for educational purposes and are not meant as an endorsement for any company or product.