ESTABLISHMENT OF WARM-SEASON NATIVE GRASSES AND FORBS ON DRASTICALLY DISTURBED LANDS[1]

by

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Abstract: Establishment of warm-season native grasses and forbs (WSNGs) has been viewed by landowners, agronomists, natural resource managers and reclamation specialists as being too expensive and difficult, especially for reclamation, which requires early stand closure and erosion control. Natural resource managers have learned a great deal about establishing WSNGs since the implementation of the 1985 Farm Bill's Conservation Reserve Program (CRP). Reclamation specialists must begin to use this information to improve reclamation success. Quality control of seed equipment and planting methods has been proven to be the crucial first step in successful establishment. Seedling germination, growth and development of WSNGs are different from that of introduced cool-season grasses and legumes. Specialized seed drills and spring planting periods are essential. Because shoot growth lags far behind root growth the first two seasons, WSNGs often are rejected for reclamation use. Usually, the rejection is based on preconceived notions that bare ground will erode and on reclamation specialists' desire for a closed, uniform, grassy "lawn." WSNGs' extensive root systems inhibit rill and gully erosion by the fall of the first season. Planting a weakly competitive, short-lived nurse crop such as perennial ryegrass (*Lolium perenne*) at low rates with the WSNG mixture can reduce first-season sheet and rill erosion problems and give an appearance of a closed stand. Benefits of WSNGs in soil building and their acid-tolerance make them ideal species for reclamation of drastically disturbed lands. WSNGs and forbs enhance wildlife habitat and promote natural succession and the invasion of the reclamation site by other native species, particularly hardwood trees, increasing diversity and integrating the site into the local ecosystem. This is perhaps their most important attribute. Most alien grasses and legumes inhibit natural succession, slowing the development of a stable mine soil ecosystem. This paper outlines one successful methodology to establish warm-season grasses and forbs on abandoned mine lands in Missouri. The methodology can be successfully adapted for reclamation of all drastically disturbed lands including Title V lands under the Surface Mining Control Reclamation Act of 1977 (PL95-87) to promote ecosystem diversity and stability.

Additional Key Words: Reclamation, Prairie Restoration, Abandoned Mine Lands, Ecosystem Restoration.

Introduction

Tallgrass prairie was once the signatory landscape of the American Midwest. Virtually this entire ecosystem is gone. The tallgrass prairie soils are the foundation of American agriculture. Prairies were plowed to grow corn and soybeans. Of Missouri's original 15 million acres of prairie, only 80,000 acres remain in small, isolated tracts (Schroeder 1981). The story is much the same throughout the Midwestern states.

Reclamation with warm-season native grasses can greatly improve soil quality and overall reclamation success. Reclamation specialists must begin to view their work not as a construction task, but as ecosystem restoration. Reclamation need not restore all the pieces, but the work must promote, not inhibit, diversity and ecosystem function. In the Midwest, establishing warm-season native grasses and forbs (WSNGs) best achieves these lofty goals.

WSNGs are adapted to droughty soils with high acidity, low nutrient levels and low organic matter levels. Warm-season native grasses and forbs have evolved coarse, deep-growing, extensive root systems that form symbiotic relationships with mycorrhizal fungi to increase uptake of water and nutrients, especially phosphorus, in droughty, low-fertility soils. (Hetrick et al 1988). Researchers have determined that C_4 warm-season native grasses and C_3 forbs are physiologically adapted to occasional severe droughts in the Midwest (Martin et al

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1991 & Weaver 1969). These conditions are typically associated with abandoned mine land soils. WSNGs ameliorate the harsh soil conditions of mine lands, building biological systems that promote nutrient cycling. WSNGs are unsurpassed for wildlife habitat on reclamation projects and can play a major role in restoration of threatened or endangered prairie species like northern harrier, upland sandpiper and prairie chicken. Native plants play the same role, whether it is sagebrush or aspen or mast-producing hardwoods.

This paper is an attempt in plain language to help land managers and reclamation specialists plant warm-season native grasses based on tried-and-true methods. I make no claims as to the scientific veracity or the applicability to a specific location. This paper can be viewed as a testimonial to one methodology that has worked in Missouri. It is a starting point for other natural resource managers to experiment and adapt to their particular conditions. Furthermore, these methods are applicable to SMCRA Title V and non-coal reclamation, not just AML sites.

The problem with WSNGs is that establishment is slow and the seeds are difficult to plant due to their hairy or "bearded" seed coats. WSNGs initially grow downward, building an extensive root system that enables the plants to survive harsh, dry soil conditions so common on the prairie during August and September (Weaver 1954). Shoot growth is minimal during the first two years, giving the appearance that the stand has failed. Patience and the ability to identify WSNG seedlings are the two most critical factors for the reclamation specialist. WSNGs are difficult to establish because they require special planting equipment to handle the bearded seeds and plant them at the appropriate depth with proper seed-to-soil contact. WSNGs appear small and weak in the first year, but by the third year, there can be no doubt as to their hardiness. Once the root system is established, WSNGs can endure severe drought, low nutrient levels and acidic mine spoils.

Reclamation is a soil-building process. In natural systems, drastically disturbed lands undergo a succession of living organisms that may take decades or even centuries for successful colonization to occur. The foundation of natural succession is the development of a system with the plant community being the most visible portion. However, before this plant community can be expressed, a soil biological system must be developed that creates the correct environmental conditions to allow those plants to complete their life cycles. Plants are most susceptible to harsh environmental conditions and disturbance just after germination. Many plants produce abundant seeds because most seedlings will die. The environmental changes of the micro-site that result from a developing soil biological system enable many young seedlings to survive this early establishment period (Blake 1935).

Reclamation attempts to telescope this multi-seasonal development of a diverse and complex soil biological system into a few short years. Often, on an abandoned mine land site, reclamation specialists attempt to create a stable soil system in one season. Reclamation failures give testimony to our lack of understanding of natural processes. Bradshaw (1987) writes that ecosystem restoration "... is a considerable intellectual challenge requiring that we not only understand the nature of the ecosystem itself, but also the nature of the damage and how to repair it ***... land restoration is an acid test of our ecological understanding.***" The goal should be to develop a sustainable soil biological system even if it takes several years. It will take time to develop such a system unless topsoil is imported with its biological system intact In most instances, topsoil should not be "borrowed" because it is never returned, and this practice only increases the amount of disturbance.

Organic matter plays an important role in soil development. Organic carbon, nitrogen and phosphorus are essential for all living organisms. Mine soils are usually low in organic matter, nitrogen and phosphorus, and have a high clay content. Enriching reclaimed mine soils with organic matter may accelerate soil system development. Weaver determined that the amount of organic matter in the upper four inches of tallgrass prairie sod was 2.5 to 4.5 tons by dry weight per acre (Weaver 1968). This amount of organic matter in mine soils greatly increases microbial activity and nutrient cycling.

Methods

The best methodology to establish WSNGs incorporates multiple green manure crops into the mine soil for several growing seasons prior to WSNG planting. Green manure crops are plantings of quickly established, fast-growing cereal grasses and legumes that are turned into the soil while they are green, hence "green manure." This is an old agricultural practice used to improve soil tilth, infiltration rate and water-holding capacity. Incorporating legumes into the mix adds nitrogen, which promotes the development of a soil biological system, resulting in improved nutrient cycling. Multiple seasons of green manure crops in the humid East and Midwest increase the length of time soil microbes and fungi have to colonize a reclamation site. This may be especially important because it may take five to seven years for mycorrhiza to colonize a drastically disturbed site (Linderman 1988).

Warm-season native grasses and forbs should be planted in the spring or winter. WSNG seed planted in the fall may germinate during an Indian summer, making the immature seedlings susceptible to frost heaving and winter kill. WSNGs can be frost-seeded, but erosion may remove seed from an unprotected site. The site can be protected from erosion by planting a green manure crop of cereal grasses and legumes. These plants should be turned into the soil before their seeds ripen.

A heavy mulch may be applied to protect the site from erosion. The mulch can be native prairie hay or cereal straw free of cool-season grass seed such as fescue. Old hay that is unfit for livestock may be used because the goals are site protection and the incorporation of organic matter. Mulch may be incorporated into the soil in the winter if enough (five tons per acre) is applied.

A summer-planted green manure crop of milo, corn or sorghum-sudan grass and a legume like common lespedeza, soybeans or hairy vetch can be useful in protecting the reclamation site from summer storms. This should be turned into the soil in late summer and a second green manure crop of wheat and a legume planted. In this fashion, two green manure crops can be worked into the reclamation soil prior to planting WSNGs.

In the spring before planting, the green manure crop or mulch must be turned into the soil by discing to increase the organic matter content. Soil tests should be taken and the soil top-dressed at the time of discing. Never should more than 30 pounds of nitrogen per acre be applied for WSNG establishment, regardless of soil test recommendations. Excess nitrogen will only stimulate weedy competition.

An example of a diverse WSNG and forb seed mixture for the Midwest follows:

WARM-SEASON NATIVE GRASS SEED MIX

COMMON NAME	SCIENTIFIC NAME	VARIETY	PLS/ACRE*
Sideoats Grama	*Bouteloua curtipendula*	El Reno	3.0
Perennial Ryegrass	*Lolium perenne*	Manhattan	3.0
Switchgrass	*Panicum virgatum*	Cave-In-Rock	0.5
Western Wheatgrass	*Agropyron smithii*	Barton	2.0
Illinois Bundle-flower	*Desmanthus illinoensis*		3.0
Partridge Pea	*Cassia fasciculata*		0.5
Eastern Gamagrass	*Tripsacum dactyloides*		7.0
Maximillian Sun-flower	*Helianthus maximilliani*		2 ounces
Common Lespedeza	*Lespedeza striata*		3.0
	Fluffy Seed Mixture**		
Big Bluestem	*Andropogon gerardii*	Roundtree	4.0
Indiangrass	*Sorghastrum nutans*	Rumsey	4.0
Little Bluestem	*Andropogon scoparium*	Aldous	1.0
Roundhead Lespedeza	*Lespedeza capitata*		4 ounces
Compassplant	*Silphium laciniatum*		2 ounces
Common Sunflower	*Helianthus annus*		4 ounces
Leadplant	*Amorpha canescens*		4 ounces
Purple Prairie Clover	*Petalosteman purpurea*		0.5
Purple Coneflower	*Echiniacea purpurea*		2 ounces
Rattlesnake Master	*Eryngium yuccifulium*		1 ounces
Blazing Star	*Liatris pycnostachya*		1 ounces

* Pounds of PLS/Acres is the seeding application rate in terms of Pure Live Seed per acre.

** The "fluffy" or "chaffy" seeds refer to species that may need to be seeded with a special box within the warm-season grass drill that forces these light, hairy seeds through the drill.

The seed should be purchased from a dealer of certified seed, and free of noxious weeds. Warm-season native grass must be purchased on a pure live seed (PLS) basis. PLS equals the purity of the seed times the germination and firm seed percentage and ensures that the seed is viable and of high quality. Seed should be stratified for immediate germination upon planting. The seed dealer must certify seed purity and that the seed is free of contamination by old world bluestems. The addition of prairie forbs to the seed mixture provides structural diversity and multiple sources of food for wildlife. Forbs are not purchased on a PLS basis. Forb seeds can be expensive, and the reclamation budget may limit the number of species in the mixtures.

The seedbed should be firm. Cultipacking may be required in loose, sandy or dry soils. The seed in the drill hoppers must be thoroughly mixed to ensure adequate distribution of seed that will result in the proper stand diversity. Seedbox agitators are necessary to prevent denser seed from falling to the bottom and bridging of the light seed in the box. Agitators will save time and result in a more diverse grass stand. A specifically designed native-grass seed drill is far and away the best tool to establish a successful and diverse stand. Grain drills or cool-season grass drills "adapted" to planting natives perform poorly. Duct tape has many uses, but converting a grain drill to plant WSNGs is not one of them. Brillion WSNG seeders are considered by many to be top-of-the-line, but are expensive (Calvert 1995). Truax drills have been well-received and perform well under most conditions. Earlier models have low ground clearance and require transport with a trailer (Clubine 1995). Newer "flex" Truax drills have nearly the same clearance as other comparable drills but still should be trailered to extend operational life. Nesbet drills have specialty uses and perform well with an experienced operator but are no longer manufactured (Schramm 1978). Great Plains drills perform well if equipped with a box for chaffy seed. Also, Great Plains drills have agitators and picker wheels as a manufacturing option that improves planting success (Clubine 1995).

Mixing the seed with chopped corn enables the fluffy native grass seed to flow smoothly through a traditional grass seed drill. The Missouri Department of Conservation and the Natural Resource Conservation Service has been using this method with good establishment success. Debearded big bluestem and indiangrass seed is available but costs 20 to 25 percent more than bearded seed. A traditional grass drill can be used to plant debearded seed. Native grasses and forbs can be successfully planted with both of these methods reducing the need for specialized native grass drills. However, tight control on planting depth and good seed-to-soil contact remains essential for good establishment success.

Good seed-to-soil contact and proper planting depth are necessary for WSNG seed germination and development. The seed should be placed ***no deeper than one-quarter (¼) inch*** (controlled by depth bands) and pressed firmly into the soil by press wheels. If the seed is deeper than ¼ inch, the cotyledon may not be able to penetrate through the soil surface (Blake 1935). Expensive WSNG and forb seed will be wasted if it is improperly planted. Cutting corners with poor quality seed or using inferior planting methods is bad management.

No-till, native grass drills are very useful when erosion is a concern and land mangers do not want to disc or plow under a cover crop. Seed is "no-tilled" or direct seeded into a dead cover crop. Dead roots of the annual grasses and forbs hold the soil in place while the native grasses are established. As with conventional native grass drills, seed box agitators, depth control and good soil-to-seed contact remain crucial factors in native grass establishment when using a no-till, native grass drill. Other essential features for no-till, native grass drills are trash racks or blades that cut organic litter or "trash"from cover crops rather than pressing it into the soil. Crimped trash and straw act like a wick, drawing moisture away from the seedbed and the germinating seed.

Prairie hay should be used as a mulch to avoid introducing cool-season grasses via seed in the mulch. Mulch should be applied at two tons per acre. Prairie hay may contain forb and grass seed of desirable species unavailable or too expensive to purchase. This increases stand diversity and may result in the establishment of rare prairie species. However, prairie mulch may increase the risk of introducing old world bluestems (OWBs) into the stand. OWBs are aggressive and force out more desirable native species and should not be planted due to their invasive nature. Once a prairie or WSNG stand is contaminated, the only way to remove OWBs is to kill the entire stand or prairie, which is unacceptable. If uncontaminated prairie hay is not available, straw of oats or wheat is preferable mulching material to cool-season hay. WSNG planting should be completed between March 15 and May 30. Planting after May 31 increases the risk that inadequate summer rainfall will result in excessive seedling mortality. This is especially true for droughty, AML mine spoils.

A successful first-year reclamation planting should have a minimum of one WSNG plant per square foot by September 1. This does not include perennial ryegrass. If this density is not present, the weak areas should be reseeded the following spring. Wheat or mulch can be used on the bare areas for overwinter protection.

The warm-season grass stand will look very weak, perhaps weedy, in the first season. Do not be discouraged by this appearance. It only takes one WSNG plant per square foot to grow into a closed canopy in three years. Warm-season grasses expend most of their energy developing rhizomes and growing roots deep within the soil during the first two years. The soil protects the roots and rhizomes from sudden environmental change on the harsh prairie. A six-inch-tall big bluestem seedling may have a four-foot-deep root system extending over an area of one foot in diameter. There may be only a few leaves scattered in small clumps. The ground may be mostly barren, but roots and rhizomes are extensive in the first year, making the site far more resistant to erosion than a casual observer would suspect. The thick, extensive woody roots and rhizomes of WSNGs and forbs are adaptations to the periodic droughts of the Midwest. As with oaks or hickories, survival under these conditions forces plants to develop extensive root systems and a physiology that place a premium on drought and low-nutrient tolerances, conditions that are common on drastically disturbed lands. Rhizomes enable WSNGs to spread following drought. The roots and rhizomes of prairie plants are the perennial living parts of prairie plants unlike the shoots that die every year.

Perennial ryegrass plays a significant role in the early establishment of the stand. It quickly establishes itself following seeding. The result is a closed ground cover for both aesthetics and erosion control. Perennial ryegrass planted at a low rate (never more than three pounds PLS/acre) is not overly competitive, allowing the native grasses to germinate and grow through and above the shorter perennial ryegrass. Perennial ryegrass will persist only two to three seasons. Thus, when the ryegrass is dying out in the third year, the native grasses should experience rapid shoot growth.

Shotgun mixtures of an equal seeding rate of various cool-season and warm-season species usually result in poor WSNG establishment. These mixes are often touted as "wildlife habitat." The cool-seasons dominate the stand because they green up early in the spring and shade out the WSNGs. Landowner management usually favors the cool-season plants, hence the WSNGs are eliminated. Shotgun mixes of WSNGs and cool-season grasses are a waste of time and money. Furthermore, when sold to regulatory agencies as wildlife habitat, they indicate ignorance at best and deceit at worst.

Reclamation mine soils rarely have a large weed seedbank, and therefore weeds usually do not threaten WSNG establishment during the first season. Ragweed, cocklebur and other tall weeds can shade out WSNG seedlings. By the second growing season, more weeds will invade the mine site, but the WSNGs should not be greatly affected. Annual weeds can be mowed in May of the second growing season if it appears the weeds are excessive. The mower should be set at 12 inches to miss the grasses and forbs. The site must be protected from grazing during the second year because the WSNGs are still developing their root systems. The site should not be hayed the second year because that can inhibit root and shoot growth the next season. Always remember, mowing and grazing reduce photosynthesis, which in turn reduces the production of carbohydrates. WSNGs must be allowed to recharge their carbohydrate reserves to prepare for winter and to grow well the following season.

In the spring of the third year, the warm-season grass stand can be burned by the landowner or manager to promote maximum shoot growth. Burning releases some nutrients in the ash and allows sunshine to warm the soil and begin new growth earlier in the spring. Burning also promotes development and flowering of the prairie forbs, enhancing diversity and the beauty of the stand. Technical assistance in planning the burn can be obtained from the local Natural Resource Conservation Service office, local extension offices, the Soil and Water Conservation District and state wildlife conservation agencies. The site can be lightly grazed or hayed in the third year if the stand is robust and thriving. However, cattle should not be allowed to graze, nor should the grass be cut for hay after August 1 in the third year. This will allow the WSNGs to replenish carbohydrate reserves for the next season. To promote soil development and nutrient cycling, the landowner should be discouraged from removing organic matter from the site by grazing and haying. Removing organic matter in the third year will retard the natural reclamation process and will slow the closure of the WSNG stand.

Reclamation staff must discuss with the landowner the various phases of the three years required to establish native grasses. Patience should be emphasized, especially in the first growing season when the WSNGs are small. The landowner must be made aware of the unique management requirements, including prescribed burns and closely managed grazing and haying of WSNGs. If the landowner is unwilling to manage the WSNGs as required, then it makes no sense to go to the trouble and expense to plant them. Most failures result from bad management.

While seed mixtures may vary according to region and preferences, warm-season grasses native to the tallgrass prairie are the structural foundation of the planting. Important prairie grasses and legumes for reclamation include:

Big Bluestem

BIG BLUESTEM has been called the "king" of the prairie. Prior to cultivation, big bluestem was the ecologically dominant species throughout the Midwestern tallgrass prairies, maintaining itself for centuries. Big bluestem will ultimately dominate warm-season grass stands on reclamation sites. It is fast growing, with an extensive root system, and spreads by means of underground stems called rhizomes. Rhizomes in native prairies enable grasses to store carbohydrate reserves and function as a "life preserver" for the plant during extreme environmental stress (Weaver 1968). Big bluestem is high in nutrition, and cattle eat it before most other grasses. Its great size, up to seven or eight feet on reclamation sites, gives big bluestem a competitive advantage over other prairie plants and provides a high quantity and quality of forage. Although big bluestem leafiness increases with light grazing, excessive early grazing decreases the growth of rhizomes and shoots, reduces the extent of the plant's radial spread and therefore reduces the number of shoots for the following spring (Weaver 1968). Big bluestem should not be cut after August 1 or grazed after September I, leaving a minimum of 12 inches of stubble to restore carbohydrate reserves. Overgrazing or late haying can quickly weaken or destroy big bluestem stands by removing carbohydrate reserves. Big bluestem provides excellent nesting, resting and escape cover for small animals and birds, making it a preferred plant for wildlife habitat. Big bluestem is an attractive plant throughout the year. The stems turn various colors, from wine red to purple, and patterns, from striations to solids. The beautiful fall colors rival the brilliant reds, oranges and browns of hardwood trees. It is also known as "turkey's foot," an allusion to the seed head's resemblance to a three-toed turkey's foot.

Indiangrass

INDIANGRASS is a tallgrass prairie pioneer that quickly establishes itself by seed and provides excellent forage and vegetative habitat for wildlife and for erosion control. Indiangrass gradually gives way to big bluestem in warm-season grass stands and native prairies, except in areas of disturbance. Areas disturbed by hot, killing fires and floods that destroy the prairie sod are quickly colonized in by indiangrass. Eventually, big bluestem out-competes indiangrass on the prairie and in warm-season grass stands. Indiangrass grows to seven feet tall. It can be identified from big bluestem by its lighter green color and the attractive, golden lance-like seed head. Like big bluestem, indiangrass turns beautiful colors in the fall, making a wonderful contrast to the golden seedheads. The soft, ripe seed is easily stripped by hand for next season's planting.

Eastern Gamagrass

EASTERN GAMAGRASS is a native, warm-season perennial tallgrass that is adapted to mesic and hydric soils. It tolerates saturated soil conditions and was formerly found in single species stands on such sites. However, gamagrass does require a period of dry soil in the summer. It can do well on dry upland sites as well. Gamagrass grows and spreads from coarse rhizomes into clumps from one to four feet in diameter, attaining heights of five to nine feet. The foliage is abundant and highly nutritious. Most native stands were grazed out by cattle in settlement times. Gamagrass is excellent wildlife cover for overwintering, nesting and escape cover. It greens up in May and matures in June, several months before most WSNGs, yet remains palatable throughout the summer and into the fall.

This close relative of maize can be established with a corn planter. It is important to purchase stratified seed from a reputable dealer. Gamagrass seed is slow to germinate in nature. The seeds must be cold-treated to force germination in the spring. Otherwise, unstratified dormant seed must be seeded no later than 45 days before the last spring frost. Fall plantings of unstratified seed have been tried but with little success. Some of the large seeds are eaten by rodents, others rot in winter's saturated soils. There should be at least six to eight inches of stubble 60 days prior to first frost to allow for regrowth and recharge of carbohydrates stored in the roots for winter hardiness and early spring green-up (Clubine 1993). Haying and grazing should be restricted after this date until the first killing frost. At that point, cattle can graze the dead leaves. Overgrazing or late haying in the fall can quickly and easily destroy a gamagrass stand. Burning increases seed production, promotes earlier spring green-up and reduces thatch, but fire is not required to maintain the gamagrass stand. Nitrogen fertilizer can greatly increase yields, and weeds can be controlled with herbicides labeled for use with corn. It should be noted that several of these herbicides have had negative effects on other WSNG species at the time of establishment and will kill native forbs and legumes.

Eastern gamagrass provides landowners with excellent forage and wildlife habitat, especially in WSNG mixtures. The spreading clumps are often hollow in the middle, forming a "circus top" canopy of leaves growing from the ring of rhizomes and falling into the center. This hollow center makes excellent nesting sites for ground-dwelling birds such as quail and turkeys. Gamagrass also provides excellent erosion control in wet areas where few other hardy grasses will survive. It withstands dry summer conditions that kill most other wet-mesic or hydrophytic plants.

Little Bluestem

LITTLE BLUESTEM is a smaller, three- to four-foot-tall relative of big bluestem that is best adapted to harsh, droughty soils – conditions that often approximate those of reclaimed sites. Little bluestem's extensive fibrous root system is more efficient in absorbing nutrients and water than any other native grass. While its roots do not grow as deeply as big bluestem's, little bluestem's root system comprises a greater percentage by volume of the upper two feet of soil than big bluestem (Weaver 1954). Little bluestem forage is of high quality and can provide winter grazing because the dried leaves have some nutritional value. Little bluestem has shown to be extremely acid tolerant by invading acid mine spoils throughout the Midwest. It is common and indigenous on the extremely acid shale-derived soils of the West (Fisher 1994). As with big bluestem, little bluestem has brilliant wine red to purple stems and leaves in the fall, giving rise to the name bluestem. It cannot compete with big bluestem under better soil conditions, but will hold its own on the more droughty sites in the tallgrass prairie and on reclamation land. Little bluestem is an important wildlife species, providing cover and structural diversity.

Switchgrass

SWITCHGRASS is quickly established and provides cover to the reclamation site. It is aggressive and will stunt the growth of big bluestem and indiangrass if the seeding rates are too high. It will form a monoculture, which reduces wildlife habitat. In the long term, switchgrass cannot compete with big bluestem and indiangrass once the WSNG stand is established. Switchgrass relies almost exclusively on seeds germinating in the bare mineral soil of disturbed areas, requiring full sun to mature, while big bluestem rhizomes spread into switchgrass stands, forcing out mature switchgrass and shading switchgrass seedlings. Although pure stands of switchgrass have been planted to simplify haying and grazing management, a mixed stand of WSNG and forbs is much more effective in promoting biodiversity and enhancing wildlife habitat.

Native Prairie Legumes and Forbs

ILLINOIS BUNDLEFLOWER is a native legume that is highly nutritious and is being developed by researchers into cultivated varieties for commercial production. For wildlife, bundleflower provides structural habitat diversity, insect food and seeds for birds such as quail or pheasants. Livestock prefer it over any other plant, including alfalfa, often grazing it out of pastures. As with most legumes, Illinois bundleflower fixes atmospheric nitrogen, which enriches the soil. It is a pioneer species, invading disturbed areas in old fields, roadsides and prairies. Hence, Illinois bundleflower is an excellent reclamation species adapted to harsh, dry conditions.

PARTRIDGE PEA, a native legume, is easily established from seed in the first season and is an important food source for wildlife. In later stages of growth, partridge pea can be unpalatable and even toxic to cattle. Its use should be limited to wildlife habitat restoration. As a legume, it fixes atmospheric nitrogen. Partridge pea is a pioneer species and, like bundleflower, is an excellent reclamation species enduring harsh, dry conditions.

Included in the seeding mixture should be other native, non-grass plants, or forbs, that promote diversity and the growth and development of the reclaimed ecosystem. Plant diversity is essential to a healthy, productive system that will accelerate the natural reclamation process. Native SUNFLOWERS provide seed and forage to wildlife and livestock but also tap nutrients deep in the soil. This improves the efficiency of the nutrient cycling system and improves the fertility of the soil. Most prairie forbs are extremely deep-rooted, with roots extending beyond that of competing WSNGs near the surface. Shallow-rooted plants can then tap nutrients that formerly were too deep in the soil. LEADPLANT and PRAIRIE CLOVER are native legumes that increase forage quality and wildlife carrying capacity. Other forbs may be added to the mixture depending upon the availability and cost of the seed and in accordance to the wishes of the landowner and the AML staff. Showy prairie forbs such as compass plant, coneflower, blazing star, rattlesnake master, maximillian sunflower, pitcher sage and coreopsis can be included in small amounts (approximately 1 ounce per acre) to add beauty and diversity.

COMMON LESPEDEZA (*Lespedeza striata*) is a warm-season annual plant that can be an important source of nitrogen and wildlife food, especially for quail. Do not plant more than 3.0 pounds per acre in a new WSNG stand. Do not plant common lespedeza in old field plantings or topsoiled reclamation sites, where it can become overly competitive. Common lespedeza can be broadcast seeded after three years to enhance these sites. It is extremely tolerant of drought and of poor soils with low nutrient levels.

Do not confuse common lespedeza with sericea lespedeza. Sericea is a long-lived perennial that is overly aggressive, shading out WSNGs and tree seedlings, ultimately forming a monoculture. Livestock avoid eating it, and its importance to wildlife is minimal. Sericea inhibits natural succession. It is invasive, spreading into neighboring fields, and should not be planted.

Introduced legumes like hairy vetch, birdsfoot trefoil, crownvetch and red, white and ladino clover *should not be planted* with WSNGs. They are too aggressive in the crucial two-year establishment period of WSNGs. They produce large quantities of hard seed that can persist for years in the soil before germinating.

Conclusion

SMCRA Section 515 (b)(19) requires Title V reclamation to create " ... a ***diverse***, effective, and permanent vegetative cover of the same seasonal variety ***native*** to the area of land to be affected and capable of self-regeneration and ***plant succession*** at least equal in extent to the natural vegetation of the area ..." Reclamation throughout the country has not often achieved this goal, largely because of the next clause, which reads: "... except that ***introduced species*** may be used in the revegetation process where desirable and necessary to achieve the approved postmining land use plan;" (SMCRA 1993) (italics are the author's). Tall fescue, crested wheatgrass, crownvetch and sericea lespedeza are planted because they are inexpensive, easily established and fit easily into a pasture postmining land use. These monocultures of introduced aliens prevent natural succession and inhibit ecosystem functioning. If economic development destroys native plant communities, environmental specialists should at minimum plant species that will promote colonization of native plants and natural succession on drastically disturbed sites. The western states are making great strides in enhancing the diversity of reclamation sites. The East and Midwest should make comparable efforts. Although Title IV reclamation is not required to adhere to Section 515, AML programs should set goals to enhance and restore diversity and ecosystem functioning, rather than create more low-quality pasture composed solely of alien monocultures.

The objective of a land reclamation specialist is to develop a diverse productive, sustainable ecosystem where the release of nutrients by mineral weathering and organic decomposition is balanced by plant uptake. A stable, diverse ecosystem implies that the reclamation site is geomorphically stable. Warm-season native grasses are inherently better adapted to Midwestern environmental conditions. WSNGs enhance natural succession and accelerate the development of a soil biological system that improves biological diversity and productivity of a reclamation site. Cool-season grasses such as tall fescue impede such processes, creating a biological desert. WSNGs should not be dismissed for use on reclamation projects simply because they are too expensive or too difficult to establish. Experienced gained in planting WSNGs under the 1985 Farm Bill's Conservation Reserve Program has led to the development of highly successful establishment practices. Quality control of seed, equipment and planting methodology greatly improves planting success. Seed costs have come down. Landowners and managers familiar with WSNGs no longer dismiss them as "horse hay." ***There are few good agronomic reasons for not planting WSNGs.*** The questions about planting WSNGs are now: 1) Will the landowner manage them correctly? and 2) Are reclamation specialists prejudiced against WSNGs and refuse to plant them based solely upon inexperience and bias?

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Attachment I

Time Schedule for Establishing Warm-Season Native Grasses

I. Earthwork Completed.

- A. Spread and incorporate agricultural lime.
- B. If earthwork completed in early spring go to Step III.
- C. If earthwork completed in summer or fall go to Step II.

II. Plant Green Manure Crop (using conventional agronomic practices).

- A. Green manure crops planted in the summer could include: oats, milo, sorghum-sudan grass, hairy vetch, common lespedeza or black medic.
- B. Green manure crops planted in the fall could include: oats, wheat, hairy vetch, red clover and white clover.
- C. A third option is to apply and crimp in a heavy mulch (5 tons/acre).

III. Prepare Site for Planting Spring First Year.

- A. Mow down debris and cereal heads before seed matures.
- B. Incorporate green manure crop and agricultural lime into the soil.
- C. Plant WSNG between March 1 and May 31.

IV. Summer - First Year.

- A. Monitor germination and survival of WSNG.
- B. If the stand is unsuccessful go back to Step II.
- C. If the stand is spotty in success, plant wheat (at 25-30lbs an acre) cover crop in bare areas or apply mulch to weak areas for over-winter protection. Go to Step V, B.

V. Spring - Second Year.

- A. Monitor WSNG survival. Some plants may be lost during winter due to frost heaving.
- B. If a cover crop was planted in weak or barren areas, mow wheat before the seed heads ripen. Repeat Step III by direct drilling of WSNG.

VI. Summer - Second Year.

- A. If weeds are excessive, clip tops with mower set at 12 inches from the ground.
- B. Do not mow or hay.

VII. Spring - Third Year.

- A. Burn the stand prior to spring green-up.
- B. Monitor WSNG survival and density.

VII. Summer - Third Year.

- A. Monitor WSNG development.
- B. A light mowing or grazing can be permitted.