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Florida Native Plant Collection, Production and Direct Seeding Techniques: Interim Report

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Florida Native Plant Collection, Production and Direct Seeding Techniques: Interim Report

by Sharon Pfaff and Mary Anne Gonter

Clarence Maura, Jr., Technical Editor

U.S. Department of Agriculture
Natural Resources Conservation Service
Plant Materials Center
14119 Broad Street
Brooksville, FL 34601
(352) 796-9600

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Florida Institute of Phosphate Research
1855 West Main Street
Bartow, Florida 33830-7718
(941) 534-7160
http://www.fipr.state.fl.us
Contract Manager: Steven G. Richardson

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Introduction

In November of 1990, the Florida Institute of Phosphate Research provided a five year grant to the USDA Natural Resources Conservation Service (formerly the Soil Conservation Service), with the goal of developing sources of seed for native upland species, along with planting and production technology. The phosphate industry reclaims thousands of acres of uplands each year, a portion of which could be revegetated with native upland species. However, reclamation efforts were limited because good quality native seed is difficult to obtain.

Previous attempts to direct seed native species had often met with failure. Very little was known about Florida native upland species, namely seed collection dates, seed characteristics, germination rates, seedling vigor, management practices necessary to induce flowering, etc. In addition, technology and mechanical methods of collection, seed conditioning, and direct seeding needed to be researched to make native habitat reclamation feasible on a large scale.

The intent of this publication is to combine a review of pertinent literature, with the data obtained under this agreement into a comprehensive users manual. It is written to provide guidance to anyone who wishes to harvest, produce or direct seed native upland species. The selected plant materials discussed in this publication were chosen based on their characteristics and performance. These were the species studied under this agreement, which showed the greatest potential for being included in a native upland seed mixture. This is not intended to be an all-inclusive list, or even the final word on the species discussed. Other species will be added as seed sources and research data continue to become available.

We gratefully acknowledge the following agencies for their assistance in this research agreement: Avon Park Air Force Range; State of Florida, Division of Forestry; Florida Department of Environmental Protection, Division of Recreation and Parks - especially Park personnel at Fort Cooper State Park and Myakka State Park. We would like to thank Cargill Fertilizer, Inc. and IMC-Agrico for their contribution of research field sites. We extend a special thanks to Dr. Steven Richardson for his guidance and encouragement on this project; Andre Clewell for his wisdom and guidance on this project, as well as his knowledgeable direction in the development of the species descriptions in this publication; and Charlie Riddle and staff of the Mined Lands Agricultural Research/Demonstration Project, for providing equipment and a helping hand for our research plantings.

Seed Collection

One of the major challenges involved in native reseeding endeavors is the collection of adequate quantities of viable native seed. Two mechanical methods of harvesting large quantities of native seed have been used successfully in Florida. The first method is to use forage harvesting equipment to cut or chop a native stand. The second is the use of specialized seed harvesting equipment. The advantages of the first method are that ripe seed from a broad spectrum of desirable native species can be harvested at the same time, regardless of seed characteristics such as beards or awns. Also, the equipment is often readily available.

The disadvantages are that large quantities of green material are harvested and heating becomes a problem. Material must be kept aerated and/or planted quickly to avoid loss of seed viability. Only seed from those species that ripen within the same period can be gathered with this method. Unfortunately, the collection windows for many of the more desirable native species often do not overlap. In addition, undesirable weedy species will be gathered using this method, and cannot be easily removed. This material generally can only be applied by broadcasting. The percentage of pure live seed, and therefore cost effective application rates, are more difficult to determine under this method.

Specialized seed harvesting equipment has the advantage of harvesting only seed and small amounts of chaff from the desired species. This reduces or eliminates heating problems, thereby reducing handling expenditures during harvest. Less bulk material is gathered, allowing more storage and planting flexibility. A smaller spectrum of native species are collected at one time, which may or may not be advantageous. Although undesirable weedy species may be inadvertently gathered, they can be removed with seed cleaning equipment.

Figure 1. Harvesting lopsided indiangrass with the Flail-Vac Seed Stripper.

The disadvantages of this method are that equipment is often costly and not readily available. Also, specialized equipment is limited in the range of species that can be harvested effectively. For instance, conventional three screen combines can only be used to harvest native species that do not have long awns or hairy appendages. Examples are eastern gamagrass (*Tripsacum dactyloides*) and species with panicle-type seedheads, such as switchgrass (*Panicum virgatum*). However, many other desirable native species have seed characteristics that hinder flow through a screen system. A few examples are wiregrass (*Aristida stricta*), lopsided indiangrass (*Sorghastrum secundum*), and the *Andropogon* species. These species can be effectively harvested using tractor mounted grass seed strippers such as the Flail-Vac Seed Stripper (Figure 1). This type of harvester employees a large rotating brush and vacuum system that strips seed from the seed stalk. Only ripe seed is harvested allowing several harvests to be conducted each year in the same field, with very low impact.

Seed viability is one of the most important factors to be considered when harvesting a native stand. Prior to harvest, samples should be taken to determine percentage seed germination and therefore, cost effectiveness of harvest operations. Care must be taken not to collect immature seed, or germination will decrease substantially. Seed viability is commonly low in native stands. For instance, wiregrass if burned in the early spring appears to flower prolifically, yet seed viability may be zero. Insects and other pathogens may also damage seed and reduce viability.

Other factors that need to be considered are site accessibility, the presence of endangered species, and noxious weeds. Sites infested with noxious weeds should be avoided to prevent their spread. Heavy stands of trees and shrubs, felled timber and marshy areas may obstruct collection. The impact of harvest equipment on the donor site also needs to be assessed prior to harvest.

Direct Seeding

Direct seeding has the potential of being the most economic method of revegetating native habitats on disturbed lands. In recent years, several attempts have been made throughout Florida to direct seed native species. These efforts have met with mixed success. Although a great deal of information still needs to be obtained through concerted research efforts, the information gathered thus far has been extremely valuable. In addition, many sound principles of reclamation have been established in mined land reclamation studies throughout the US. Many of these principles, if applied to native reclamation efforts in Florida, will increase establishment success.

Land Use

The first factor to consider when direct seeding native species is the proposed long-term land use. This will determine the type and variety of species seeded. In general, plant species diversity provides greater diversity of use. Both food and cover for targeted wildlife or livestock species should be considered. Other factors to be considered are management practices necessary to maintain established native stands, and proximity to urbanized areas. For example, pineland wiregrass communities require prescribed burning for maintenance. However, burning may not be an acceptable practice if the site is adjacent

to an urban area. This may also be true for some chemical herbicides.

Soils, Climate and Hydrology

The type of soils, climate, and hydrology all have a bearing on species selection and seeding success. A major portion of Florida is considered as having a subtropical climate, with 50-60 inches of precipitation per year. However, because of coarse sandy soils, and long dry seasons, many sites actually undergo severe drought conditions. This is especially prevalent on the reclaimed phosphate mined land sand tailing soils. These coarse soils have very poor water holding capacities. Overburden soils used for reclaiming phosphate mined lands are finer textured, and have greater water holding capacity. However, the clay component in these soils causes severe crusting, and therefore poor water infiltration. Organic matter is also extremely low. Intense rain events on coarse soils allow nitrogen and other plant nutrients to be quickly leached out of the soil profile. This produces an environment low in fertility. Due to the high water table in Florida, a minor lowering in elevation may produce frequent flooding or ponding. In native situations, this can drastically alter plant populations within a very short distance. Therefore, it is especially important to know the soils and hydrology of a given site, and select species accordingly.

Fertilization

It is generally not recommended that chemical fertilizers be applied to new seedings. Fertilizer tends to stimulate weedy species. It is preferable to include sustainable sources of nitrogen instead. Legumes such as partridge pea (*Chamaecrista fasciculata*) and lupine (*Lupinus* spp.) are two examples of sustainable sources of nitrogen in native systems.

Slope

Because of intense storm events, even minor slopes in Florida are susceptible to water erosion. It often requires 2 to 5 years for a native stand to become established (Thornburg, 1982). Species which can become established relatively quickly, (e.g., *Andropogon* species) and/or have a rhizomatous verses a bunch-type growth habit should be considered for steeper sites.

Weed Competition

Since many of the desirable native species are very slow to establish, they are not able to compete with weedy species, and are especially vulnerable to invasion by noxious weeds such as cogongrass (*Imperata cylindrica*). Results from recent native plantings have also shown that native grass seedlings are not able to compete with introduced grasses such as bahiagrass (*Paspalum notatum*) or bermudagrass (*Cynodon dactylon*). Therefore, the seedbed should be as free of weeds and introduced grasses as possible before planting. Follow-up weed control may also be necessary. Noxious weeds should be eliminated from the planting site prior to planting native species. If this is not possible, then establishment of a native plant community should be reconsidered.

Nurse Crops

No scientific data is currently available concerning the use of nurse crops to establish native stands in Florida. In general, nurse crops, whether planted in the winter or summer, have the advantage of reducing erosion, suppressing weedy species, and providing a more favorable microclimate in which to plant native species. The disadvantages of nurse crops are that they reduce soil moisture and nutrients available to native species. If the nurse crop is able to produce seed, volunteer plants may offer competition to native species in subsequent years.

Seedbed Preparation

Seedbed preparation is one of the critical elements of successful establishment. The seedbed should be bare mineral soil, which, if necessary, has been tilled to loosen any crusted surface layers. Tilled soil should then be smoothed and packed to break up large clods and provide an even planting surface. A firm even seedbed is especially important when drilling seed, to obtain precise depth placement of seed. As mentioned above, it is especially critical that the seedbed be as free of weeds and introduced grasses as possible. If these undesirable species are present, it may be necessary to conduct a weed control program for one to two years prior to planting, to ensure establishment success.

Seeding Method

The two primary methods of direct seeding grasses and forbs are broadcasting and drilling. The advantages of broadcasting are that equipment is often less expensive and more readily available than for drilling. Light fluffy, awned or chaffy seed may be dispersed from mechanical broadcasters

Figure 2. Packing reclaimed mined land sand tailing soils after broadcasting.

without requiring further conditioning, depending on the species. Seed mixes with a large number of species (having different seed weights and sizes) are best seeded by broadcasting. Broadcasting, however, does not provide precise depth and spatial placement as does drilling. Therefore, it is recommended that twice the drill seeding rate be used (Cook *et al.*, 1974). After broadcasting, the field should be lightly disked or packed to incorporate the seed (Figure 2).

Seed of many of the more desirable native species will not flow through a conventional drill without further conditioning. Even then, the seed of some species, such as wiregrass, are still too light, and will bridge. Specialized warm season grass drills with picker wheels or air flow systems are necessary to overcome bridging. The higher cost of this specialized equipment can be quickly realized by lower seeding rates if large acreages are to be seeded. Row widths should be between 6 and 24 inches, depending on the species being seeded. Narrower row widths increase seedling competition, while wider widths allow increased weed competition and reduced stand establishment. As mentioned above, legumes can provide much needed nitrogen in a native system. However, legumes are often more aggressive than native grass species, and will reduce grass seedling densities. One seeding method which overcomes this problem is alternate row seeding. Seeding legumes in alternate rows with grasses reduces competition between seedlings and increases the survival of all species (Lohmiller *et al.*, 1990).

A third type of seeding method, which has limited application, is the plug mix planter. Plug mix planters were originally developed as a means of direct seeding very small seeded vegetable crops such as tomatoes and peppers. The seed is mixed with potting soil and a small "plug" of this mixture is inserted into the soil by the planter. The planter pictured in Figure 3 was used to seed lopsided indiangrass at two reclaimed mined land sites in central Florida, an overburden site, and a sand tailings site (see Appendix A). On the overburden site, drilling produced a superior stand to the plug mix planter. On the sand tailing site, both drilling and the plug mix planter produced approximately the same plant density. However, seedlings from the plug mix were much more vigorous, healthy, and capable of withstanding drought. Some of these plants even produced seedheads in their first year. The potting soil plug may have provided a more favorable environment for seedling germination and growth. The plug mix had a higher water holding capacity than the surrounding sand tailing soils, and also higher fertility. It is also possible that the plugs allowed the more robust seedlings to reach down, past the very arid surface layer, and tap into the higher moisture lying 4 to 6 inches beneath the surface. The potting soil adds to the expense of this planting method, however, some of this cost may be recouped in lower seeding rates and reduced cleaning costs. An added advantage of this system is that seed need not be debearded or cleaned in order to flow properly through the openers. A single row planter is not practical for seeding large acreages. A multi-row planter may provide a feasible method of quickly establishing native species on very coarse soils.

Figure 3. One row plug mix planter at reclaimed mined land site.

Seeding Depth

Seeding depth is critical in small seeded species, especially if soils tend to crust. In general, small seeded species (e.g., wiregrass) should be planted 1/4 inch deep; medium sized seed (e.g., lopsided indiangrass) 1/2 inch deep; and large seed (e.g., gamagrass) 1 inch deep. In sandy soils, medium and large seed can be planted 1/2 inch deeper (Lohmiller *et al.*, 1990).

Seeding Rate

Despite differences in climate and soils, research results throughout the US show that, in general, seed must be applied at a rate of 15 to 25 pure live seed (pls) per square foot to obtain a satisfactory stand when drilling on favorable sites. (Percent pure live seed is determined by multiplying the percent germination times the percent purity for a given species and dividing by 100.) This rate should be increased by 50 to 100% on critical or unfavorable sites, to obtain a satisfactory stand. In arid western regions, a satisfactory stand is considered to be 13 plants per square meter (Cook *et al.*, 1974). In its natural environment in Florida, wiregrass averages five plants per square meter (Clewell, 1989). Higher seeding rates should also be used for those species which lack seedling vigor, and do not spread readily once established. As mentioned above, the broadcast rate is generally two times the drill rate. A seeding rate that is too low will produce unsatisfactory stands, too high a seeding rate produces unnecessary plant competition and seed costs.

Season of Seeding

A general rule-of-thumb for determining the seeding date, is to plant just prior to the season of most dependable moisture. In Florida, this would be in May or June, just prior to the summer rainy season. Although the winter rains are not as dependable, late

fall/early winter also appears to be a favorable planting season. In recent studies (see Appendix A), several native grasses and forbs have been successfully established during both seasons. Some species, such as beaked panicum (*Panicum anceps*) and the *Liatris* species may actually require a period of colder soil temperatures to germinate.

Mulching

Mulching has not been proven to be a beneficial practice in most Florida environments. Weed competition is generally increased by mulching. It is difficult to find clean, weed-free mulch material in Florida, since the primary hay crop is bahiagrass, which inevitably contains seed. If clean materials can be found, and the seedbed is relatively weed free, the soils that gain the greatest benefit from mulching are the reclaimed sand tailing soils. Mulches appeared to substantially reduce evaporation on these soils, and released some nutrients to the growing plants upon decay.

Production Fields

At present, the only seed source for Florida native species are tracts of native vegetation. Although these tracts contain a good mixture of native species, seed production and viability is often low. Plants are in competition for light, water and nutrients, resulting in lower seed viability and production in all species. A diversity of species have differing responses to cultural practices, such as burning and grazing. Therefore, cultural practices which increase seed production in one species will result in the decline in the seed production and plant populations of other species. For instance wiregrass must be burned every year to induce flowering, however, this will decrease lopsided indiangrass and *Andropogon* populations substantially.

If seed viability is too low, it may not be economically feasible to harvest a native stand. Seed lots with a very small percentage of pure live seed require that a large quantity of bulk material be seeded. Large quantities of material inhibit the flow of seed through mechanical seeders, especially drills.

Production fields of desirable native species planted in monoculture are one means of overcoming these problems. Cultural practices such as burning, clipping, fertilizing and irrigation can be applied discriminately, to maximize seed production for a given species. Plants receiving ample water and nutrients will produce plumper seeds. These seeds will in turn produce more robust vigorous seedlings. Practices to control insects and pathogens can be applied to a greater extent in a monoculture. Production fields have the disadvantage of being expensive to establish. Establishment may take two or more years before a crop can be harvested. However, as superior varieties of native species are released, and demand for native seed increases, production fields become the most economical source of high quality seed.

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Selected Plant Species

Following are the grass and forb species selected as having potential for use in a native seed mix. Selection criteria included adaptation range, potential use, ease of seed collection, seed production, seed conditioning requirements, potential for direct seeding, and cultural management practices necessary for seed production. Featured species are those which generally limit wind and water erosion, improve water quality, have good forage production and wildlife benefits, and have the ability to carry fire.

The species descriptions in this manual were written with the seed collector in mind, and were developed using the sources listed below. Those desiring more technical descriptions for plant identification should refer to these or other sources designed for that purpose.

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Glossary

Accession: Plant material (plant, seed, or vegetative part) collected and assigned a number to maintain its identity during evaluation, increase, and storage.

Bract: The reduced leaves or chaff of the inflorescence and upper part of a shoot.

Collection window: The period of time during which seed is ripe, and remains attached to the plant.

Cultural practices: In the case of seed yield, those methods used to increase seed viability and production (e.g., burning regimes, stand fertilization and irrigation). In the case of direct seeding, those methods used to plant the seed and obtain successful establishment (e.g., seedbed preparation, seeding method, and weed control).

Direct seeding: Establishing plants on a site by incorporating seed directly into the soil. Direct seeding is to be distinguished from vegetative plantings, which place vegetative material (e.g., stems, roots or whole plants) in the soil. The two most common methods of direct seeding are broadcasting the seed upon the soil surface, and using a seed drill, which more precisely places the seed at a given depth and row spacing.

FLPMC: Brooksville Florida Plant Materials Center.

Glumes: The pair of bracts at the base of a spikelet.

Inflorescence: A flower cluster.

Ligule: In grasses, a membrane or line of hairs across the top of the leaf sheath, facing the stem.

Mesic: A hydrological term for a site which falls between a wetland (hydric) site and a sandhill (xeric) site. A flatwoods site would be considered a mesic site.

Panicle: A copiously branched inflorescence, typically a compound raceme consisting of a principal axis that supports secondary branches which bear flowers or, in grasses, spikelets.

Peduncle: The stalk or stem of an inflorescence.

PLS (pure live seed): Calculated by multiplying percent germination by percent purity and dividing by 100 (e.g., a pound of wiregrass seed that consists of 53% actual seed by weight, and has a germination rate of 42%, would contain 22% pls).

PMC: Plant Materials Center.

Raceme: An inflorescence in which the spikelets are connected to the main axis (rachis) by small stems.

Rachis: The axis of a spike or raceme.

Sheath: The lower part of the leaf below the blade that encloses the stem.

Smut: A fungus that forms dark powdery masses of spores on affected parts of a plant.

Spathe: A sheathing bract of the inflorescence found commonly in bluestems.

Spike: An unbranching inflorescence consisting of spikelets attached directly to the rachis.

Spikelet: The basic unit of a grass inflorescence, consisting of two basal bracts, called glumes, and one or more flowers, called florets. A spikelet is compact and superficially resembles a single flower or fruit.

Stratification: The process of placing seeds between layers of moist soil or peat and exposing them to low temperatures to encourage germination. Seed from some plants such as species of *Liatris* require this process in order to germinate.

Splitbeard Bluestem

Andropogon ternarius Michx.

Description and Growth Characteristics: Warm season perennial bunchgrass. **Leaf blades** are 1/8 to 1/4 inch wide, and 12 to 16 inches long. Plants are generally 2 to 8 inches in diameter. Vegetative growth begins in early spring. **Seed stalks** are 2 to 3 feet tall. **Seed heads** are paired racemes, approx. 2 inches long, silvery white, on long peduncles (stems). Flowering occurs in May, and seed is ripe in June in central Florida. Occasionally flowering will occur again in October, with seed ripening in November. The seedhead of this species closely resembles that of *Andropogon arctatus*, which also ripens in November.

Habitat: Adapted to longleaf pine-turkey oak sandhill communities.

Uses: In a stable native community, splitbeard bluestem is an important component, but seldom dominates a site, as it is not an aggressive plant. However, it has fair forage production, and does provide some fuel for burn management programs. It also provides cover for wildlife, and is a very palatable species to livestock.

Seed Collection: Ripe seed are reddish brown in color, approximately 1/8 inch long and less that 1/6 inch wide. Seeds are cylindrical in shape, tapering to a point at both ends. Seeds are contained in spikelets which have long awns and whitish silky appendages. These characteristics, coupled with the light weight of the seed make harvest with traditional equipment difficult. This species may be harvested with the Flail-Vac Seed Stripper.

Seed Germination and Conditioning: Splitbeard bluestem appears to have fair seed production and viability. Laboratory

germination tests at the FLPMC produced a germination rate of 28%. *A. arctatus* had a germination rate of 14 %. In this instance, germination rates may have been reduced by collecting seed before it was fully ripe.

Seed can be debearded in the manner used for other *Andropogon* species, with a debearder. Chaff and seed can then be separated using an air- screen cleaner (Brown *et al.*, 1981).

Propagation by Seed: Splitbeard bluestem and *A. arctatus* have good potential for establishment by direct seeding. In FLPMC test plots on reclaimed mined lands *A. arctatus* emerged within two months from both overburden and sand tailing soils, when planted in late May.

Cultural Management: Controlled spring burns have been observed to have an influence on the amount and timing of flowering of *A. arctatus* in North Florida longleaf pine savannahs (Brewer and Platt, 1994). The effect of burning on seed production and viability for splitbeard bluestem has yet to be researched.

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Chalky Bluestem

Andropogon virginicus L. var. *glaucus* Hack.
[or *Andropogon capillipes* Nash; *Andropogon virginicus* var. *glaucopsis* (Ell.) A.S. Hitchc. misapplied]

Description and Growth Characteristics: Warm season perennial bunchgrass. **Leaf blades** are usually 1/2 inch wide and 20 to 25 inches long. Blades are sharply folded at base, and flatten out toward the tip, often very bluish in color. Stems, blades and sheaths are covered with a conspicuous white chalky residue. Vegetative growth begins late winter. **Seed stalks** are 3 to 5 feet tall. **Seed heads** are 2 paired racemes partially enclosed in a purplish spathe or sheath. Seedheads appear in September and early October. Seed is ripe November through early December. The collection window lasts several weeks.

Habitat: Adapted to flatwoods, and margins of freshwater ponds or marshes.

Uses: Chalky bluestem is important for erosion control in wet areas, as it readily colonizes disturbed areas. It has good forage production, which provides fuel for burn management programs, however, annual burning reduces vigor in this species. It provides cover for wildlife, and is considered to be one of the most palatable native grass species on flatwoods sites for livestock.

Seed Collection: Ripe seed are cylindrical in shape, 1/16 inch long and less than 1/16 inch wide. They are contained in a spikelet which has awns and silky appendages. These, coupled with the small light seed, makes collection with conventional equipment difficult. A Flail-Vac Seed Stripper was used by the FLPMC to harvest

a native stand of chalky bluestem, with good success.

Seed Germination and Conditioning: Chalky bluestem appears to have very good seed production and viability. Laboratory and greenhouse germination tests on Florida accessions at the FLPMC resulted in germination rates of 41 to 58%, from native stands.

Spikelets can be debearded using a debearder and an air-screen cleaner. Big bluestem (*Andropogon gerardii*) conditioned in this manner maintained its viability under controlled storage conditions, up to 3 years (Brown *et al.*, 1981).

Propagation by Seed: Tanner and Terry (1984) were unable to establish chalky bluestem by broadcasting seed on a prepared seedbed, and then lightly chopping or disking the field. However, this species appears to have good potential for direct seeding mesic areas, as it readily colonizes disturbed lands, such as abandoned firebreaks in flatwoods sites.

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Wiregrass

Aristida stricta Michx.
[Florida populations were recently recognized as a separate species, *Aristida beyrichiana* Trin. & Rupr., by some botanists]

Other Common Names: Pineland threeawn

Description and Growth Characteristics: Cool season perennial bunchgrass. **Leaf blades** are narrow and rolled inward (wire-like), 12 to 20 inches long. Vegetative growth begins late winter. This species can be distinguished from *Muhlenbergia capillaris* and *Sporobolus junceus* species by the small tuft of hair at the upper side of the leaf blade, where it meets the leaf sheath.

Seed stalks are 1 to 3 feet tall. The **seedheads** are a panicle, 10 to 12 inches long. Spring and early summer burning induces flowering. Seed is ripe in November and December. The collection window lasts several weeks.

Habitat: Adapted to a broad range of soil and moisture regimes, from wet flatwoods to longleaf pine-turkey oak sandhills.

Uses: Wiregrass is considered an important component of pineland habitats, because of its ability to carry fire. In native situations, wiregrass contributes a large percentage of the fuel for understory burn management programs. New growth is readily grazed by livestock after a burn. Wiregrass also provides cover and nesting sites for wildlife (Sharpe and Curtis, 1988).

Seed Collection: Ripe seed are cylindrical in shape, 1/4 inch long or less, and less than 1/16 inch wide, with three awns (1/4 inch long or more) attached at one end. If burned during the growing season, wiregrass will often flower prodigiously, producing an abundance of seed. However, these seed

may never fill (a viable seed may never develop within the outer covering of the seed). Before harvesting a site, seedheads should be sampled for fill and germination rate, to determine economic feasibility of harvest. A seed which has filled is plump and very brittle, and will snap when bent. An unfilled seed is very soft and pliable, and will not snap or break when bent. Light seed weight and awns make harvest with conventional equipment difficult. Native stands of wiregrass have been harvested successfully by the FLPMC with the Flail-Vac Seed Stripper.

Seed Germination and Conditioning: Seed viability varies widely, depending on climatic conditions, burn management and collection site. Laboratory germination tests conducted at the FLPMC on Florida accessions produced germination rates of 0 to 48%. Greenhouse germination rates averaged 32%. Parrott (1967), working with North Carolina wiregrass populations, conducted several germination experiments. He found that this population of wiregrass germinated between 58 - 103° F, with optimum germination occurring between 85 - 95° F. He also found that one-year-old seed germinated more quickly than new seed, which may indicate some dormancy.

Seed can be debearded using a debearder or hammermill. An air-screen cleaner can then be used to separate seed from chaff. Wiregrass seed is brittle and easily damaged in the debearding process.

The shelf life of wiregrass appears to be three or more years under ideal conditions (45-55° F and 45-55% humidity). A gray fungus is often observed on wiregrass seed, however, its effect on seed viability is unknown.

Propagation by Seed: Care should be taken to collect seed from habitats with the same moisture regime as the planting site. There is some evidence that seed harvested from flatwoods sites establishes best on moist sites, and seed gathered from sandhill sites establishes best on drier sites. More research will need to be conducted to determine if this is in fact the case.

Wiregrass has been direct seeded on a variety of sites throughout Florida, with mixed success (Bissett, 1996; see also Appendix A). Seedlings lack vigor, and germination and establishment are severely inhibited by weed competition. Introduced pasture grasses out-compete wiregrass seedlings, therefore, planting sites should be as free of weeds and introduced grass species as possible.

Cultural Management: It has been well established that wiregrass must undergo a growing season burn to flower and produce viable seed (Seamon and Myers, 1992). However, the month of burning appears to have a profound impact on seed viability. Seed viability appears to be highest when native stands of wiregrass are burned during the months of May through July (personal correspondence with Tim Pittman, FL Division of Forestry). The FLPMC personnel have observed that a sandhill site in central Florida burned in February, flowered abundantly, however, seed viability was 0%. When this site was burned in early May, germination increased to 2%. A similar nearby site burned in late June had a germination rate of 12%. Aside from burning dates, climate and available soil moisture appear to have a strong influence on seed production. Wiregrass populations in flatwoods areas that had undergone growing season burns had much higher germination rates than those listed above for the sandhill sites.

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Toothache grass

Ctenium aromaticum
(Walt.) Wood [or *Campulosus aromaticus* (Walt.) Scribn.]

Description and Growth Characteristics: Warm season perennial bunchgrass. Plants form dense clumps, and occasionally occur in pure stands. However, this species is typically a minor component in the sites where it occurs. **Leaf blades** 1/4 to 1/2 inch wide, 6 to 10 inches long. Blades are stiff, flat or with margins rolled inward, lighter green on the bottom and darker green on top. Growth occurs in early spring, with regrowth occurring in late fall. The base of this plant contains a substance which deadens the tongue and gums when chewed. **Seedstalks** erect 3 to 5 feet long. **Seedhead** is a curved spike with the spikelets arranged on one side of the rachis, giving a comb-like appearance. Flowering occurs in September. Seed ripens October through December. The collection window lasts two or more weeks, due to uneven ripening.

Habitat: Occurs in low pine flatwoods and palmetto prairies on moist or boggy soil, which may be briefly flooded after heavy rainfall.

Uses: Toothache grass is readily grazed by livestock in the spring and summer. It will decrease in native stands from heavy grazing, if not managed properly.

Seed Collection: A dormant or growing season fire is required to stimulate seed production (MacRoberts and MacRoberts, 1992). Ripe seed are long (1/8 inch) and narrow, dark brown to black in color. Seed is contained in a small spikelet (1/4 inch long), which has several

flowers, only one of which is perfect and able to mature into a viable seed. A Flail-Vac Seed Stripper was used successfully by the FLPMC to harvest toothache grass from a native site. When harvesting, care should be exercised in wet sites to avoid rutting and soil compaction.

Seed Germination: In FLPMC laboratory germination tests, toothache grass had a germination rate of 13%. In greenhouse tests, germination was poor, and seedlings lacked vigor.

Seed Conditioning: Seed hulls (spikelets) have only minuscule awns and hairs, therefore, they do not require debearding. Seed can be separated from chaff with an air-screen cleaner.

Propagation by seed: A Florida collection of toothache grass was established in the FLPMC greenhouse with moderate success. Poor competitiveness with weed species, and low seed germination make it difficult to establish toothache grass by direct seeding. Planting date trials (plots planted at six week intervals from Jan. through Oct.) were conducted at the FLPMC in 1996. In this study, a native seed mix containing toothache grass was broadcast onto plots and incorporated into the soil. No toothache grass seedlings emerged, although other native species did germinate. However, Bissett (1996) reported establishment of toothache grass seedlings on a reclaimed mined land site, by broadcasting a native grass mulch in December.

Literature Cited

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Hairawn Muhly

Muhlenbergia capillaris (Lam.) Trin.

Description and Growth Characteristics: Perennial bunchgrass. **Leaf blades** 1/4 inch wide or smaller, flat or rolled inward (wire-like). Often mistaken for wiregrass in the vegetative stage. **Seed stalks** 1 to 3 feet tall. **Seedhead** is a distinctive delicate purple panicle. Seedheads begin emerging in August. Seed ripens October through early November.

Habitat: Adapted to a broad range of sites from seeps and marshes to longleaf pine-turkey oak sandhill communities. It is more common on wetter sites.

Uses: Hairawn muhly fills the same role as wiregrass in pineland habitats. In native communities, it provides fuel for understory burn management programs, and cover for wildlife.

Seed Collection: Spikelets are less than 1/4 inch in length, with long awns 1/4 to 1/2 inch in length. Seed weight is extremely light. It is not yet known whether this species can be harvested with a conventional combine or a Flail-Vac Seed Stripper. At present, collecting the seedheads with a forage chopper or similar implement appears to be the most practicable method of harvest.

Seed Germination and Conditioning: No data available.

Propagation by Seed: No data available.

Cultural Management: Burning does not appear to be necessary to stimulate flowering. However, the effect of burning on seed viability has not yet been researched.

Beaked Panicum

Panicum anceps Michx.

Description and Growth Characteristics: Warm season perennial rhizomatous grass. **Leaf blades** are 1/2 inch wide, 2 to 4 feet tall. Blades are folded at the base, V-shaped towards the tip, and stiffly erect, giving the plant a distinctly upright appearance. Vegetative growth begins in late winter, around February. Beaked panicum is tolerant of shade and often grows in solid stands. **Seedhead** is an open panicle 6 to 14 inches long. **Spikelets** are 1/8 to 1/4 inches long. The curved end of the second glume resemble a bird's beak, hence the name. Seedheads appear in August or September. Seed ripens in September through

December. The collection window lasts several weeks.

Habitat: Moist to wet sandy soils along fresh water marshes, swamps and streambanks.

Uses: Seeds provide a food source for waterfowl and upland birds. Beaked panicum is readily grazed by livestock and deer. Heavy grazing pressure can decrease stands. It appears to be well suited for erosion control in wet areas.

Seed Collection: Lack of awns or hairy appendages make this species a good candidate for collecting seed with conventional equipment. Ripe seed have an extremely hard waxy seedcoat. Seed are relatively small (1/16 inch or more long and less than 1/16 inch wide), tapering to a point at both ends.

Seed Germination and Conditioning: Beaked panicum is a prolific seed producer, however, seed germination rates can be quite low. Cold stratification appears to be one of the best methods for breaking dormancy. At

the Coffeeville, MS PMC, dormancy was overcome by conditioning seed in a damp mixture of 50% peat moss, 50% sand, held around 5° C for four months (Coffeeville PMC, 1990). Dr. Robert Ahring, working at Oklahoma State University in 1962, found that moist storage at 5° C significantly improved germination. Seed three years old or less had optimum germination when prechilled 9 to 10 weeks. Seed more than three years old had optimum germination at 6 weeks. Presoaking seeds in concentrated sodium hypochlorite was also an effective method of breaking dormancy (personal correspondence with Dr. Ahring). Unstratified seed planted in Georgia and Tennessee by PMC personnel during the fall had good emergence in the spring, however, spring plantings of unconditioned seed failed to germinate (personal correspondence with Georgia PMC personnel). Whether cold stratification would be effective in breaking dormancy of Florida accessions has not been researched. It would appear, however, that seed remains viable for a relatively long period of time.

Seed can be readily separated from chaff using an air-screen cleaner.

Literature Cited

USDA, SCS. 1990. Technical Notes No. 1. Coffeeville Plant Materials Center. pp 1-3.

Switchgrass

Panicum virgatum L.

Description and Growth Characteristics: Warm season perennial rhizomatous grass, forming dense bunches or sod. **Leaf blades** are flat, 1/2 inch wide and 30 inches long or more. **Stems** are round, hard and hollow. Vegetative growth begins in the early spring. **Seed stalks** are 3 to 6 feet in height. **Seedhead** is an open panicle 10 to 15 inches long. Seedheads appear in August and September. Seed ripens in September and October. The window of collection lasts two weeks or more.

Habitat: Adapted to flatwoods, upland hardwood hammocks and salt marshes.

Uses: Switchgrass has received a great deal of attention as a forage grass for livestock. It produces a tremendous amount of high quality, palatable forage in the early part of the growing season. The seed is eaten by birds, and it also provides cover for wildlife.

Seed Collection: Ripe seed are relatively small (1/16 inch long or more and less than 1/6 inch wide) round or oblong, with a hard waxy coating. A conventional combine can be used to harvest seed.

Seed Germination and Conditioning: Florida accessions of switchgrass flower readily and produce large quantities of seed. However, seed viability is extremely low, as the seeds often do not fill. The reason for this is unknown. In 1991, vegetative material of three Florida accessions were sent to PMC's in Georgia, Louisiana, east and south Texas, to determine if seed viability would increase in a colder climate. Percent

germination of new seedlings ranged from 25 to 56% at the FLPMC in 1991. It ranged from 53 to 71% at the other locations. In 1992, percent germination dropped to a range of 1 to 9% at the FLPMC. It ranged from 1 to 37% at the other locations. These results indicate that it may be possible to increase seed viability of Florida accessions by growing them in a colder climate. However, germination rates dropped dramatically once the plants became established, indicating that other stress mechanisms are involved (unpublished data).

Seed can be readily separated from chaff using a hammermill and air-screen cleaner.

Propagation by Seed: Because of a smooth, hard seed coat, switchgrass can be direct seeded using a conventional drill. Florida accessions of this species have poor seed viability and lack seedling vigor. More genetic selection needs to occur, before Florida native cultivars suitable for direct seeding are available.

A cultivar from Texas, 'Alamo' is adapted to Florida. It has fair seedling vigor and seed production under Florida conditions. Seeding recommendations for this species are 2 lbs. pure live seed/ac on favorable sites, planted in 36-42 inch rows. The seeding rate should be increased to 3-5 lbs. pls/ac for broadcasting. Recommended seeding depth is 1/4 to 1/2 inch. Recommended planting dates are November 1 to March 1 and June 1 to August 1 without irrigation.

Creeping Bluestem

Schizachyrium stoloniferum Nash

[*Schizachyrium stoloniferum* is not considered to be a distinct species from *Schizachyrium scoparium* (Michx.) Nash, by most grass specialists. However, *S. stoloniferum* has remained in usage by range biologists in Florida.]

Description and Growth Characteristics: Warm season perennial rhizomatous grass. **Leaf blades** are 1/4 to 3/8 inch wide, up to 24 inches long, flat or V-shaped. Vegetative growth begins mid to late winter. **Seed stalks** are 2 to 6 feet tall. **Seedheads** up to 2 feet long, branched, bearing 1 inch or longer racemes singly or in groups, in a zigzag

pattern. Seedheads appear in September and ripen in October through November. The collection window lasts several weeks, possibly into December.

Habitat: Adapted to flatwoods, hardwood hammocks, and longleaf pine-turkey oak sandhills.

Uses: Creeping bluestem has superior forage production, and is preferred by livestock on native range sites. Because it is a sod-former, it is also an important species for controlling erosion.

Seed Collection: Ripe seed is long and cylindrical (approx. 1/8 inch long and 1/16 inch wide) tapering to a point on both ends. It is contained in a spikelet which has an awn and hairy appendages. This, coupled with light seed weight makes harvest with a conventional combine very difficult. Creeping bluestem seed was harvested in native wiregrass stands with the Flail-Vac Seed Stripper, by the FLPMC.

Seed Germination and Conditioning: Creeping bluestem generally has very poor

seed production and viability. Plants may flower, but spikelets often do not contain seed. Kalmbacher and associates (1991) working with a large collection of Florida accessions over a two year period, found that an average of only 27% of spikelets contained seed. These seed had an average germination rate of 45%. Seed dormancy did not appear to be significant. However, seed only had a shelf life of about one year.

FLPMC laboratory germination tests on unconditioned seed (spikelets) of a sandhills accession of creeping bluestem produced a germination rate of 1%. (Germination rate of the actual seed itself was 61%) Greenhouse tests produced a germination rate of 4%.

Spikelets can be debearded using a hammermill or debearder. Chaff can then be separated out using an air-screen cleaner.

Propagation by Seed: Tanner and Terry (1984) attempted to direct seed creeping bluestem by broadcasting seed on a prepared seedbed, and disking lightly or chopping. No seedlings emerged. It will be necessary to develop a cultivar with improved seed production and seedling vigor before this species can be successfully direct seeded.

Cultural Management: It appears that a growing season fire may increase seed production and viability. However, frequent burning decreased creeping bluestem populations in native stands (Sievers, 1985).

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Lopsided Indiangrass

Sorghastrum secundum
(Ell.) Nash

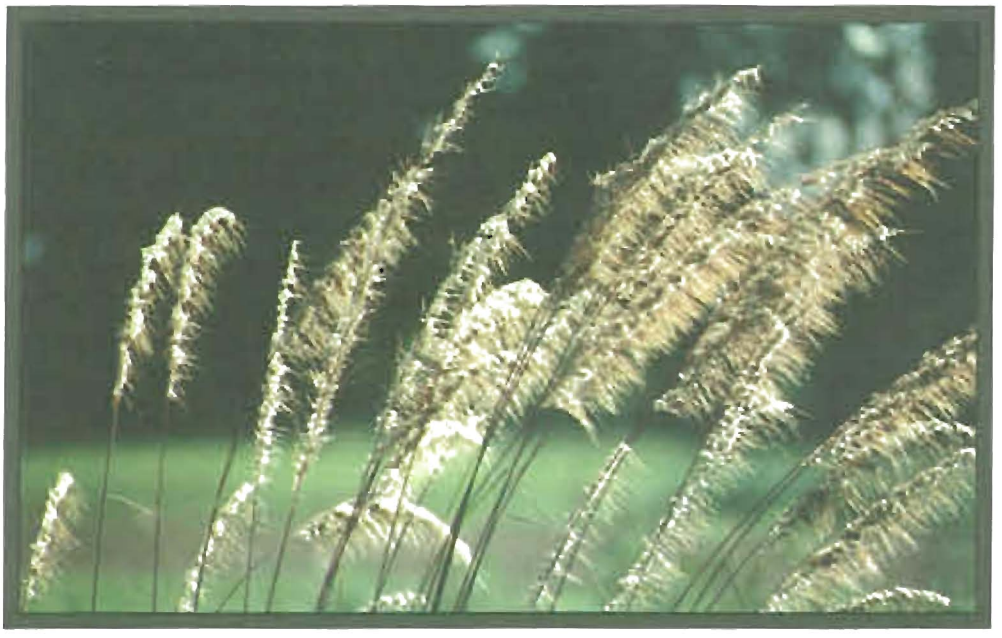
Other Common Names: Wildoats

Description and Growth Characteristics: Warm season perennial bunchgrass. **Leaf blades** flat and narrow 1/4 to 1/2 inch wide, and 1 to 2 feet long. The margins of the sheath where it meets the blade are prolonged into distinctive ear-like projections (1/4 to 1/2 inch long), which allow this species to be easily identified in the vegetative stage. Vegetative growth occurs in the spring. **Seed stalks** appear in September and are 3 to 6 feet tall, having a very distinctive one-sided golden-colored **seedhead**. Seed ripening occurs in October throughout Florida, and is generally very uniform at a given site. Upon ripening, seed is wind dispersed within 5 to 10 days, so the collection window is very narrow.

Habitat: Adapted to well drained soils on flatwoods and longleaf pine-turkey oak sandhill communities.

Uses: Lopsided indiangrass provides cover, and an unknown contribution to the diet of many wildlife species. It also contributes fuel for burn management programs, as it is a major component of many native habitats. It is readily grazed by livestock and deer throughout the year.

Seed Collection:. Ripe seed are hard, cylindrical (less than 1/8 inch in length), and light reddish brown in color. Seed is contained in a 1/4 inch long spikelet with hairy appendages and a long (over 1/2 inch) twisted awn. These attributes cause seed to cling together in a mat when collected, impairing harvest and cleaning with conventional screen systems. Some lodging of tall seed



stalks does occur, and height of seed heads is quite variable. The Flail-Vac Seed Stripper was used successfully by the FLPMC to harvest lopsided indiangrass seed from native sites.

Seed Germination and Conditioning: Seed viability fluctuates greatly, depending on climatic conditions, burn management and collection site. Over a period of four years, FLPMC has conducted laboratory germination tests on a large number of lopsided indiangrass accessions collected from native stands. Germination rates have varied from 0% to 59%. Results from seed dormancy testing on one accession showed that up to 75% of the seed was viable. However, because of unknown dormancy mechanisms, only 38 - 59% of this seed would germinate under ideal conditions.

Prechilling is one method which has been used effectively to break dormancy and increase seed germination in yellow indiangrass (*Sorghastrum nutans*). Fulbright (1988) reported that in one study, highest germination of unchilled seeds occurred between 12 and 15° C, while highest germination of prechilled seeds occurred at 20 to 30° C. Whether Florida accessions of lopsided indiangrass would perform similarly is unknown.

It appears that lopsided indiangrass seed has a relatively short shelf life. Based on germination tests at the FLPMC, seed remained viable for two to three years, under ideal conditions (45% humidity, 45-55° F). Randomly conducted germination tests on several accessions showed percent germination remained the same or decreased slightly after the second year. By the third year it had dropped sharply, and was 0% after four years.

Lopsided indiangrass spikelets can be debearded using a hammermill or a debearder. An air-screen cleaner can be used to separate seed from chaff. The seed can be separated from the hull using the hammermill. However, this process damages a portion of the seed and may not be necessary, depending on planting method to be employed. Results from studies on yellow indiangrass showed that removing the hull increased germination in the laboratory. However, germination in the field decreased, possibly because of damage to the seed and increased vulnerability to microbe attack (Geng and Barnett, 1969).

Propagation by Seed: Lopsided indiangrass has been successfully established by direct seeding, at a variety of sites throughout Florida (Penfield, 1994; Tanner and Terry, 1984). The FLPMC successfully established this species on both sand tailing and overburden reclaimed mined land sites near Bartow. Mechanically broadcasting and drilling debearded seed were both effective seedling establishment methods (see Appendix A).

Lopsided indiangrass appears to be capable of germinating throughout the year, as long as adequate moisture is available. Although this species has more seedling vigor than many native upland species, seedling establishment is severely inhibited by aggressive weedy species of grasses and legumes. Introduced pasture grasses will also out-compete indiangrass.

Rafii and Barnett (1970) found that percent germination and, to a lesser extent, seed weight, had a significant impact on seedling establishment of yellow indiangrass. Good quality seed with a high viability is critical for successful stand establishment (Callahan and Cates, 1991).

Cultural management: A growing season fire appears to stimulate seed production and viability in the following 2 to 3 years. However, Sievers (1985) reported that

burning every other year and continuous grazing of native rangeland decreased lopsided indiangrass populations. It was recommended that native stands should not be burned more than every three years, to maintain or increase indiangrass populations.

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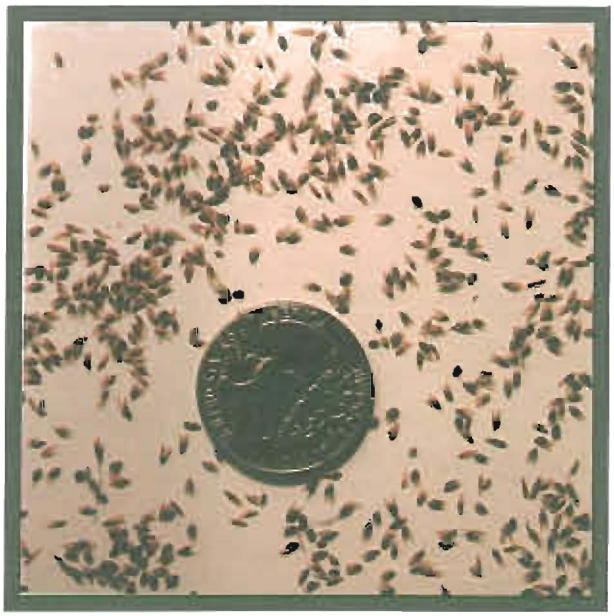
Pinewoods Dropseed

Sporobolus junceus (Beauv.) Kunth

Description and Growth Characteristics: Cool season perennial bunchgrass. **Leaf blades** are very narrow (less than 1/16 inch) and rolled inward when dry (wire-like), 8 to 15 inches long. Closely resembles wiregrass. Vegetative growth begins late winter. **Seed stalks** are 24 to 36 inches tall. **Seed head** is an open panicle, 4 to 6 inches long, with branches in regular whirls around the stem, bronze or purplish in color. Seed heads appear in March and April, ripen April through May. Seed gradually ripens from the top of the seedhead down, making timing of collection difficult.



Habitat: Adapted to flatwoods and longleaf pine-turkey oak sandhills.

Uses: Pinewoods dropseed fills the same role as wiregrass in pineland habitats. However, this species has a shorter, more compact growth habit than wiregrass, so that total contribution of biomass (for fuel or cover) is relatively small in comparison. Deer and livestock graze this species mostly in the early spring. Pinewoods dropseed is somewhat shade tolerant.

Seed Collection: Ripe seed is round or oblong, flattened, approximately 1/16 inch long and wide. Seed is loosely held in papery bracts. Under cultivation, this species could be harvested with a conventional combine, if seed stalks are not too short.

Seed Germination and Conditioning: Laboratory germination tests conducted at the FLPMC on three Florida accessions, found germination rates of 67 - 72%. Harvesting seed before ripe dramatically reduces germination rates.
Chaff can be removed from seed using an air-screen cleaner.

Propagation by Seed: Pinewoods dropseed is a very good candidate for direct seeding. It is a prolific seed producer and can be seeded with a conventional drill. Seed appears to germinate readily in bare mineral soils, and colonize disturbed areas.

Cultural Management: The effect of fire on seed production and viability is unknown. However, fire is not necessary to induce flowering.

Purpletop

Tridens flavus (L.) A.S. Hitchc.

Other Common Names: Greasegrass

Description and Growth Characteristics: Warm season perennial bunchgrass. **Leaf blades** are flat, 1/2 inch wide, 10 to 30 inches long, glossy green in color. Vegetative growth begins early spring. **Seed stalks** 3 to 5 feet tall. **Seedhead** is an open panicle, 8 to 14 inches long, in a pyramid shape, purple to nearly black in color. A distinctive oily or grease-like substance covers branchlets. Seedheads appear in August and September, and ripen in October through November. The collection window lasts several weeks.

Habitat: Adapted to pine flatwoods, and open grassy pine-oak-hickory woodlands.

Uses: Purpletop is grazed by livestock. It also provides wildlife cover, and seeds are eaten by birds.

Seed Collection: Ripe seed is oblong 1/16 inch long, less than 1/16 inch wide. Seed is contained within a papery hull. Under cultivation, conventional equipment could be used to harvest this species.

Seed Germination and Conditioning: Laboratory germination tests conducted by the FLPMC on several Florida accessions, found germination rates to be 17 to 84%. Harvesting seed too early reduced percent germination. Greenhouse germination tests revealed germination rates of 8 to 75%. A healthy stand of purpletop, harvested at the correct time generally has very high seed viability.

Smut was observed on purpletop accessions at the Quicksand, KY PMC (personal correspondence with KY PMC

personnel). The effect of this fungus on seed production was not known.

Seed can be separated from chaff using an air-screen cleaner.

Propagation by Seed: Purpletop is a good candidate for direct seeding, as the seed is adaptable to conventional equipment. However, site adaptation range and stand persistence in Florida have yet to be researched. When using northern accessions, it is recommended that seed hulls be removed or seed be prechilled to obtain germination the first year after planting (Rose Lake PMC, 1993). Since Florida accessions evolved under a different climate, this may not be necessary.

Recommended seeding rates for northern accessions are 2 to 3 lbs. pure live seed/ac when drilling on favorable sites. Recommended planting depth is 1/4 inch.

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Rose Lake PMC. 1993. Native Plant Propagation Techniques For National Parks, *Ed.* Ellen Link. East Lansing, MI.

Eastern Gamagrass

Tripsacum dactyloides (L.) L.

Description and Growth Characteristics: Robust warm season rhizomatous perennial grass. **Leaf blades** can range in width from 3/8 inch to more than 1 inch, with a pronounced midrib. Blades are 12 to 24 inches long or longer. Vegetative growth begins in the spring, and a large quantity of forage is produced throughout the growing season. **Seed stalks** are 3 to 6 feet or taller. **Seed heads** are 6 to 10 inches long, composed of 1 to 3 (or more) jointed racemes. The seed develops on the lower 1/4 of the spikelet, which is the female (pistillate) portion of the flower. The upper 3/4 of the spikelet is the male (staminate)

portion of the flower. Seed is produced June through September and gradually ripens from the top of the seed head down. Once seed is ripe, it drops off of the spikelet very quickly. These factors combine to make collection of viable seed in adequate quantities very difficult.

Habitat: Adapted to fertile soils in wet pine flatwoods and prairies. Often found in solid stands.

Uses: Eastern gamagrass produces a tremendous amount of good quality forage, which is very palatable to livestock and wildlife. However, the growing point is elevated several inches above the soil surface, causing this species to decrease quickly if overgrazed. Gamagrass also provides food and cover for wildlife.

Seed Collection: Ripe seed is contained within a smooth hard tubular fruit case, bronze in color, approximately 3/8 inch long and 1/4 inch wide. In large stands, seed can be harvested with a conventional combine. However, since seed generally does not ripen at the same time along the seed head, a

portion of the seed collected mechanically will not be viable.

Seed Germination and Conditioning: Laboratory germination tests conducted at the FLPMC on several Florida accessions, found germination rates of 0 to 30%. Seed from midwestern and northeastern cultivars has been found to have high levels of dormancy (Ahring and Frank, 1968). Chilling seed in a moist substrate prior to planting was found to significantly increase germination in these cultivars (Hardin, 1994). However, Dewald (1993) reported that dormancy was low in southern ecotypes. Good seed can be separated from empty fruit cases using cleaning equipment which employs air separation.

Propagation by Seed: Eastern gamagrass can be direct seeded using conventional equipment such as a grain drill or a corn planter. Seed may need to be separated by size classes to avoid metering problems and extensive skips when using a corn planter (Dickerson *et al.*, 1993).

Successful plantings were obtained in the midwest using a seeding rate of 10 pounds of good seed per acre. Good seed was considered to contain approximately 6000 seed units per pound. Higher seeding rates (12-15 lb/ac) were necessary if seed units per pound were greater than 6000. (Dewald, 1993). Recommended row spacing is 40 to 48" and planting depth is 1 to 1-1/2 inches. Fall plantings produced the greatest establishment success in northern ecotypes, because of natural cold stratification. However, this may not be true when dealing with Florida native ecotypes.

Cultural Management: The effect of fire on seed production and viability is unknown. However, fire is not necessary to induce flowering.

Eastern gamagrass responds positively to fertilization in terms of forage production (Kalmbacher *et al.*, 1989) and seed production (Hardin, 1994).

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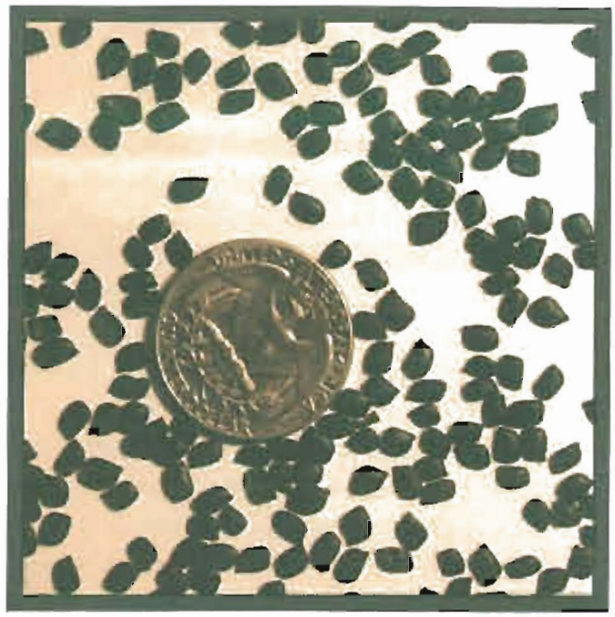
Partridge pea

Chamaecrista fasciculata (Michx.) Greene [or *Cassia fasciculata* (Michx.) and *Cassia chamaecrista* L.]



Description and Growth Characteristics: Warm season annual legume. Feather-like **leaves** composed of many leaflets. Much branching stems. Bright yellow pea-like **flowers**. Seed are contained in a pod. Seedlings generally emerge in the spring and summer. Flowering occurs throughout the summer and fall, with the largest percentage of seed becoming ripe in September and October. Seed is rapidly ejected from seed pods when they split open, shortly after becoming ripe. The collection window lasts several weeks due to uneven ripening.

Habitat: Dry sandy sites and open disturbed areas.

Uses: Partridge pea seed is an important source of food for many species of wildlife. The foliage is preferentially grazed by livestock and deer. Being a legume, it provides a sustainable source of nitrogen to native systems. In a greenhouse study, partridge pea grown in pots with pearl millet contributed 34% of the nitrogen found in the millet. Under this treatment, the dry matter production of the millet was similar to that of millet fertilized with 112 kg N/ha (Redmon *et al.*, 1995).

Seed Collection: Ripe seeds are smooth, squarish in shape (approximately 1/8 inch wide and long) and flattened. Under cultivation, partridge pea can be harvested using conventional harvesters.

Seed Germination and Conditioning: In laboratory and greenhouse germination tests

conducted at FLPMC, germination rates four months after collection averaged 50%. Germination rates of the same accessions nine months after collection were 10%. Apparently seed coat hardening limits germination of stored seed. Seed must be scarified prior to planting to obtain maximum germination. Everitt and Heizer (1984) found optimum germination (>56%) occurred at alternating temperatures of 15-25° C, and that light was not required for germination.

Seed can be separated from pods using a hammermill and air-screen cleaner. Seed storage life is not known, however, seed is thought to remain viable for several years due to the hard seed coat.

Propagation by Seed: Seed can be readily planted using a conventional drill. Seed should be inoculated with the appropriate *Rhizobium* bacteria to insure proper nitrogen fixation. Recommended seeding rates are 7-8 lb/ac when drilling. Optimum time to plant is mid February through March (Ball *et al.*, 1991).

Literature Cited

Ball, D.M., C.S. Hoveland, and G.D. Lacefield. 1991. Southern Forages. Potash & Phosphate Institute. Norcross, GA.

Everitt, J.H. and R.B. Heizer. 1984. Seed germination characteristics of maximilian sunflower (*Helianthus maximiliani*) and partridge pea (*Cassia fasciculata*). J. Rio Grande Valley Hort. Soc. 37:49-54.

Redmon, L.A., F.M. Rouquette, Jr., G.R. Smith, and J.W. Stuth. 1995. Nitrogen transfer from warm-season annual legumes to pearl millet. J. Plant Nutrition. 18(4):803-813.

Blazing Star

Liatris tenuifolia
Nutt.

Other Common Names: Gayfeather; Button Snakeroot

Growth Characteristics: A hardy perennial herb. One to several long upright spikes (1 to 3 feet) arise from a tuber (woody corm). Stems that have been damaged or grazed may produce multiple spikes. **Leaves** are alternate, gradually decreasing in length from the base of the stem to the inflorescence. Many rose-red or purple colored **flowers** are produced on the spikes September through November. Seeds mature from the top down in October through

December, and can be harvested after seed heads appear dry and fluffy. The collection window lasts several weeks because of uneven ripening.

Habitat: Pinelands, dry clearings and flatwoods throughout Florida.

Uses: Livestock and wildlife graze the spring and early summer growth of blazing star. The flowers appear to be attractive to bees, butterflies and other insects.

Seed Collection: Ripe seed have long (approximately 1/4 inch) narrow achenes (hulls), ridged and dark brown to black in color. A tuft of bristles (1/4 inch or more) are attached to the upper end of the achene. A Flail-Vac Seed Stripper was used very effectively by the FLPMC to harvest a native field containing *Liatris tenuifolia*. The Manhattan, Kansas PMC used a Flail-Vac, and also a conventional combine to harvest *Liatris* species, both with good success (personal correspondence with KS PMC).

Seed Germination: FLPMC laboratory germination tests on *Liatris tenuifolia*, resulted in germination rates of 8% to 63%. Collecting seed before it was completely ripe severely lowered germination rates. Salac and associates (1978) reported that optimum temperature for germination of *Liatris punctata* seed collected in Nebraska was 26° C. Research results from studies on *Liatris* species collected from Georgia and Nebraska showed germination was highest when seed underwent cold stratification (Baskin and Baskin, 1989; Salac and Hesse, 1975). Salac and Hesse also studied length of seed viability, and found that the viability of seed stored at room temperature for 2.5 years was 74%, at 3.5 years 53%, and by 4.5 years it was 0%.

Seed Conditioning: A hammermill or debearder can be used to debeard seed. Chaff can be separated from seed using an air-screen cleaner.

Propagation By Seed: In direct seeding studies at the FLPMC, *Liatris tenuifolia* was successfully established by broadcasting seed on a clean seedbed in January. Seed planted in February had very sparse emergence. Seed planted after February did not germinate although germination tests confirmed that seed was still viable. Therefore, Florida accessions of this species may require a cold stratification period for successful emergence. The Kansas PMC reported similar results with direct seeded plantings of *Liatris punctata*. Early April, early May, and late October plantings all failed. A successful planting was achieved in early December (unpublished data from KS PMC). Weed competition appeared to be the greatest hindrance to attaining a successful stand, and the December planting appeared to provide the seedlings time to get established before weed competition became severe. They reported that the most successful, efficient method of establishing seed increase fields was to transplant seedlings started in the greenhouse. In greenhouse tests, *Liatris squarrosa* seedlings did not flower the first year. Only 50% flowered the second year, and all flowered the third year (Baskin and Baskin, 1989).

Literature Cited

Baskin, J.M. and C.C. Baskin. 1989. Ecophysiology of seed germination and flowering in *Liatris squarrosa*. Bull. Torrey Botanical Club. 116(1): 45-51.

Salac, S.S., P.M. Jensen, J.A. Dickerson and R.W. Gray Jr. 1978 Wildflowers for Nebraska Landscapes, Lincoln, NE: The Agricultural Experiment Station, University of Nebraska - Lincoln, 28 pp.

Salac, S.S. and M.C. Hesse. 1975. Effects of storage and germination conditions on the germination of four species of wild flowers. J. Amer. Soc. Hort. Sci. 100(4):359-361.

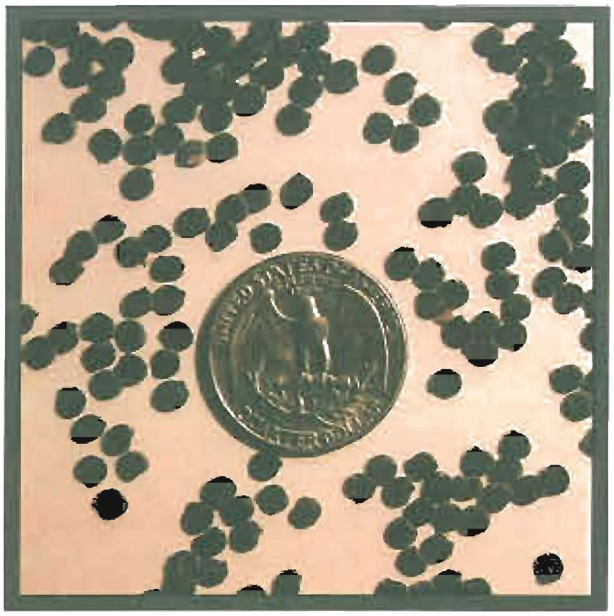
Lupine

Lupinus diffusus Nutt.

Description and Growth Characteristics: Cool season perennial legume. **Leaves** are oval or elliptic in shape, hairy, branching off of woody stems. **Flowers** pea-shaped, of varying shades of blue with white upper petals. Vegetative growth begins in the winter. Flowering occurs in March. Seed is contained in hairy pods, which split open upon ripening in May. Timing of collection is critical, as seed will be lost once pods split open. However, the collection window lasts for several weeks, as seed pods ripen unevenly on the plant and in the plant community.

Habitat: Adapted to pinelands and long leaf pine-turkey oak sandhills.

Uses: Being a legume, lupines provide a sustainable source of nitrogen to native systems. The seed are eaten by some wildlife species.



Seed Collection: Ripe seed are smooth, round and flattened in shape, approximately 1/8 inch in diameter. Under cultivation lupine seed can be collected with conventional harvesters.

Seed Germination and Conditioning: Fresh lupine seed appears to germinate readily. However, a portion of stored seed becomes dormant and must be soaked in hot water or scarified prior to planting to increase germination (Rose Lake PMC, 1993). Seed storage life is thought to be fairly long due to the hard seed coat.

Seed can be removed from pods using a hammermill and air-screen cleaner.

Propagation by Seed: Lupine seed can be readily planted with conventional equipment. Seed should be inoculated with the appropriate *Rhizobium* bacteria to insure proper nitrogen fixation.

Cultural Management: The effect of fire on seed production and viability is unknown. However, fire in not necessary to induce flowering.

Literature Cited

Rose Lake PMC. 1993. Native Plant Propagation Techniques For National Parks, *Ed.* Ellen Link. East Lansing, MI.

Grassleaf Goldenaster

Pityopsis graminifolia (Michx.) Nutt.

Description and Growth Characteristics: Hardy perennial herb, up to 3 feet tall. Multi-branching stems with silvery colored narrow **leaves**, covered with silky hairs. Many yellow **flowers** are generally produced in the fall. Flowering, seed development and disbursal occur simultaneously upon the same plant for several weeks, making timing of collection difficult. Seed is readily disbursed by wind once it is ripe.

Habitat: Pinelands and sandhills.

Uses: Provides food for wildlife and is grazed by livestock.

Seed Collection: Ripe seed is long and narrow in shape (approximately 1/8 inch long and less than 1/32 inch wide). A tuft of bristles (3/8 inch) are attached to the upper end of the seed. Because seed is very light, and easily dispersed by moving air, specialized harvesters which contain a vacuum system must be used for mechanical collection.

Seed Germination and Conditioning: Laboratory germination tests conducted by the FLPMC on several Florida accessions found germination rates to be 1 to 30%. Greenhouse germination tests revealed germination rates to be 5 to 16%.

Bristles can be partially removed using a hammermill or debearder, and an air-screen cleaner. It is very difficult to obtain 100% clean seed.

Propagation by Seed: Cleaned seed may be broadcast or drilled in a mixture with other larger seeded species.

Seed Collection Tables

Table 1. Seed collection and conditioning information for grasses and sedges.

Scientific Name	Common Name	Collection Location and Date	Mec. Coll.	100 Seed Wt. (g)	Seed Conditioning
GRASSES					
Andropogon arctatus	pinewoods bluestem	(C)11/17	FV	0.17	
A. capillipes	chalky bluestem	(FL)11/8-12/7	FV	0.05	
A. ternarius	splitbeard bluestem	(C)7/3		0.17	
A. virginicus var. *glaucopsis*	purple bluestem	(C)12/7	FV	0.03	
Aristida stricta	wiregrass	(C)11/15-12/7	FV	0.07 0.10*	Hammermill or Debearder, Clipper, Aspirator.
Chasmanthium sessiliflorum	longleaf uniola	(C)12/3		0.16	
Ctenium aromaticum	toothache grass	(C)11/10 - 12/6	FV	0.11	
Erianthus giganteus	plumegrass	(C)11/27			
Muhlenbergia capillaris	hairawn muhly	(C)10/30		0.018	
Panicum anceps	beaked panicum	(C)8/20-11/18		0.035	Hammermill, Clipper, Aspirator.
Panicum virgatum	switchgrass	(C)8/20-11/24	C	0.16	Hammermill, Clipper, Aspirator.
Schizachyrium scoparium	little bluestem	(C)11/17-12/27	FV	0.06	
Schizachyrium stoloniferum	creeping bluestem	(C)11/15	FV		
Sorghastrum secundum	lopsided indiangrass	(FL)9/30-10/30	FV	0.25 0.14 - 0.18*	Hammermill or Debearder, Clipper, Aspirator.
Sporobolus junceus	pineywoods dropseed	(C)4/9-6/1		0.04	Hand cleaned-2 screens, Aspirator.
Stipa avenacea	blackseed needlegrass	(C)5/1-5/15			Could not clean or deawn, seed too brittle.
Tridens flavus	purpletop	(C)9/30-11/22		0.1	Hand cleaned-2 screen, Aspirator.
Tripsacum dactyloides	eastern gamagrass	(C)5/31-10/13		5 - 9	Hand cleaned-1 screen.
SEDGES/RUSHES					
Rhynchospora megalocarpa	sandyfield beaksedge	(C)5/30-9/30			
Xyris fimbriata	yelloweyed grass	(C)5/8-12/7			Hand cleaned-1 screen.

Collection Date - Region and date seed collected. N=north of Ocala; C=Ocala south to Okeechobee; FL=state wide collection with collection dates being fairly uniform across the state.
Mechanical Collection - Flail-Vac Seed Stripper (FV) or conventional combine (C) used for harvest.
Weight of 100 Seed (grams) -"*" designates conditioned seed weight, all others unconditioned. (a)(Rose Lake PMC. 1993. Native Plant Prop. Tech. For Nat. Parks. Ed. E. Link. East Lansing, MI.).
Seed Conditioning - Seed cleaning equipment at PMC: Two h.p. variable speed Viking brand hammermill debeards, separates seeds from hulls. Clipper brand Debearder processes large lots of seed. Clipper brand 2 screen cleaner with bottom air separates chaff and seed by weight and size. Small lots were cleaned using small hand-held screens. Bates Laboratory brand Aspirator separates seed and chaff by weight.

Table 2. Seed collection and conditioning information for forbs and shrubs.

Scientific Name	Common Name	Collection Location and Date	Mec. Coll.	100 Seed Wt. (g)	Seed Conditioning
FORBS					
Carphephorus corymbosus		(C)11/16-11/27		0.15	
Carphephorus odoratissimus	vanilla plant	(C)12/7			
Chamaecrista fasciculata	partridge pea	(C)9/25-11/3		1.00*	Hammermill, hand cleaned-2 screens.
Chamaecrista nictitans	wild sensitive plant	(C)10/15			Hammermill, hand cleaned-2 screens.
Crotalaria lanceolata	lanceleaf rattlebox	(C)9/17-11/23			Hammermill, hand cleaned-2 screens.
Dalea carnea		(C)7/28			
Desmodium spp.	beggarweed	(C)9/17-10/23			
Garberia heterophylla	garberia	(C)3/6			
Helianthus angustifolius	swamp sunflower	(C)10/19-11/11			
Helianthus radula	rayless sunflower	(C)11/16			
Liatris elegans	gayfeather	(C)11/16		0.24	
Liatris garberi	gayfeather	(C)9/13-12/11			
Liatris tenuifolia	gayfeather	(C)11/16-12/4	FV	0.16	
Lupinus diffusus	sky-blue lupine	(C)5/22			Hammermill, hand cleaned-2 screens.
Pityopsis graminifolia	grassleaf goldenaster	(C)11/16-12/4		0.04 - 0.12	
Sabatia brevifolia	narrow-leaved sabatia	(C)10/6			
SHRUBS					
Callicarpa americana	American beautyberry	(C)8/20-11/24		0.35 (a)	Depulp with blender, rinse with water, and dry.
Licania michauxii	gopher apple	(C)8/10-9/9			Rub decayed fruit on screen to depulp, rinse under running water.
Rhus copallinum	winged sumac	(C)8/30-12/22		0.8 (a)	Depulp with blender, rinse with water, and dry.
Sambucus canadensis	elderberry	(C)6/19-10/2		0.19 (a)	Same as above.

See Table 1 for explanation of information and symbols.

Seed Evaluation Tables

Table 3. Laboratory, greenhouse and field seed test results for grasses and sedges.

Scientific Name	Lab Germ (%)	Greenhouse Germ (%)	Field Test (# Acc.)				Mech. Direct Seed	Production Fields PMC
				Mined Land				
			PMC	C	O	ST		
GRASSES								
Andropogon arctatus	14	52			1s	1s		1 acc.
A. capillipes	41	58			1*	1*		
A. ternarius	28							
A. virginicus var. *glaucopsis*	21	58			1*	1*		
Aristida stricta	0 - 48	32	1s		2s	2*	Y	2 acc.
Chasmanthium sessiliflorum	18							
Ctenium aromaticum	13	8	1*		1*	1*		
Erianthus giganteus	2							
Muhlenbergia capillaris								1 acc.
Panicum anceps		> 1	8u	8u				7 acc.
Panicum virgatum	0 - 56		4u	4u				2 acc.
Schizachyrium scoparium	1	4						1 acc.
Schizachyrium stoloniferum								5 acc.
Sorghastrum secundum	12 - 35		15u, 2s	15u,	4s	4s	Y	1 acc.
Sporobolus junceus	67 - 72							
Stipa avenacea	1							
Tridens flavus	17 - 84	8 - 75	5u	5u	2*	2*		3 acc.
Tripsacum dactyloides	0 - 32		38u	38u				1 acc.
SEDGES/RUSHES								
Rhynchospora megalocarpa		0	1u	1u				
Xyris fimbriata	0		6u	1u				

Lab germination (%) - The percent seed that germinated in the laboratory germinator. Expressed as a single number or a range, depending on how many accessions were tested.

Greenhouse germination (%) - The percent seed that germinated in potting soil in the greenhouse. If an actual seed count was not made at the time of planting, then percent germination is expressed as > 1 if any seed germinated and 0 if none did.

Field Test Plantings at the PMC - Number of accessions that successfully germinated (s) or did not germinate(u) when direct seeded. Unsuccessful plantings were primarily due to low seed viability, poor seedling vigor, and weed competition.

Field Test Plantings on reclaimed mined land sites - Number of accessions that did or did not successfully germinate on clay (C), overburden (O) or sand tailing (ST) mined land soils. An (*) indicates that evaluation data was not available at the time of printing. Unsuccessful plantings were primarily due to low seed viability, poor seedling vigor, and weed competition.

Mechanically direct seeded - By broadcasting, drilling and/or with plug mix planter.

Production Fields at PMC - Indicates number of accessions which have been planted to increase seed and study cultural management practices.

Table 4. Laboratory, greenhouse and field seed test results for forbs and shrubs.

Scientific Name	Lab Germ (%)	Greenhouse Germ (%)	Field Test (# Acc.)				Mech. Direct Seed	Production Fields PMC
				Mined Land				
			PMC	C	O	ST		
FORBS								
Carphephorus corymbosus	15	2			1*	1*		
Carphephorus odoratissimus		*						
Chamaecrista fasciculata	10 - 22	48 - 57	15s	14s	1s	1s	Y	1 acc.
Chamaecrista nictitans			1s					
Crotalaria lanceolata			14s	14s				
Dalea carnea			1u	1u				
Desmodium spp.		> 1	25u	25u				
Garberia heterophylla	24		1u	1u				
Helianthus angustifolius	19		3u	3u				
Helianthus radula		> 1	1u	1u				
Liatris elegans	20	40			1*	1*		
Liatris garberi	8	> 1	11u	11u				
Liatris tenuifolia	8 - 60	2 - 55			1*	1*		
Lupinus diffusus	*							
Pityopsis graminifolia	1 - 30	5 - 16	4u	4u	2*	2*		
Sabatia brevifolia			1u	1u				
SHRUBS								
Callicarpa americana	3	> 1	14u	14u				
Licania michauxii		> 1						
Rhus copallinum	0	> 1	11u	11u				
Sambucus canadensis	0		50u	50u				

See Table 3 for explanation of information and symbols.

Appendix A

Native Upland Grass Seeding Methodology Trials

USDA NRCS Plant Materials Center
Brooksville, Florida

Introduction

The phosphate mining industry in Central Florida desires the ability to reintroduce indigenous vegetation on reclaimed mined lands. Due to the large scale of reclamation efforts, a mechanical means of direct seeding native materials is sought. Revegetation through traditional mechanical seeding methods is often difficult or impossible. Low germination, seed dormancy, small seed size and weight, awns and seed pubescence are factors which must be overcome to obtain successful plantings. The purpose of this study was to compare mechanical methods of planting two native warm season grass species, lopsided indiangrass (*Sorghastrum secundum*) and wiregrass (*Aristida stricta*) on reclaimed mined lands.

Literature Review

Only recently, has there been a concerted effort in Florida to find practical, economical methods to seed native upland species. Therefore, the volume of published works pertaining to wiregrass and lopsided indiangrass is small. In an early study, several native forage grasses, including lopsided indiangrass, were successfully established by broadcasting seed with a hand seeder, and then lightly disking or roller chopping plots to incorporate seed (Tanner and Terry, 1984). More recently, lopsided indiangrass was successfully established by hand broadcasting on a flatwoods range site which had been double roller chopped in July and August (Penfield, 1994).

Many forest, park and nature preserve personnel in Florida have been attempting to direct seed wiregrass. Results have varied and not all efforts have been successful (Seamon and Myers, 1992). In South Carolina, wiregrass was successfully established on dry sandy forest sites by broadcasting seed and covering with soil or pine needle litter (Outcalt, 1994). Lopsided indiangrass and wiregrass seedlings are not overly competitive or vigorous compared to introduced species, and stands are slow to establish.

Reclaimed mined lands in the eastern and western USA have different soils, climate and species compared to those found in Florida. However, reclamation research has been conducted on these mined lands for several decades, and many of the general principles evolving from this work can be applied to reclamation efforts in Florida. Season of seeding (timing), seeding rate and seeding method are three factors which must be considered when seeding upland species (Lohmiller, Dollhopf and Martinson, 1990). In arid western states, seedings are more successful if planted just prior to periods of most dependable precipitation. Recommended seeding rate varies, depending on the species and site. Most researchers in mine reclamation recommend an average rate of 20 pure live seeds per square foot on favorable sites (Thornburg, 1982). Seeding rate should be increased for unfavorable sites. An inverse relationship exits between seeding rate and seedling mortality. Although higher seeding rates initially provide higher plant densities, increased seedling mortality, due to increased competition between plants, does not justify the added expense.

Broadcasting and drilling are the two primary methods which have been used for seeding native grasses. Drilling has been proven to provide more uniform distribution and placement of seed, thus, is the most desirable method to use on favorable sites (Thornburg, 1982). An ordinary grain drill will not properly dispense the light, fluffy seed of many of the native species. However, due to renewed interest in planting native species in the Midwest, specialized equipment has been developed for processing and planting chaffy grass seed (Dewald, Berg, and Sims, 1985).

Proper seeding depth is critical for successful establishment. The general recommendation for proper seeding depth is 1/4" for small seed, 1/2" for medium size seed, and 1" for large seed. Medium and large seed may be planted 1/2" deeper in sandy soils (Lohmiller, Dollhopf and Martinson, 1990). Broadcasting seed does not provide as accurate placement of seed as drilling, but still provides satisfactory stands, especially in rough terrain where drilling is not possible. Although depth can not be regulated, broadcasting is more useful for planting mixes which have seeds of varying sizes, and native grasses with fluffy seed, which will not feed through an ordinary drill. Best results are obtained when the seedbed is bare mineral soil and the field is lightly disked or packed after seed is broadcast. It is generally recommended that seeding rates be doubled when broadcasting.

A third seeding method which was considered in this study, is plug mix seeding. This technique was developed for seeding small seeded vegetable crops such as tomatoes and peppers. Seed is mixed with potting mix and a "plug" is placed in the soil using a plug mix planter (Hayslip, 1973). The advantage of this method is that seeds are provided with a richer growing medium than mineral soil, without the labor and expense of growing seedlings in a greenhouse. Early research results showed this method provided quicker maturing, more uniform plants with better stands than direct seeding. Fluffy native grass seed is adaptable to this method. Equipment is available for this practice in Florida, however there is no indication it has been used for planting any crop other than vegetables.

Another practice which may enhance seeding success is mulching. Mulching after seeding is expensive, but may encourage seedling establishment by conserving moisture, decreasing soil crusting, soil temperature and erosion. In studies conducted on reclaimed mined lands in western states, mulching was shown to be beneficial for areas receiving ten to eighteen inches annual precipitation. In areas that received less than ten inches, results were mixed. No benefit was found in areas that received more than twenty inches of annual precipitation (Cook, Hyde and Sims, 1974). Results from mined land reclamation studies in Kentucky showed that there was no difference in plant density on mulched and unmulched plots after three years (Kuenstler, Sanders and Henry, 1980), although mulched plots initially had higher plant densities.

Materials and Methods

Lopsided Indiangrass

Lopsided indiangrass was collected from the Avon Park Air Force Range near Avon Park, Florida in the fall of 1993 and 1994, using a Flail-Vac Seed Stripper. Seed was debearded and cleaned, and germination tests were conducted to determine percent pure live seed. The number of seeds per pound was determined to be 317,800 (approx. 700 seeds per gram).

Field plantings of lopsided indiangrass were established on two sites. The first site was at the Fort Green mine on IMC-Agrico reclaimed mined lands, approximately 30 miles southwest of Bartow, Florida. Soils consisted of overburden capped sand tailings. Overburden is the stockpiled surface layer. Sand tailings from the ore are commonly deposited in the mine pits, and overburden piles are bull-dozed over the top of the sand. Overburden layer thickness varies from a few inches to several feet. Because of a greater clay component than in natural sandy soils, overburden material generally has lower permeability, higher water erosion potential, and is more subject to severe crusting. Conversely, overburden has higher water holding capacity and higher fertility than sand tailings. Since these two soil types co-mingle on the soil surface, soils have very inconsistent texture, fertility and pH. The sand tailings component consists of washed sands which are very low in organic matter and nutrients, and have poor water holding capacity. Wind erosion is usually of greater concern than water erosion on sand tailing sites. The second site was located at Cargill's Hooker's Prairie, approximately 20 miles southwest of Bartow, on sand tailings. Several soil samples were taken at each site, to a 12 inch depth. Samples were analyzed for texture, pH, organic matter, N, P, K, and macro and micronutrients.

At the IMC-Agrico site, 10 by 200 foot (3 by 61 meter) plots were planted just prior to the rainy season, in late May of 1995. At the Cargill sand tailing site, 10 by 100 foot (3 by 31 meter) plots were planted in late June of 1995 in the midst of the rainy season, to ensure maximum precipitation on emerging seedlings. Plots were replicated three times.

Treatments were as follows: All plots were disked or rototilled, and leveled or packed, prior to seeding. In the first treatment, seed was broadcast at a rate of 3 lbs. per acre (approx. 20 seeds per square foot) using a hand-held cyclone seeder, and plots were then packed. In the second treatment, seed was drilled at a rate of 3 lbs. per acre using a double cone seeder. Between row spacing was 18 inches.

The third treatment was planted using a one row plug mix planter, provided by Dr. Lawrance Shaw (Professor of Agricultural Machinery, Agricultural Engineering Dept. at the University of Florida, Gainesville). To test how this implement would handle seeds of different conditioning, two seed treatments were applied with the plug mix planter at the IMC-Agrico site. Debearded seed and seed with beards, which had not undergone any type of cleaning, were each combined with a starter potting mix composed of sphagnum peat moss and vermiculite. Each plug used approximately 1/2 cup potting soil (an application rate of approximately 82 cubic feet per acre). A water absorbent polymer was also added to this mix. Seed and potting mix were combined in a cement mixer and allowed to mix thoroughly, according to the procedure reported by Hayslip (1973). Seeding rate was reduced to 2 lbs. per acre because of concentration of the seed in the plugs. Within and between row spacing was 18 inches. A 50 foot portion of all treatment plots at the IMC site were mulched with a grass hay at a rate of 2 tons per acre.

At the Cargill site, the broadcast and drilled treatments were the same as those listed above. The plug mix treatments varied in that they were composed of a wet mix and a dry mix. Debearded seed was used in both cases. The dry mix was combined with a water absorbent polymer and debearded seed in the same manner as outlined above. The dry mix treatment required 82 cubic feet of mix per acre. For the wet mix, the volume of starter mix was cut by 40%, and water was added at a rate of 12% by volume, to

determine if it would reduce leakage and spillage from the plug mix planter, thus decreasing the input of potting mix. Between row spacing was 12 inches and within row spacing between plugs was 18 inches. A 50 foot portion of all treatment plots were mulched with wheat straw, at a rate of 2 tons per acre.

Wiregrass

Wiregrass seed was collected from the Avon Park Air Force Range in the fall of 1994. Seed was processed as outlined above for indiangrass. Number of seed per pound was 454,000 (approx. 1000 seeds per gram).

Due to a shortage of seed, wiregrass was planted only at the IMC-Agrico site. Plot size was 10 by 100 feet (3 by 31 meters), with three replications per treatment. Seed was broadcast with a hand held cyclone seeder at a rate of 2 lbs. per acre (approx. 20 seeds per square foot). Plots were packed directly after seeding. Due to problems with clogging, seed was drilled with the cone seeders at an average rate of 1.6 lbs. per acre (approx. 16 seeds per square foot). Between row spacing was 18 inches. A debearded seed and non-debearded seed treatment was applied with the plug mix planter at a rate of 1.5 lbs. per acre. Spacing between rows was 12 inches and 18 inches within rows. Grass hay mulch was applied across 50 feet of all plots directly after planting.

One year after planting, stand counts were made to evaluate establishment success. Three random meter square samples were taken in each plot to determine plant density, size and vigor.

Data were analyzed using the MSTAT - C analysis of variance (MSTAT - C, 1983). Duncan's procedure was used for the mean separation tests.

Results and Discussion

Even though the seed of both species had been debearded, it was still very light and chaffy. The broadcast and plug mix treatments were able to dispense this seed with little problem. However, seed did not feed through the openers of the cone seeder correctly. Clogging and bridging caused skips and uneven application of seed. Seed depth was set for approx. 1/4 inch, but, without depth bands, it was impossible to maintain this depth throughout uneven areas in the plots. This resulted in very uneven stands in the drilled treatments. Adding water to the plug mix did not decrease leakage from the plug mix planter appreciably. Also, the wet mix treatment did not flow through the planter as cleanly as did the dry mix treatment.

Soils analysis results to a 12 inch depth are listed in Table 1. All nutrients were extremely low in both soil types except phosphorous and calcium, which are extremely high. Sodium and aluminum are high. However, this should not adversely affect seedling establishment since calcium levels are high. Organic matter is extremely low. However, the pH range was favorable.

In another study sponsored by FIPR, surface soil textures of overburden capped sand tailings averaged 90, 2, and 7% sand, silt and clay respectively. Surface soil textures of sand tailings alone averaged 95, 1 and 3% sand, silt and clay respectively (unpublished data from FIPR project 90-03-100). Although the overburden soil would normally be classified as a loam or a sandy loam, in reality the sand and clay components are not equally interspersed. Because of this, these soils have a tendency to develop a crust 1 or more inches thick, which is fairly impermeable to water and very difficult for young seedlings to break through. Heavy rains after planting caused

soil to wash over the top of the plugs. Because the plugs extended down 1 to 1 1/2 inches into the soil, small seeded grass species may not have had enough energy to extend through the potting mix and break through the overburden crust. This may explain the lower emergence from the plug mix treatment in the overburden soils.

Lopsided Indiangrass on Overburden Soils

Results from the one year stand density counts are shown in Figure 1. Both soil types provide a very unfavorable environment in which to plant native grass seed. However, even with heavy crusting, the overburden soils produced greater indiangrass stand densities. This is most likely due to more available moisture and nutrients. Despite problems with the drill, this method produced the greatest plant densities on the unmulched overburden soils (27.3 plants/m^2). Plant densities on these same soils for the broadcast treatment were significantly less (10 plants/m^2). As mentioned above, too great a seeding depth, and surface crusting probably decreased indiangrass emergence from both plug mix treatments significantly (4.6 and 2.8 plants/m^2 for debearded and unconditioned seed respectively). It would appear that the plug mix method of direct seeding is not suitable for overburden soils.

According to Cook and his associates (1974), a satisfactory stand is considered to be four plants per square foot (approx. 43 plants/m^2). Although none of the seeding methods met this criteria on the overburden

Table 1. Soil analysis results for reclaimed mined land soils.

	Overburden		Sand Tailings	
Nutrient (ppm)	Average	Range	Average	Range
Nitrate (NO3-N)	1.17	0.54 - 2.13	0.58	0.37 - 0.75
Ammonium (NH4-N)	2.69	0.32 - 7.21	1.19	0.72 -2.24
Phosphorus (P)	1,428.10	287.22 - 2,926.06	2,404.14	1,950.45 - 2,594.99
Potassium (K)	12.33	5.16 - 25.62	5.09	2.99 - 6.70
Calcium (Ca)	3,216.91	803.37 - 6,095.47	4,965.82	640.06 - 5,721.13
Magnesium (Mg)	131.82	70.32 -262.88	40.12	10.11 - 54.26
Iron (Fe)	89.37	41.23 - 133.35	45.69	5.37 - 55.18
Manganese (Mn)	1.07	0.03 - 1.72	4.61	0.56 - 5.87
Boron (B)	0.23	0.09 - 0.44	0.48	0.04 - 0.57
Copper (Cu)	0.30	0.09 - 0.67	0.17	0.12 - 0.29
Zinc (Zn)	0.34	0.20 - 0.51	1.53	0.42 - 1.80
Molybdenum (Mo)	0.01	0.01	0.01	0.01
Sodium (Na)	56.46	38.55 - 83.30	94.27	18.31 - 110.33
Aluminum (Al)	245.73	80.46 - 387.58	89.38	20.32 - 121.78
pH	4.9	4.4 - 5.9	5.8	5.6 - 6.3

soils, some benchmark data was produced, which can be used for estimating seeding rates in future studies. At this standard, the seeding rate of the drill treatment would have to be doubled, and the broadcast treatment quadrupled. This is not unexpected, as it fits with the parameters found in other reclamation reseeding studies mentioned above.

Mulching significantly reduced indiangrass emergence in all treatments on the overburden soils (4.8, 2.9, 1.4 and 1.6 plants/m^2 for broadcast, drilled, debearded plug and unconditioned plug respectively), primarily because of increased competition from weedy species and introduced grasses, especially bahiagrass (*Paspalum notatum*). The overburden research site lay next to a reclaimed area that had been seeded to introduced pasture grasses shortly before the study plots were seeded. A portion of the area staked off for the research sites had been inadvertently seeded with introduced species, however, this was not discovered until after the research plots were established. Although not planned, this did provide an opportunity to observe how well native species compete with introduced pasture grasses. The indiangrass accession used in this study was not able to compete with the more vigorous introduced species. The introduced grasses reduced native seedling emergence in the areas where they were seeded, and were beginning to encroach upon and outcompete the established indiangrass plants for water and nutrients after one year of growth.

Wiregrass on Overburden Soils

In its natural environment in Florida, wiregrass averages five plants per square meter (Clewell, 1989). Satisfactory stands of wiregrass were not established using any of the four seeding methods. Broadcasting produced a plant density of 1 plant/m^2, however, stands of all other treatments were

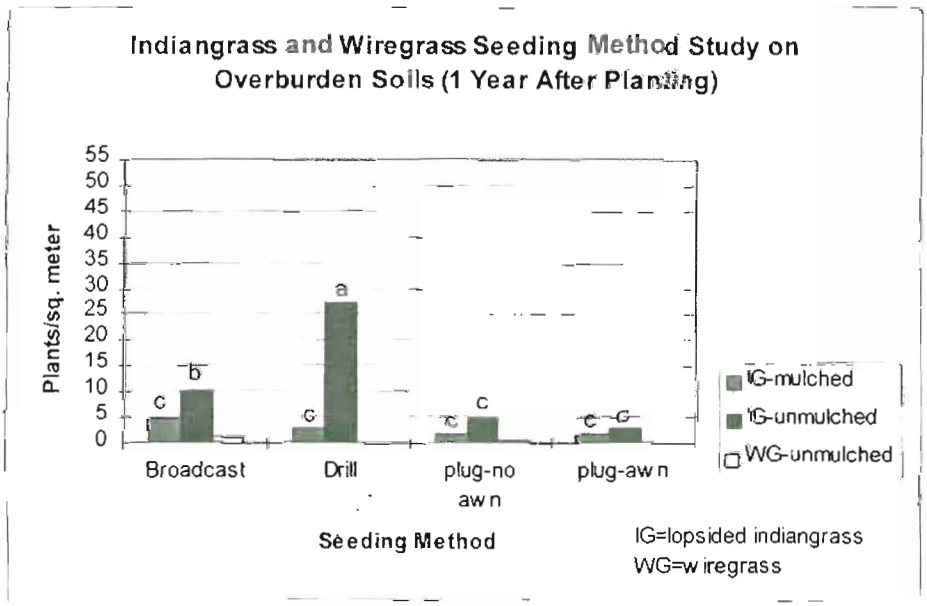


Figure 1. Indiangrass and wiregrass plants per square meter on overburden soils, one year after planting. Densities with the same letter signify no significant difference at $P<0.05$.

so low that this was not statistically significant. The seed lot used in this study was tested before planting, and seeded into trays of potting soil in the greenhouse at the Brooksville PMC shortly after these research plots were seeded, with good emergence. Therefore, seed quality was good. The primary reason for lack of establishment was probably due to heavy competition from the more aggressive introduced grasses. Other possible reasons are season of seeding, and ecotype incompatibility (seed was harvested from a flatwoods site, and planted on a sandhill-type site). Once it emerged at the study site, wiregrass was observed to be very slow to develop a primary root system. This made it very susceptible to drought and competition from weeds. Wiregrass appears to be inhibited from germination and very easily crowded out by weed competition.

The season of seeding may also have a strong influence on wiregrass establishment success, especially as it relates to the soil surface temperature and moisture. Bissett and associates (1996) were able to successfully established wiregrass by broadcasting a native mulch in December of 1994, on an overburden site.

Since broadcasting was also employed in Bissett's study, planting depth may not be as important to establishment success as seeding date. Ecotype compatibility may also be of primary importance, however, more research studies will need to be conducted in this area before any definite conclusions can be drawn.

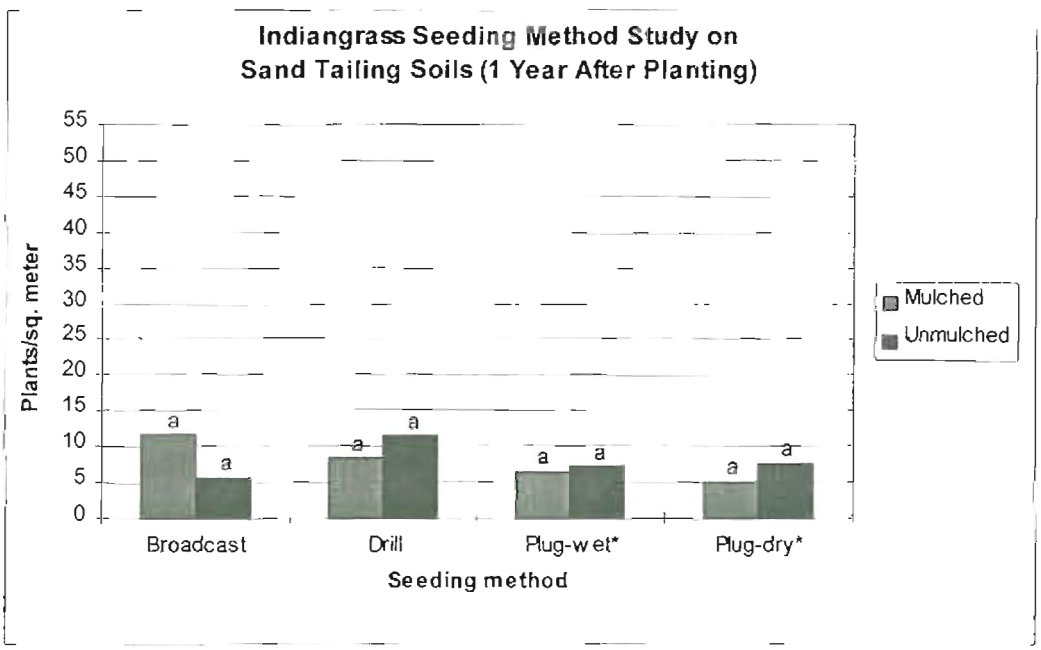


Figure 2. Indiangrass plants per square meter on sand tailing soils, one year after planting. Densities with the same letter signify no significant difference at $P<0.05$.

*Means for plug mix treatments are number of plugs that had germinated, and not number of actual plants. Plugs often contained more than one plant, however the plug area was so small that individual plants were difficult to distinguish.

Lopsided Indiangrass on Sand Tailing Soils

There were no statistically significant differences between any of the plant populations of the different seeding methods on the sand tailing soils. This included mulched and unmulched treatments. (Unmulched plant densities were 5.7, 11.5, 7.2 and 7.5 plants/m^2 for broadcast, drilled, wet plug and dry plug respectively. Mulched plant densities were 11.6, 8.5, 6.3 and 5 plants/m^2 respectively.) As on the overburden site, mulching tended to promote weed growth. The sand tailing site also had a heavy population of introduced pasture grasses. These species competed strongly with the native species for moisture and nutrients, especially under the mulch. Two factors were apparent visually, that are not reflected in plant density counts. First, seedlings in the plug mix treatment were much more healthy, robust and drought resistant than broadcast or drilled populations (many, in fact, were producing seed heads). The plug mix gave seedlings the advantage of increased nutrients and moisture. This may have allowed developing root systems to tap into moisture reserves held in lower soil zones. Unmulched drilled and broadcast populations produced significantly smaller plants. This is reflected in the plant height data listed in Table 2. The mulch did not appear to provide any extra advantage to the plug mix, but, there was a definite advantage to the drilled and broadcast treatments, despite increased weed competition. Unmulched broadcast seedlings especially, lacked vigor and appeared to be suffering from drought stress. Whether this trend will continue remains to be seen. Given two to four more years for establishment of mature plants, there may be no advantage to mulching in the long term. If a plug mix planter capable of seeding large acreages is available, and if it is necessary to quickly establish a native stand, then the extra expense involved with plug mix planting may be justifiable on sand tailing soils. Although weed-free mulch is difficult to obtain in Florida, mulching has potential for enhancing rapid seedling establishment on sand tailing soils. More studies will need to be conducted to determine recommended seeding rates on these soils. Due to their droughty nature, sand tailings may not be able to sustain plant densities found on overburden sites.

Summary

In conclusion, the results of this study showed that lopsided indiangrass has very good potential for being direct seeded on

Table 2. Plant height and plant density for lopsided indiangrass on sand tailing soils, one year after planting.

	Mulched		Unmulched	
Seeding Method	Plant Ht. (cm)	Density (plts./m^2)	Plant Ht. (cm)	Density (plts./m^2)
Broadcast	23.9ab*	11.6a	14.13c	5.7a
Drilled	27.7a	8.5a	19.97b	11.5a
Plug Mix - Dry	28.4a	6.3a	24.10ab	7.2a
Plug Mix - Wet	24.9ab	5.0a	25.73a	7.5a

*Means followed by the same letter are not significantly different at $P<0.05$.

overburden and sand tailing soils. Broadcasting and drilling were both found to have good potential as methods of direct seeding. However, a drill designed to handle light chaffy native seed will need to be used if proper coverage is to be obtained. Based on data gathered from this research, predicted seeding rates for future studies are 40 pure live seed/ft^2 for drill applications and 80 pls/ft^2 for broadcast applications, to obtain adequate indiangrass stands on overburden soils. Wiregrass did not produce adequate stands on the overburden site under any seeding method. This was thought to be due primarily to competition from introduced pasture species, and also timing of seeding. Neither native grass species was capable of competing with weedy and introduced grass species, on either site. Mulching proved detrimental to stand establishment on overburden soils, because of increased weed competition.

Despite increased costs, plug mix planting or mulching may have potential for establishment of lopsided indiangrass on sand tailing soils. However, over the long term, broadcasting and drilling may produce adequate stands on a more economical basis.

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Appendix B

Upland Native Grass and Legume Seed Mix Establishment Trials

USDA NRCS Plant Materials Center
Brooksville, Florida

Introduction

The phosphate mining industry in Central Florida desires to restore reclaimed mined lands to indigenous plant communities, as part of their overall reclamation program. However, soil textures and profiles on these sites have been changed drastically, and nitrogen and organic matter levels are very low. Seeding legumes with native grasses is a sustainable method of providing nitrogen to a reclaimed system. The objective of this research is to study population dynamics of three native grass species, lopsided indiangrass (*Sorghastrum secundum*), wiregrass (*Aristida stricta*), and switchgrass (*Panicum virgatum*), planted in conjunction with the legume species, partridge pea (*Chamaecrista fasciculata*) on reclaimed mined land soils.

Literature Review

Interest in the restoration of native plant communities is relatively recent in Florida, and very little research has been directed towards this subject. In a mined land revegetation study conducted by the Brooksville PMC in 1986, 'Alamo' switchgrass and partridge pea were successfully established on reclaimed mined lands when planted either as a mix or monoculture. Drilling switchgrass at a rate of 5 lbs. pure live seed per acre, and partridge pea at a rate of 4 lbs. per acre (1 lb. switchgrass and 2 lbs. partridge pea for mix) provided an average of four plants per square foot. A broadcast treatment provided adequate stands if the seeding rate was doubled (unpublished data). Four plants per square foot is considered a satisfactory stand on reclaimed mined lands in the western US (Cook, Hyde and Sims, 1974).

Monocultures may be easier to seed and manage than a mixture. However, a diverse plant community has greater stability than a monoculture, and provides a greater spectrum of use. Reclaimed mined land soils are often very low in nitrogen and organic matter. Applying chemical nitrogen to a new seeding often proves detrimental to stand establishment, because of increased weed competition (Thornburg, 1982). Planting a legume/grass mixture provides nitrogen to a system in a more sustainable manner.

Factors which need to be considered when rehabilitating a plant community are: The proposed use and management of the area, plant species present before disturbance, chemical and physical properties of the soil, topography and climate (Ries and DePuit, 1984). The availability of seed and the ability to mechanically distribute it, especially chaffy seed species, influence species selection. Also the short and long term competitive relationships between a variety of species must be considered, and seeding rates adjusted accordingly. Some species may be quicker to establish, and others shorter lived. In general if a mix of grasses and forbs are planted, grass species will eventually dominate a plant community, so a higher ratio of forb species must initially be planted (Lohmiller, Dollhopf and Martinson, 1990).

Materials and Methods

Seed of three native grass species were seeded in monoculture or in combination

with the nitrogen fixing legume, partridge pea. Field trials were established at the IMC-Agrico Fort Green mine on overburden soils, and at Cargill's Hookers Prairie on sand tailing soils, located approximately 30 and 20 miles southwest of Bartow, Florida, respectively. A summary of the soils analysis of these two soil types can be found in the Native Upland Grass Seeding Methodology Trials report (Appendix A), as well as a description of procedures used for collecting and processing wiregrass and lopsided indiangrass seed. 'Alamo' switchgrass and partridge pea seed were obtained from a commercial source. Partridge pea seed was inoculated just prior to seeding. At the IMC-Agrico site, 10 by 200 foot (3 by 61 meter) plots were planted in late May of 1995. At the Cargill site, 20 by 40 foot (6 by 12 meter) plots were planted in late June of 1995. All treatments were replicated three times.

A seedbed was prepared at the IMC-Agrico site by disking and leveling prior to planting. All treatments were drilled using a double cone seeder. Due to the type of drill employed, a between row spacing of 18 inches was used. An approximate rate of 20 seeds per square foot was used for monoculture seedings. Treatments were as follows: 'Alamo' switchgrass (2 lbs./ac.); partridge pea (4 lbs./ac.);'Alamo' switchgrass/partridge pea (2/4 lbs./ac.); lopsided indiangrass/partridge pea (3/4 lbs./ac.); wiregrass/partridge pea (2/4 lbs./ac.); lopsided indiangrass/wiregrass/partridge pea (2.1/0.6/4 lbs./ac.). Partridge pea seeding rate was not changed from monoculture to mixture, so that comparisons could be made between monoculture grass stands and those seeded in a mixture. Due to a shortage of seed, monocultures of indiangrass and wiregrass were not planted. Rather, the drilled indiangrass and wiregrass treatments from the seeding methodology study were used as the standard of comparison. Planting depth was set for 1/4 inch, but this could not always be maintained because of an uneven seedbed and lack of depth bands on the drill.

A seedbed was prepared at the Cargill site by rototilling and packing prior to planting. All treatments were the same as those listed above, except that no wiregrass treatments were included.

One year after planting, stand counts were made to evaluate establishment success. Three random meter square samples were taken in each plot to determine plant density, size and vigor. Data were analyzed using the MSTAT-C analysis of variance (MSTAT-C, 1983). Duncan's procedure was used for the mean separation tests.

Results and Discussion

The cone seeder drill was able to readily distribute switchgrass and partridge pea seed. The light fluffy indiangrass and wiregrass seed, however, often bridged or clogged openers, causing skips and poor distribution in plots. This seed did flow better when mixed with partridge pea seed, probably due to the greater weight of the seed mixture.

Introduced pasture grass species, namely bahiagrass (*Paspalum notatum*), suppressed native seedling emergence, and competed heavily with established native species at both sites. The sand tailing site also produced a heavy stand of hairy indigo (*Indigofera hirsuta*). Weed competition almost completely suppressed seedling emergence on this site, and population densities were too sparse to measure.

One year stand counts at the overburden site are displayed in Figure 1. Switchgrass, indiangrass and partridge pea were all able to emerge, despite heavy weed competition.

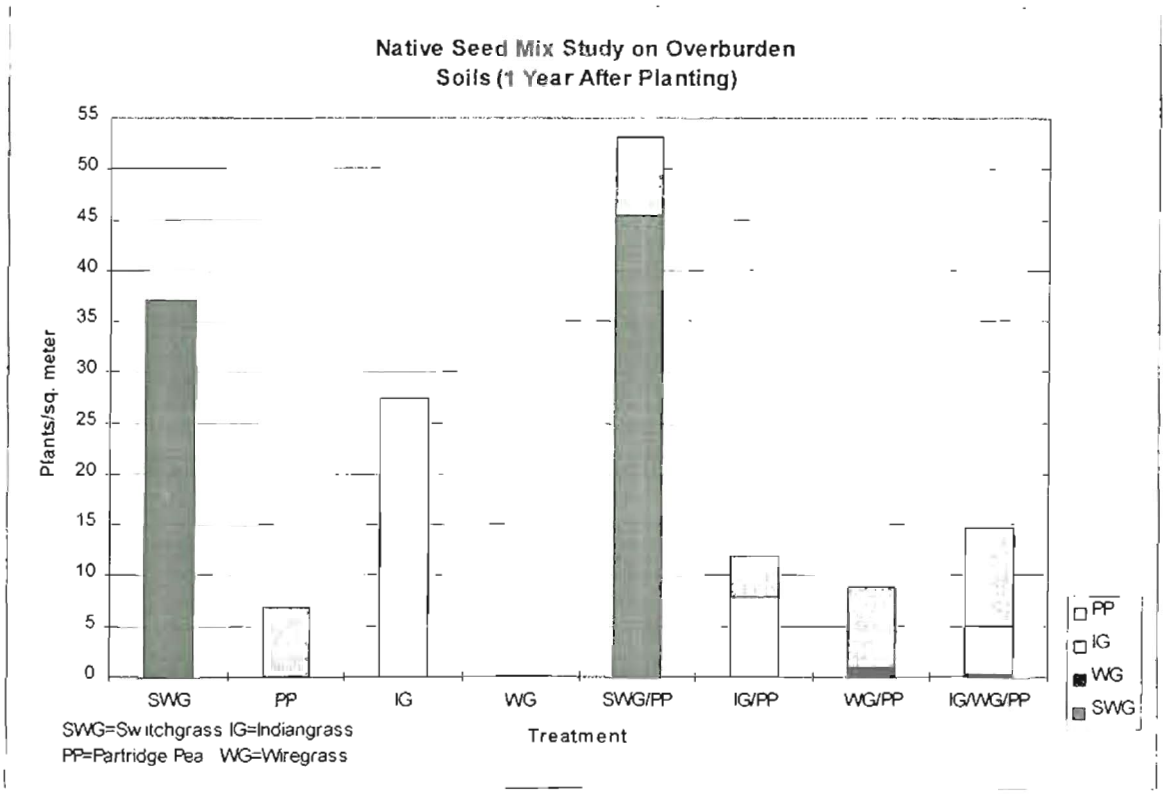

Figure 1. Plant densities in plants per square meter of native grasses seeded alone and in a mix with partridge pea on overburden soils.

In switchgrass, higher plant densities were obtained using a mix verses a monoculture (45.5 and 37.1 plants/m^2 respectively). However, heavy weed competition interfered with population dynamics, so these results may not be directly attributable to the grass/legume interaction. There were no apparent differences in plant size or vigor between monocultures and mixes in any of the three species.

For lopsided indiangrass, seeding a monoculture appeared to significantly improve plant populations (see Table 1). Along with weed competition, partridge pea seedlings may have vied with indiangrass seedlings for moisture and nutrients, thereby reducing total plant populations below that found in the monoculture treatment

Germination of wiregrass appeared to be severely inhibited by weed competition Wiregrass planted with partridge pea produced the greatest plant densities, at 1 plant/m^2. However, because all stands were

Table 1. Density of lopsided indiangrass in plants per square meter, when seeded in monoculture and mix with other native species.

Treatment	Indiangrass Stand Density (plants/m^2)
Indiangrass monoculture	27.3 a*
Indiangrass/partridge pea mix	7.8 b
Indiangrass/wiregrass/partridge pea mix	4.6 b

*Means followed by the same letter are not significantly different at $P<0.05$.

so sparse, this difference was not great. enough to be statistically significant.

Summary

Planting partridge pea in conjunction with native grasses may be a beneficial practice for contributing nitrogen to a reclaimed system. However, heavy weed competition greatly interfered with grass/legume interactions in this study, so that no positive conclusions could be drawn. Native species were not able to compete with weed species, especially introduced pasture grasses. Clean weed-free seedbeds are essential for successful native stand establishment.

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