DEVELOPMENT OF SEED SOURCES AND ESTABLISHMENT METHODS FOR NATIVE UPLAND RECLAMATION

2000 ANNUAL REPORT

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INTRODUCTION

There is a pressing demand in Florida for native plant materials for use in reclamation of upland habitats. Direct seeding has the potential to be the most economical method for revegetation. However, there are currently few commercial seed sources of native Florida upland species. Several problems associated with native plants have hampered reseeding efforts. First, many species have low seed production and viability. Secondly, seeds are often light and chaffy, and cannot be harvested or seeded with conventional equipment. Thirdly, desirable native plant species often lack seedling vigor, and are poor competitors with weed species.

Under a previous five-year agreement with FIPR, the Brooksville, Florida Plant Materials Center (FLPMC) collected and tested seed from a large spectrum of upland native grasses, forbs and woody species. From this initial work, several species were identified as having potential for use in a native seed mix. Selection criteria included: production of substantial quantities of viable seed which could be mechanically harvested and direct seeded; persistence; usefulness for livestock forage, wildlife food and habitat; provide ground cover for erosion control and protection of water quality. Under the present five-year agreement, the FLPMC is working to develop seed sources, seed production, harvesting, seed cleaning and planting technology for these selected species, as well as continuing to study other native species for potential use in a native seed mix.

The objectives of this five-year agreement are as follows:

1. **Identify and collect upland grasses, legumes and forbs, which show promise for use in a native seed mix**: Seed from 2 to 4 promising species will be collected, (in addition to those species selected for further study under the previous agreement). Also, 1 to 3 species identified as being good candidates for the cultivar release program will undergo state-wide assembly and be entered into initial evaluation trials.

2. **Evaluate seed and plants of collected species**: All collections will be tested at the FLPMC in the laboratory. Greenhouse and field tests will be conducted if an accession warrants further testing, and seed materials are available. Evaluation criteria include seed viability, seedling vigor, ease of establishment, seed production, forage quality, persistence, and drought, disease and insect resistance.

3. **Establish production fields of selected species**: Fields of 2 to 4 selected species (in addition to those species established under the first agreement) will be planted at the FLPMC, to increase seed supplies and test cultural practices which will increase seed production and viability.

4. **Develop and test cultural practices for direct seeding native species on disturbed sites in monoculture and mixes**: One or more major experiments, testing such things as seeding rates, depths and dates, will be established on reclaimed mined lands.

SEED COLLECTION

OBJECTIVE # 1: Identify and collect upland grasses, legumes and forbs, which show promise for use in a native seed mix

Native Site Hand Collections:

Work conducted in 2000 shifted from collection to field testing and developing cultural management information on promising native species. No new grass or forb species were collected other than those in the cultivar development program. However, seed and cuttings were obtained from several *Vaccinium* species and *Ilex vomitoria* to study propagation methods for these woody species.

Seed Cleaning:

A South Dakota Seed Blower was obtained in June. This instrument uses air to separate chaff and empty seed hulls from small lots of viable seed. It is one of the few instruments that can separate viable eastern gamagrass (*Tripsacum dactyloides*) seed from empty fruitcases. Even visually, it is difficult to determine whether fruitcases contain viable seed.

The FLPMC provides seed cleaning assistance to many individuals and groups each year. In the past year, this included assisting an employee of the Nature Conservancy's Disney Preserve in cleaning seed of several native species they had hand collected.

SEED AND PLANT EVALUATIONS

OBJECTIVE #2: Evaluate seed and plants of collected species.

Seed Studies:

Effect of Seed Storage Method on Switchgrass Seed Viability: Switchgrass seed is known to undergo dormancy. Previous research suggests that seed storage methods can influence dormancy. However, these studies were conducted in states that were cooler and drier than Florida. The objective of this project was to study the effect of different storage methods in a Florida environment on switchgrass seed dormancy.

Seed used in this study came from a crossing block of two Florida ecotypes of switchgrass released by the FLPMC, 'Miami Germplasm' and 'Stuart Germplasm'. Harvest occurred in 1997. Half of the block had been fertilized. A sample packet of seed from each fertility treatment was placed in an air-conditioned office and in a seed barn, which has no climate control. The study was started 1/29/98. The control samples were kept in the seed cooler at 50 - 55^{o}F with 45-50% humidity. Tests were periodically run between 1998 and 1999. Because the amount of hard seed (seed hulls that contained a hard, viable seed) varied so much between each seed packet, viability was calculated for the hard seed only, rather than overall germination of both full and empty seed hulls.

Seed stored in the seed barn with no climate control had peak germination 6 months after it was moved from the cooler. But after two years all seed stored in the seed barn had expired (Fig. 1 & 2). Results varied between seed lots as to which storage method promoted highest germination in the short term. Over a three-year period, there appears to be very little difference in germination between storage in the seed cooler, verses storage in a temperature controlled building.

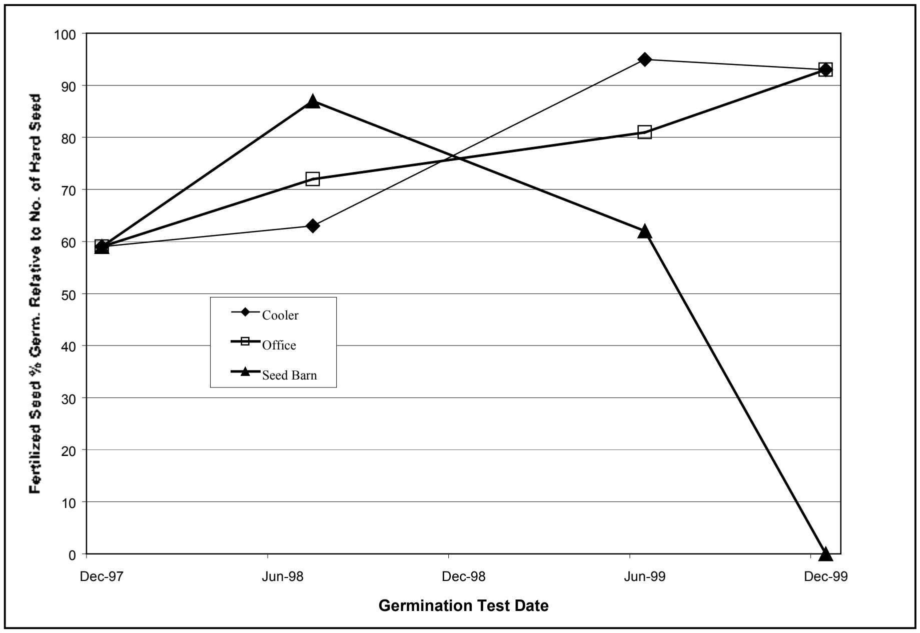

Figure 1. % Germination of switchgrass seed from unfertilized plots relative to number of hard seed under three storage treatments.

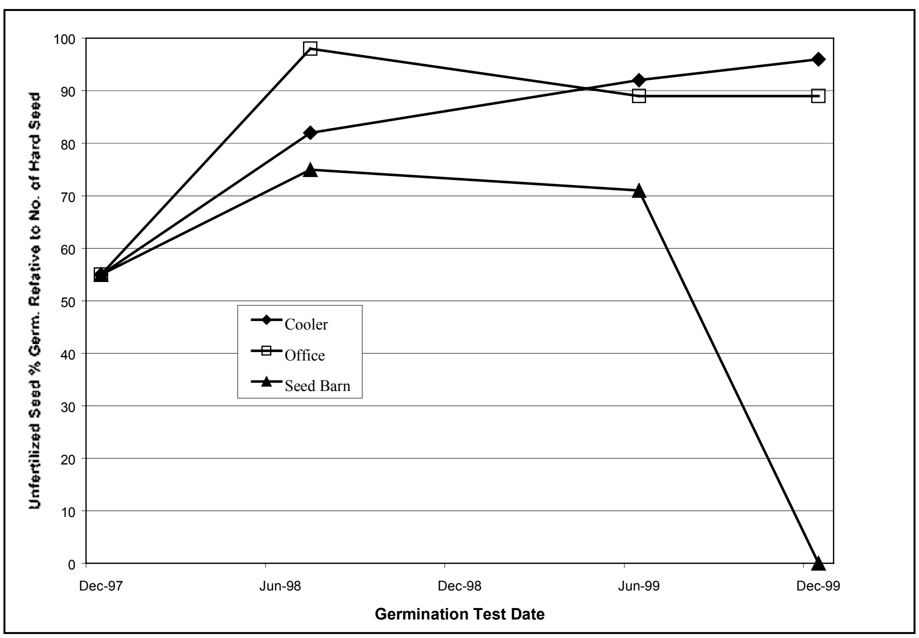

Figure 2. % Germination of switchgrass seed from fertilized plots relative to number of hard seed under three storage treatments.

Seed Treatment Methods for Promoting Germination of Eastern Gamagrass: Eastern gamagrass has several inherent traits that make it difficult to establish, including seed dormancy. Dormancy has been overcome by chilling seed on moist substrate. Maximum germination was obtained after chilling between two and four weeks, depending on the genetic population. Others have found that treatment with gibberellin (GA) increased germination. Since eastern gamagrass in Florida evolved under a milder climatic regime than more northern ecotypes, it was not known how they would respond to cold stratification. The objective of this project was to investigate methods of stimulating seed germination of Florida populations of eastern gamagrass.

Seed from two native Florida accessions of eastern gamagrass (9059213 and 9059264) was hand collected from plots established at the PMC. Seed was collected in July of 1999 and stored in a cooler at approximately 45^{o} F and 45% humidity until it was treated. Three treatments were applied to both accessions. The experiment also included an untreated control. In the first treatment, GA-plus-chilling, seed was soaked in a solution of GA and tap water (105 mg GA (A.I.)/liter water) for 24 hours. Seed was then rinsed and drained. Damp seed was placed in plastic bags and refrigerated for 4 weeks at 35 to 45^{o} F. The chill-only treatment involved rinsing with water to moisten seed, draining, placing in plastic bags and refrigerating for 4 weeks. The GA-only treatment involved soaking seed in GA solution for 24 hours before planting. Dry untreated seed stored in the cooler was used as a control. All treatments were replicated four times with 38 seed used per treatment. Seed was planted in containers of potting soil in the PMC greenhouse on September 22, 1999. Emergence was recorded every 7 to 10 days following planting for the first 4 months and monthly thereafter.

All seed treatments had significantly higher germination than did untreated seed after 45 days (Table 1). Highest germination was obtained with chilled GA-treated seed. The two accessions used in this study responded differently to chilling or GA alone. Chilling seed of accession 9059213 produced a similar response to the chilled GA treatment, indicating that this accession is very sensitive to cold stratification. Response to GA alone was significantly less than chilling. Chilling and GA alone produced very similar responses in accession 9059264, both of which promoted significantly lower germination than the chilled GA treatment at 45 days. This accession may not be as sensitive to cold stratification, and may be less prone to dormancy.

Table 1. Greenhouse emergence at 2 dates of 2 accessions of eastern gamagrass seed treated with 3 different seed treatments, and an untreated control.

Treatment	9059213		9059264	
	45 Days	8 Months	45 Days	8 Months
GA + Chill	69a	70a	59a	61ab
Chill	57ab	65ab	39bc	50abc
GA	17de	57abc	34de	57abc
No Treatment	3e	29d	9e	42cd

*Means followed by different letters are different ($P<0.05$) according to Tukey's HSD Test

A late seeding date, and cooler winter temperatures in the greenhouse may have actually simulated a natural chill treatment. Emergence slowed greatly between

December and April. At the inception of warmer spring temperatures, emergence increased rapidly in several treatments, especially in the untreated control. A final count was made on 5/31/00, eight months after planting. Emergence from GA plus chill treatments had the highest immediate and long-term emergence. Even though untreated seed had substantial emergence in the spring, it was significantly less than emergence from the other three treatments. It may be worthwhile to repeat this study in the spring of the year so that cooler winter temperatures do not confound the different treatments.

As noted above, not only did the chilled GA treatment promote the highest germination it also promoted very rapid germination (Figure 3). Most of the chilled GA seeds emerged between 5 and 10 days after planting. Only 21% of the chilled seed and 10% of the GA-treated seed that germinated in 45 days had done so within the first 10 days after planting. None of the untreated seeds had emerged within the first 10 days. The chilled GA seedlings were also taller and more robust than the other treatments, with many seedlings having double shoots.

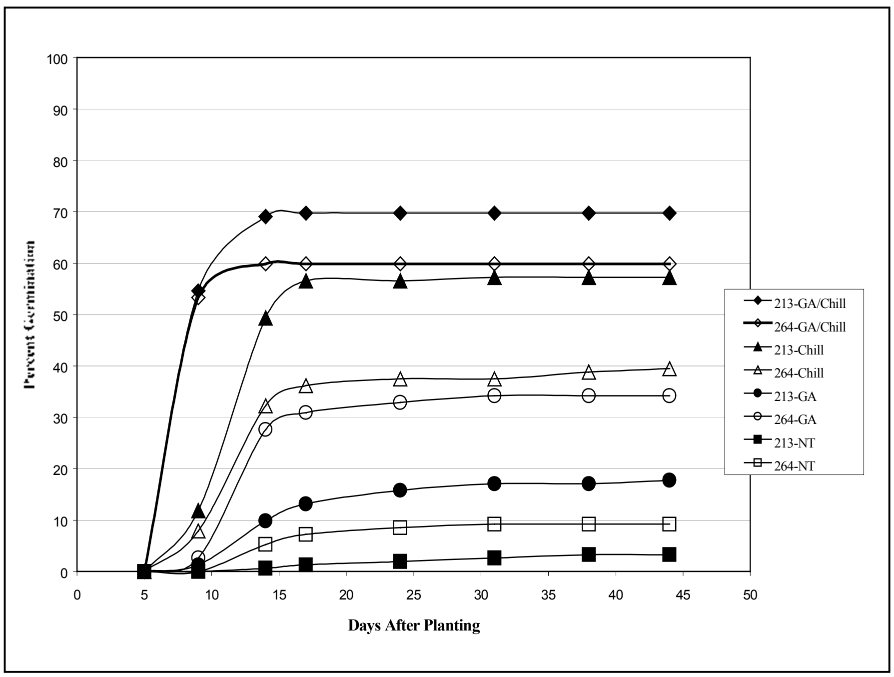

Figure 3. Percent germination of two Florida populations of eastern gamagrass seed (9059213 and 9059264) from four seed treatments: GA/Chill = soaked in GA and chilled for 4 weeks; Chill = chilled for 4 weeks; GA = soaked in GA; NT = no treatment.

In conclusion, it is apparent from the results of this study that Florida accessions of eastern gamagrass do have dormancy mechanisms. Chilling and GA both promoted germination in the two Florida accessions used in this study, but a combination of both treatments produced the greatest seed germination. In addition, this dual treatment promotes very rapid emergence and robust plants. Seed treated in this manner has the potential to dramatically increase field establishment success, if processes can be refined for large-scale plantings. It would be beneficial to repeat this study in the spring or summer, to determine if warmer soil temperatures would promote higher germination, especially in untreated seed.

Minedland Field Plantings:

Several field trials were planted on reclaimed minedlands, to study the ability of selected native species to establish by direct seeding. Plantings were made in Jan. and May of 1997, 1998 and 1999, on both overburden and sand tails, at a site south of Bartow, provided by Cargill Fertilizer, Inc. Seed collected from native sites was hand-planted in 20' rows, with 3 feet between rows on both soils. Planting depth was generally ½ to ¾ inches. Seeding rate was generally 60 pure live seed (pls) per acre. 'Alamo' switchgrass (*Panicum virgatum*) was planted each time as a standard of comparison. Due to scarcity of seed, plots were not replicated. January 2000 evaluation results for each species are discussed below.

The winter of 1997 was unusually wet, encouraging excellent establishment on both soil types. The winters of 1998, 1999 and especially 2000 were extremely windy and dry. Species that did emerge often died from lack of moisture, or were desiccated by blowing sand, particularly on sand tails. Even many established plants were not able to survive under the droughty conditions. Therefore, it was a good opportunity to study species drought resistance. Despite unfavorable conditions, some species did establish quite vigorously.

Summer rains provided a fair amount of moisture all three years, however, it usually was not enough to promote good emergence on the sand tails. Weed competition was often a problem on the overburden soils but not on the sand tails. Both soil types had very low fertility, which further reduced plant vigor. 'Alamo' switchgrass was able to establish consistently on the overburden soils (Table 2), but plants were small and lacked vigor. After one year, plant densities diminished to 2 or less plants/ft. Droughty conditions discouraged 'Alamo' establishment on sand tails soils.

Table 2. Direct seeded 'Alamo' switchgrass performance in 1997-1999 plots on reclaimed minedland overburden and sandtails at January 4, 2000 evaluation.

Year	Month	Overburden		Sandtails	
		Avg. Plants/ft	Vigor (1 to 9)*	Avg. Plants/ft	Vigor (1 to 9)*
1997	January	<1	5	9	5
	May	1	5	0	
1998	January	2	5	<1	5
	May	<1	5	0	
1999	January	2	6	<1	5
	May	<1	6	0	

*1= greatest vigor, 9 = a dead plant

Pinewoods bluestem (*Andropogon arctatus*) is one of the few species tested that managed to establish on both soil types on almost all planting dates (Table 3). Performance was often better than that of the standard, 'Alamo' especially on the sand tails. Some plants managed to produce seedheads 1997 through 1999, and a few seedlings managed to establish in areas adjacent to the study plots. This species is a prolific seed producer and seed are relatively large compared to other bluestem species. The accession used for these plantings came from a sandhills site in Ft. Cooper State Park. Based on its performance in these study plots, this accession of pinewoods bluestem was selected for further increase and testing.

Table 3. Direct seeded *Andropogon arctatus* performance in 1997-1999 plots on reclaimed minedland overburden and sandtails at January 4, 2000 evaluation.

Year	Month	Overburden		Sandtails	
		Avg. Plants/ft	Vigor (1 to 9)*	Avg. Plants/ft	Vigor (1 to 9)*
1997	May	<1	4	<1	4
1998	January	2	6	<1	6
	May	1	5	6	4
1999	January	2	5	1	5
	May	0		2	5

*1= greatest vigor, 9 = a dead plant

Chalky bluestem (*Andropogon glomeratus* var. *glaucopsis*) was planted on both soil types in 1997 and 1998. High precipitation in Jan. 1997 encouraged a few seedlings to establish on overburden soils. Some of these seedlings have managed to survive, but vigor was very poor. No seedlings were able to establish in 1998. This species is not suited to low fertility upland soils prone to drought.

Elliot bluestem (*Andropogon gyrans*) is a minor component in drier native upland sites. Initially, it was able to establish on the minedlands soils, however, plant density was severely reduced by the droughty conditions (Table 4). This species may have some potential for use if resources are available to develop it.

Table 4. Direct seeded *Andropogon gyrans* performance in 1997-1998 plots on reclaimed minedland overburden and sandtails at January 4, 2000 evaluation.

Year	Month	Overburden		Sandtails	
		Avg. Plants/ft	Vigor (1 to 9)*	Avg. Plants/ft	Vigor (1 to 9)*
1997	May	0		0	
1998	January	1	4	<1	6

*1= greatest vigor, 9 = a dead plant

Paintbrush (*Carphephorus corymnbosus*) collected from a sandhill site in Ft. Cooper State Park was planted on the minedlands site in Jan. and May of 1999, but did not establish This species appears to lack seedling vigor and is difficult to establish. Even PMC greenhouse plantings had low emergence. However, once a plant has become established in the field, it has fairly good persistence.

Spike chasmanthium (*Chasmanthium laxum*) was planted in 1997 and 1998. Emergence was good on overburden soils in Jan. plantings. However, seedlings rapidly perished because of unfavorable habitat at the test site. Chasmanthium prefers moist fertile soils under open canopy forests, with low light intensities. Because viable seed production is high, spike chasmanthium may have potential for seeding moist shady sites.

Toothachegrass (*Ctenium aromaticum*) was planted in 1997 and 1998, but never emerged. Again, the test site did not have favorable habitat for establishment.

Lovegrass (*Eragrostis spectabilis*) established well on overburden soils only, in 1998 plantings (Table 5). Plant densities and performance were as good as or better than the standard, 'Alamo'. Lovegrass generally colonizes disturbed sites, and has good potential for use as an erosion control plant, however, wildlife value is not known.

Table 5. Direct seeded *Eragrostis spectabilis* performance in 1998 plots on reclaimed minedland overburden and sandtails at January 4, 2000 evaluation.

Year	Month	Overburden		Sandtails	
		Avg. Plants/ft	Vigor (1 to 9)*	Avg. Plants/ft	Vigor (1 to 9)*
1998	January	2	5	0	
	May	2	5	0	

*1= greatest vigor, 9 = a dead plant

Liatris elegans is a very vigorous, drought-resistant species. A number of seedlings established on both soil types in 1997 through 1999, but persistence was best on sand tails soils once plants were well established (Table 6). This species does not tolerate moist soil, but seems to thrive in droughty conditions. Apparently conditions were too harsh to encourage establishment in 1999. Plants on 1997 sand tails plots produced a good quantity of viable seed in 1998 and 1999. This species has good wildlife value and very good potential for use in restoration of droughty sandhill sites. Based on its performance in these study plots, *L. elegans* was selected for further increase and testing.

Table 6. Direct seeded *Liatris elegans* performance in 1997-1999 plots on reclaimed minedland overburden and sandtails at January 4, 2000 evaluation.

Year	Month	Overburden		Sandtails	
		Avg. Plants/ft	Vigor (1 to 9)*	Avg. Plants/ft	Vigor (1 to 9)*
1997	January	<1	5	7	4
	May	0		0	
1998	January	2	4	1	5
1999	January	0		0	

*1= greatest vigor, 9 = a dead plant

Liatris tenuifolia did not establish as well or as vigorously as *L. elegans* on sand tails (Table 7). However, seedlings on overburden soils persisted longer than did those of *L. elegans*. This species also has good potential for use in a native seed mix if conditions are not too droughty. It also appears that the *Liatris* species must be planted during the winter months for the seed to germinate.

Table 7. Direct seeded *Liatris tenuifolia* performance in 1997-1999 plots on reclaimed minedland overburden and sandtails at January 4, 2000 evaluation.

Year	Month	Overburden		Sandtails	
		Avg. Plants/ft	Vigor (1 to 9)*	Avg. Plants/ft	Vigor (1 to 9)*
1997	January	3	7	<1	5

Year	Month	Overburden		Sandtails	
		Avg. Plants/ft	Vigor (1 to 9)*	Avg. Plants/ft	Vigor (1 to 9)*
	May	0		0	
1999	January	0		0	

*1= greatest vigor, 9 = a dead plant

Liatris gracilis and spicata collected from a flatwoods site were planted in Jan. of 1998 and 1999. Emergence and vigor were very low in Jan. 1998 plots. There was no emergence from 1999 plots. Conditions of the planting site were undoubtedly too dry for these species to germinate.

Sky blue lupine (*Lupinus diffusus*) is a hard-seeded native legume with tremendous vigor and drought resistance. Seed emergence and establishment was excellent for all planting dates on both soils. Robust lupine seedlings established on the sand tails, despite extremely droughty conditions. Unfortunately, this species appears to be susceptible to a soil-borne pathogen. Plants often became chlorotic, wilt and eventually die. However, some plants did manage to survive and produce seed. Plant survival did not appear to be linked to soil type, planting date or inoculation. In 1999, samples of healthy and chlorotic plants were sent to a plant pathology lab to determine the disease affecting this species. Lab results indicate that *Fusarium solani* was isolated from discolored vascular tissue. This pathogen in ubiquitous and difficult to control, and unless it can be held in check or resistant strains found, sky blue lupine will have limited value in a native seed mix.

Beaked panicum (*Panicum anceps*) planted in Jan. of 1998 had some emergence on overburden soils but none on sand tails. Surviving seedlings were poor, and lacked vigor. This species is typically found in flatwood sites, and the droughty upland test site did not encourage establishment.

Table 8. Direct seeded Miami X Stuart switchgrass (*Panicum virgatum*) performance in 1998-1999 plots on reclaimed minedland overburden and sandtails at January 4, 2000 evaluation.

Year	Month	Overburden		Sandtails	
		Avg. Plants/ft	Vigor (1 to 9)*	Avg. Plants/ft	Vigor (1 to 9)*
1998	January	4	5	<1	6
	May	1	4	1	4
1999	January	1	5	0	
	May	<1	6	<1	6

*1= greatest vigor, 9 = a dead plant

Seed obtained from crossing two native Florida switchgrass accessions (‘Miami’ and ‘Stuart’) was planted at the study site in 1998 and 1999. Plant performance was often slightly lower than that displayed by ‘Alamo’ (Table 8). Seedlings were yellower and slightly less robust than ‘Alamo’ seedlings, although once established, persistence was good. This accession is better adapted to moister, more fertile soils.

Pityopsis graminifolia was planted in Jan. and May of 1999, but seedlings established only in the January overburden plots. Plant densities were low, but vigor was a 3, substantially higher than the standard, 'Alamo'.

Table 9. Direct seeded *Schizachyrium scoparium* performance in 1998-1999 plots on reclaimed minedland overburden and sandtails at January 4, 2000 evaluation.

Year	Month	Overburden		Sandtails	
		Avg. Plants/ft	Vigor (1 to 9)*	Avg. Plants/ft	Vigor (1 to 9)*
1998	January	2	3	<1	7
	May	0			
1999	January	2	5	0	0
	May	<1	7		

*1= greatest vigor, 9 = a dead plant

An upland accession of creeping bluestem (*Schizachyrium scoparium*) collected from Ft. Cooper managed to establish on both soil types (Table 9), but predominately on the overburden soils. Once established, plants began to spread somewhat aggressively by rhizomes. With adequate seeding rates, this species may be a good candidate for direct seeding. However, problems with poor seed production will need to be overcome.

Pinewoods dropseed (*Sporobolus junceus*) established well on overburden soils (Table 10), but not on sand tails. Some plants produced viable seed during the spring of 1999 and 2000. This species has fair seed production, and good potential for use in a native seed mix.

Table 10. Direct seeded *Sporobolus junceus* performance in 1997-1999 plots on reclaimed minedland overburden and sandtails at January 4, 2000 evaluation.

Year	Month	Overburden		Sandtails	
		Avg. Plants/ft	Vigor (1 to 9)*	Avg. Plants/ft	Vigor (1 to 9)*
1997	May	<1	5	0	
1998	January	4	3	1	5
	May	<1	5	0	
1999	January	1	5	0	
	May	0		0	

*1= greatest vigor, 9 = a dead plant

Purpletop (*Tridens flavus*) was planted in 1997 through 1999. Although it generally had good emergence, even on sand tailing, vigor was very poor. Like chasmanthium, this species prefers wet fertile woodlands with partial shade. Habitat on the test sites was not suitable to maintain initial stand densities.

Several accessions of eastern gamagrass (*Tripsacum dactyloides*) were planted 1997 through 1999. Although many plants emerged on both soil types, their vigor was very poor. This species also requires moist fertile soils for best growth, and is better adapted to lowlands, than uplands.

PMC 1999 Field Plantings:

In January of 1999, several species were direct seeded on a clean-tilled well-drained non-irrigated site at the PMC for the purpose of seed production. This included *Liatris elegans, L. tenuifolia, Andropogon arctatus,* and *Schizachyrium scoparium.* Seed was hand planted ½ to ¾ inches deep in 20' rows. One to five rows of each accession were planted per species, depending on available seed stocks. The winter and spring of 1999 was very dry and windy, and only three of the species managed to establish - *L. elegans, L. tenuifolia,* and *A. arctatus*. All species were established in trays in the greenhouse in January also, along with *Carphephorous corymbosus, L. gracilis,* and another accession of *L. tenuifolia.* These seedlings were transplanted to an irrigated well-drained site and also to the non-irrigated site on the PMC in August of 1999.

L. elegans established well in the non-irrigated direct-seeded plots and produced a substantial amount of seed in 1999. Deer nipped off the tips of the plants periodically throughout the summer, causing the production of multiple seedheads on many plants. This increased seed production greatly. Approximately 1.5 pounds of seed was collected over three dates (11/10, 22 and 29). At an estimated purity of 35%, this species produced approx. 300 lbs. seed/ac. in its first year of growth. Germination ranged between 50 and 69%. Most of the plants survived another extremely droughty spring and summer in 2000. However, surviving plants did not bloom as copiously as they had in 1999. Actual production will not be known until seed is collected in late November of 2000. Transplants on the irrigated site had very low survival. This species appears to be very sensitive to soil moisture. It will be necessary to develop cultural management techniques for this species, to insure consistent seed production.

Only two direct-seeded plants of *L. tenuifolia* managed to establish on the non-irrigated site in 1999. Vacant rows were planted with greenhouse transplants in August, but these were not robust enough to bloom in 1999. Seedlings became well established on both irrigated and non-irrigated plots during 2000 and produced multiple seed heads. Deer also nibbled off the ends of this species and caused a profusion of seedheads to form on both sites. Seed is expected to ripen in late November of 2000.

Carphephorous corymbosus, and *L. gracilis* both established well on the irrigated site in 2000, and bloomed profusely. Seed on these species is not expected to ripen until mid to late November.

A. arctatus came up sporadically in the PMC plots in 1999. Those plants that did emerge bloomed prolifically in the fall of 1999. Vacant areas in the direct seeded plots were planted with greenhouse seedlings. Even very small transplants put up at least one seed head in October. A total of 39g of seed was collected from the non-irrigated plots, with average germination being 48%. In 2000, plants on both the irrigated and non-irrigated plots bloomed profusely, but seed is not expected to ripen until mid November. Persistence, disease resistance and the role of fire in seed production needs to be studied to develop cultural management guidelines for this species.

Direct seeded *Schizachyrium scoparium* did not emerge from the non-irrigated site. Greenhouse seedlings were planted in irrigated and non-irrigated plots in August of 1999. Most seedlings established well in 2000 and produced an abundance of seed heads. Actual seed production will not be known until harvest in mid November.

Evaluations of Selected Species:

In general, the Plant Materials Center uses a five-step process to develop native species for release onto the commercial market: (1) once a promising species is identified, collections are assembled from throughout the state to maximize genetic diversity, (2) these collections are planted in plots at the PMC, where they undergo initial evaluation for desirable characteristics, (3) superior accessions from the initial evaluation plots are selected and increased, (4) seed or vegetative materials are then planted in advanced evaluation trials on representative sites throughout Florida, (5) one or more accessions with overall superior performance are placed in field plantings to develop further cultural management technology prior to release. This subject was discussed in-depth in the paper "Developing Seed Sources of Florida Native Upland Grass Species", which was presented by S. Pfaff at the American Society for Surface Mining and Reclamation annual national meeting at Tampa, FL June 12, 2000.

Switchgrass (*Panicum virgatum*) Assembly: 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. It is also being studied for use in filter strips and windbreaks, because of its value for wildlife food and habitat. It has a small hard seed that is readily harvested and planted with conventional equipment. The switchgrass cultivar, 'Alamo', from Texas performs well in Florida. However, there is a demand for upland species native to Florida.

The FLPMC has released (vegetatively) two strains of Florida native switchgrass, selected from an assembly, which had undergone initial evaluation. Both strains have excellent forage production and persistence. Both flower prolifically every year. However, seed viability is very low because the caryopsis rarely fills. When the two strains were allowed to cross-pollinate, seed viability increased from less than 5% to as high as 46%. However, when progeny from the crossing block were planted and allowed to produce seed, viability dropped to 19%. Switchgrass will not cross-pollinate, and it was determined that greater genetic variability was needed to insure stable seed viability in future generations. A plant-breeding plan was developed with the assistance of Dr. Ken Quisenberry, of the University of Florida/IFAS in the spring of 2000, to develop a cultivar with high seed viability. A new assembly of Florida native switchgrasses was conducted in the fall of 2000. To date, 99 accessions have been collected from 40 counties in Florida. Seed or plants are to be initially established in pots in the greenhouse, and then planted in a crossing block in the spring of 2001.

Hairawn Muhly (*Muhlenbergia capillaris*) Initial Evaluation: Ninety-four accessions gathered from throughout Florida were planted in replicated plots at the PMC in March of 2000. Plots were evaluated in the fall for growth characteristics and seed production. Seed samples were taken for laboratory germination tests, the results of which are not yet available. Initial evaluation of this assembly is scheduled to continue for two more years.

It is not known whether this species freely cross-pollinates, or if given plants have genetically stable reproduction. This information is important if selections of muhly are to be released for commercial production. Dr. Blount of the UF/IFAS in Marianna is assisting the FLPMC in determining the answer to this question.

Lopsided Indiangrass (*Sorghastrum secundum*) Increase of Superior Accessions: An assembly of 138 Florida accessions underwent initial evaluation at the PMC in 1997 through 1999. No accessions displayed superior performance under all evaluation criteria. However, several accessions did have superior performance in several categories. To maximize genetic diversity, 25 accessions were selected for increase and advanced evaluation (Table 11). The selected accessions were established in cone-trays in the greenhouse during the spring of 2000, using seed from the original collections. Amazingly, original seed collections stored in the seed cooler still contained viable seed after 4 to 6 years.

Selected accessions are scheduled to be planted in one of three increase blocks in early 2001. A Santa Rosa County accession will be planted in its own increase block since it completes pollination before the other accessions begin to bloom. Three accessions all displayed a very similar blue-green color and had very stiff, upright leaves. These accessions will be planted together in a second increase block. The remainder of the accessions will be planted together in a third increase block since they all displayed similar growth characteristics and flowering dates. Once seed materials are increased to adequate levels, advanced evaluations are to be conducted at various sites around Florida.

Table 11. Twenty-five superior lopsided indiangrass accessions selected from IE trials in 1999.

Accession No.	County	Accession No.	County
9059725	Citrus	9060182	Madison
9059727	Citrus (Ft. Cooper State Park)	9060184	Hamilton
9060105	Osceola	9060186	Marion
9060110	Sarasota (Myakka State Park)	9060187	Desoto
9060118	Okeechobee	9060197	Levy
9060120	Santa Rosa	9060199	Citrus
9060128	Desoto	9060205	Gilchrist
9060133	Desoto	9060207	Orange
9060137	Desoto	9060208	Hernando
9060146	Manatee	9060209	Citrus
9060147	Manatee	9060210	Hernando
9060168	Levy	9060351	Dixie
9060173	Lake		

Chalky Bluestem (*Andropogon glomeratus* var. *glaucopsis*) Increase of Superior Accessions: An assembly of 91 Florida accessions established in several trials at the PMC were initially evaluated in 1997 through 1999. Several accessions performed well in all trials and under all criteria. However, performance varied between years. Ten superior accessions from all major regions in Florida were selected in order to maximize genetic diversity (Table 12). Seed from original collections was established in trays in the greenhouse in the spring of 2000. All accessions are to be planted together in one increase block in December of 2000. Seed from this composite is to be planted in various advanced evaluation trials throughout the state before the cultivar is released onto the commercial market.

Table 12. Ten superior chalky bluestem accessions selected from IE trials in 1999.

Accession No.	County
9060226	Orange
9060251	Nassua
9060277	Hardee
9060318	Brevard
9060331	Sarasota
9060340	Bay
9060347	Taylor
9060363	Citrus
9060394	Polk
9060396	Polk

Eastern Gamagrass (*Tripsacum dactyloides*) Advanced Evaluation: Four Florida accessions displaying superior growth characteristics and viable seed production were selected out of initial evaluation trials at the PMC in 1996 through 1998. These are 9059213 (Clay Co.), 9059264 (Dixie Co.), 9059266 (Polk Co.), and 9059287 (Citrus Co.). Increase fields of the four accessions were planted in the summer of 1999. Seed was hand collected on several dates during the summer of 2000. Collected seed has thus far been planted in two advanced evaluation trials.

The first trial was planted in July of 2000 on rangeland near Naples, Florida that had recently been cleared of Brazilian pepper trees. Soils are Basinger fine sands and Boca, Riviera, limestone substratum and Copeland fine sands, depressional. The site is normally a wet flatwoods, however, with the droughty summer of 2000, seeds were planted into soils that were dry down to 3 inches. Plots were 5’ x 10’ with 2 rows per plot. Plots were replicated 8 times. One hundred seed were planted in each plot at a depth of 2 to 3 inches. Blue maidencane and common maidencane under advanced evaluation were planted in alternate plots, between gamagrass plots. A six-month evaluation is to be conducted in January of 2001.

The second trial was planted in September of 2000 on reclaimed minedlands near a lake shoreline. Cargill Fertilizer Inc provided the site, which is south of Bartow. Soils have a heavy clay fraction that tends to be very sticky when wet and crust heavily when dry. Plots are 5’ x 5’ in size with 3 rows per plot. Fifty seed were planted in each plot at a depth of 1 to 2 inches. ‘Pete’ eastern gamagrass was also planted as a standard of comparison. Gamagrass plots were again alternated with plots of maidencane under advanced evaluation. The site was very wet at the time of planting, but had dried out and crusted heavily 5 weeks later. Despite heavy crusting, a few gamagrass seedlings had been able to emerge from several plots.

Seed from two of the accessions was planted on another Cargill lake shoreline site in 1999. Both accessions had excellent performance on this site. One-year evaluation results are discussed in the last section of this report. Other advanced evaluation trials will be planted throughout Florida in the next year, as sites become available.

In April of 2000, two eastern gamagrass studies were planted at the FLPMC in cooperation with the Woodward, OK ARS. Four accessions developed by the OK ARS were planted in replicated plots along with the four Florida accessions under advanced evaluation. Pete was planted as a standard of comparison. The purpose of the study is to study forage production and quality. In addition, three of the OK accessions, the four FL accessions and Pete were established in a separate trial to study seed production.

Blue Maidencane (*Amphicarpum muhlenbergianum*) Advanced Evaluation: Although blue maidencane does not produce above-ground viable seed, this species is a very important component of native mesic systems. As with common maidencane (*Panicum hemitomon*), rhizomes can be used to establish new stands. Eleven accessions were selected in the initial evaluation trial from an assembly of 157 Florida accessions (Table 13). These accessions were then increased in large tubs in early 2000 to prevent contamination. Three of the accessions came from Pasco county and had very similar characteristics, therefore they were grown together to form one new accession. Three other accessions, 2 from Sarasota county and 1 from Charlotte county also had very similar characteristics and were grown together to form a single accession.

Table 13. Eleven superior blue maidencane accessions selected from IE trials in 1999.

Accession No.	County
9059859	Pasco
9060309	Pasco
9060311	Pasco
9059866	Charlotte
9060066	Sarasota (Myakka State Park)
9060067	Sarasota (Myakka State Park)
9059869	Palm Beach
9059956	Madison
9059971	Citrus
9060008	St. Johns
9060295	Polk

Enough material was available during the summer and fall of 2000 to plant advanced evaluation trials of the seven accessions on the Naples site and the Cargill Bartow site discussed above. A planting rate of 80 bushel/acre was used at the Naples site. This however, was too heavy, so the rate was dropped to 40 bushels/acre at the Cargill site. Common maidencane, both the Mississippi release 'Halifax' and the FLPMC release 'Citrus', were planted as a standard of comparison. Rhizomes were laid into trenches 3 to 4 inches deep at both sites. The Cargill site was checked after 5 months. A few sprouts were found in several plots, however, due to the drought and heavy crusting of the soils, emergence was slow.

TESTING CULTURAL MANAGEMENT PRACTICES

OBJECTIVE #3: Establish production fields of selected species

Cultural management technology for native species must be developed, in order to make establishment and harvest of production fields economically feasible. This is necessary if dependable seed sources of native species are to be available on the commercial market. Fire, fertility and available moisture play an important role in seed production and viability in many species in native habitats. Therefore, the FLPMC has been in the process of establishing production fields of several native species for the purpose of testing such practices as irrigation, fertility, burning and clipping on seed production. Establishment methods and weed control practices are also being considered. While some of this information is being gleaned from the species evaluation studies discussed above, more intense studies have been applied to two of the grass species.

'Croom Source' Lopsided Indiangrass:

Lopsided indiangrass is an important component of native uplands in Florida. It is also one of the species that has been successfully used to revegetate upland sites. If adequate supplies of seed are to be available on the commercial market, it must be economically feasible for commercial producers to establish and maintain production fields of indiangrass. However, very little is known about growing this species under cultivation. A study was initiated in 1997 to determine the effects of canopy removal, method of canopy removal, and timing of such removal on stand persistence, seed production and seed viability of lopsided indiangrass.

Although a prolific seed producer, lopsided indiangrass typically has low seed viability, whether in the wild or on cultivated plots. Seed collected from native stands in Ft. Cooper State Park, in Citrus Co., had germination rates ranging from 20 to 28% between 1996 and 1998. Seed collected from the field of 'Croom Source' lopsided indiangrass grown at the PMC in 1997 and 1998 averaged 25% germination. The Croom field did not receive any additional fertilizer and old plant residues were not removed in the first two years of growth. In addition, it has been observed in lopsided indiangrass initial evaluation plantings at the PMC, that larger indiangrass plants on irrigated fields tend to die after they have produced seed. These plants were usually 2 years in age, and samples sent to the state plant pathology lab revealed that roots were infested with lesion nematodes. This apparently made the plants susceptible to invasion by *Rhizoctonia* and *Fusarium* species. There are no economic chemical controls for these soil-borne pathogens in the field. However, biological controls such as crop rotation, residue management and introduction of antagonistic fungi may assist in increasing stand longevity.

Burning removes mulch and plant debris. This reportedly increases the light reaching emerging shoots, thereby stimulating growth (Masters *et al*., 1993). Burning native grasslands is a common practice in Florida, which has been studied by several researchers. Sievers (1985) recommended that native sites in FL be burned in late winter (Jan. – Mar.) while desirable grasses such as lopsided indiangrass were dormant. He also recommended that native sites should not be burned more frequently than every three years. This is due to the fact that desirable native grasses are sensitive to burning and populations are reduced under high frequency burn programs.

In the Midwest, early researchers found that burning and fertilization of cultivated stands of warm-season grasses resulted in higher seed yields (Masters *et al*., 1993). Masters and his associates studied the effect of burning native grasslands in Nebraska, including the response of yellow indiangrass (*Sorghastrum nutans*). They found a combination of burning, fertilization and atrazine applications increased reproductive stem densities in comparison to no treatment or one of these treatments used alone. Late spring burns (mid-May) generally increased reproductive stem densities over earlier spring burns (Mar. – April), or unburned treatments. However, fertilization and atrazine applications were also included in these treatments.

Looking at the effects of fertilization on FL native flatwoods, Kalmbacher and Martin (1996) found that fertilization encouraged the proliferation of annual herbs and early successional species. Fertilization actually seemed to decrease populations of such species as wiregrass, creeping bluestem and maidencane, especially after annual fertilizer applications over a period of years. In Oklahoma, yellow indiangrass populations were reduced by fertilization in native warm-season grass CRP seedings (Berg, 1995). Weedy species tended to dominate the fertilized seedings. However, on pure stands of yellow indiangrass in the Ozarks, Brejda and his associates (1995) found that fertilization increased forage production. Rates of up to 150 lb./ac. were used for a period of three years in split applications. The stands were burned in April of each year, but weed control methods were not discussed. Based on the above research results, it would appear that fertilization may only be beneficial on pure stands if weed competition is controlled.

A field of lopsided indiangrass was established on an irrigated site at the FLPMC in March of 1996. Seed came from the Croom tract of the Withlacoochee State Forest in Hernando Co. Transplants raised in the greenhouse were planted on 2' centers. Many plants were choked out by weed competition during the 1996-growing season. Therefore, the field was reestablished in the fall of 1997 with transplants. The study was a split-plot design, with main plots being the date of canopy removal. Subplots were canopy removal method. Treatments were as follows: Winter burn (Feb.), summer burn (July), winter clipping (Feb.), summer clipping (July), and an untreated control. Plots were clipped with a forage harvester so that residue could be removed from the plots. Clipping height was 6-8". Plants burned to the ground in the Feb. burn treatment because they were dormant. However, most plants were very green in July, and would not burn well. Each plot contained four rows of plants (approx. 104 plants/plot). Approx. plot size was 8' x 56'. Each treatment was replicated 4 times. Weeds were controlled chemically and by hand hoeing. No fertilizer treatments were applied due to severity of weed competition. Statistical analysis was done using MSTATC Factor program for split-plot designs.

The number of plants in each plot were counted in July of 1999 before summer treatments were applied and in Oct. just before seed ripening. Percent plant loss during the 1999 growing season and treatment effects on seed production and viability are shown in Table 14. There is very little difference between plant population numbers of the various treatments. However, summer burning reduced the size and vigor of plants severely. It is interesting to note that untreated plots had the greatest plant losses. Most untreated plants looked brown and dead by October.

Table 14. 'Croom Source' lopsided indiangrass 1999 percent plant loss and seed production (lbs./ac.) and % seed viability under 5 residue management treatments.

Treatment	% Plant Loss (Jan. to Oct.)	Seed (lbs./ac.)*	% Viable Seed
Winter Clip	29%	16.3ab	12
Winter Burn	32%	17.4ab	11
Summer Clip	25%	20.6a	13
Summer Burn	37%	3.9b	11
No Treatment	38%	10.3ab	10

*Means followed by different letters are different (P<0.05) according to Tukey's HSD Test

In 1998, the newly established 'Croom' indiangrass field produced 75 pounds of seed per acre. Average seed viability was 26%. Highest production in 1999 occurred in the summer clipped plots, which averaged 20.6 lbs./ac. Possibly, soil-borne pathogens had severely reduced plant vigor by 1999, and residue management only marginally overcame disease symptoms. Statistically, there was no difference between any of the treatments except summer clipping and summer burning. Most summer burned plants did not produce seedheads. Those that did probably did not actually burn because of too much green matter. There was no significant difference in seed viability between any of the treatments.

Live plants were counted again in early 2000. Plants in most treatments had died or were very small and weak, so the experiment was brought to an end. Plant longevity may be increased by removing plant residues each year, rather than waiting until the third year as in the case of this experiment.

Based on the results of this study, it appears that removing indiangrass residue to ground level while the plants are dormant (as in the case of the Feb. burn) does not hurt plant productivity. Neither does clipping above growing points (6") in early July. However, summer burning severely hurt plant productivity. Residue management is important for maintaining stand productivity. Of greater impact though are soil-borne pathogens. If seed production is to be commercially feasible, more research needs to be conducted on controlling or reducing the impact of pathogens in lopsided indiangrass production fields.

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'Avon Park Source' Wiregrass:

Wiregrass is considered an important component of pineland habitats, because of its ability to carry fire. In native situations, wiregrass contributes fuel for understory burn management programs. Many public agencies and private conservation groups, among others, are interested in using wiregrass to revegetate native habitat. Dependable supplies of seed need to be available on the commercial market to meet this growing demand. In order to do this, it must be economically feasible for commercial producers to establish and maintain production fields of wiregrass. However, very little is known about growing this species under cultivation. Cultural methods, which will maximize viable seed production and stand longevity, need to be developed. It has been shown that wiregrass requires a growing season burn to produce viable seed. There is also some evidence that the hotter the fire, the greater the subsequent seed viability will be. The effect of other factors such as burn frequency and fertility on seed viability is not well understood.

Although wiregrass requires fire to produce viable seed, burning is not always feasible. Clipping would be more practical in some situations, but it is not known if clipping will have the same effect as burning. Secondly, some research indicates that burning annually decreases stand vitality of native species. There presently is no research to suggest whether fertilization can offset this trend in wiregrass. The objectives of this project are first, to study the effects of method of canopy removal and fertility on seed production and seed viability of wiregrass. Secondly to study the relationship between burn frequency and fertility as it relates to seed production and viability.

Wiregrass has been observed to flower after burning, defoliation and minor soil disturbance. It was not recorded whether viable seed was subsequently produced by defoliation or soil disturbance (Clewell, 1989). However, late spring and summer burns are known to promote the production of viable seed. Wiregrass is more tolerant of burning than other native grass species in Florida. For instance, annual burning of a central Florida flatwoods site did not appear to decrease wiregrass stand density over a 5-year period (Kirk *et al*, 1974). The effects of annual burning on viable seed production have not been documented, however.

Wiregrass is thought to have a shallow root system that allows plants to take advantage of the flush of nutrients released following a burn. Nitrogen is volatilized by burning, therefore, much of this nutrient, along with some of the phosphorous, is permanently lost. On the other hand, beneficial nutrients such as Ca, K and Mg are released in the ash, and may be important for stimulating production of viable seed. Kalmbacher (1983) reported that the highest percentage of K in wiregrass was found in the inflorescence. Wiregrass does not appear to respond positively to nitrogen fertilizer. Kalmbacher and Martin (1996) found that fertilizing native range actually eliminated wiregrass from test plots. Wiregrass was only a minor component in the test plots, however, so this data had only limited application.

A field of 'Avon Park Source' wiregrass was established on an irrigated site at the FLPMC with 4" tubelings in February of 1996. Transplants were planted on 2' centers. The field was extended with 6" tubelings planted in October of 1997, so that the entire field measures 40' x 390' (0.35 acres). Soils on this site are predominately Kendrick fine sand which is well drained, and some Sparr find sand on one end of the field, which is poorly drained. Plants were allowed to become well established, and the field was then divided into subplots in 1999, in preparation for the studies. Two separate studies were applied to the field, a canopy removal method study, and a burn frequency study.

Wiregrass Canopy Removal Method Study: This study is a split-plot design, with main plots being canopy removal method (burn vs. clip). Subplots are fertilization treatment (none vs. 50 lbs./ac. of 0-10-20 applied just after canopy removal). Nitrogen was not applied since it is not a major component of native wiregrass systems, and other researchers had not found it to be beneficial. Plot size is 10' x 40' and each treatment is replicated 4 times. Study duration is to be for 3 to 5 years depending on results and funding. Statistical analysis is conducted using MSTATC Anova program for split plots.

Table 15. PMC Avon Park wiregrass clip vs. burn study 1999 soil sample analysis results, including pH, P, K and Mg at two depths.

Depth	pH	P	K	Mg
	---------Parts per million soil------			
0-6 inches	6.2	170	5	35
6-12 inches	5.7	149	1	18

Soil samples were taken on May 26, 1999, and sent to a commercial laboratory for analysis (Table 15). According to a bulletin put out by the Florida Cooperative Extension Service/IFAS (1990) the pH in these plots was slightly high, compared to the average recommended for bahiagrass (5.5). The level of P was considered to be "very high", the level of K "very low" and the level of Mg "medium". Very little N was detected in the samples.

In 1999, plots were clipped and burned July 8 between 1:00 and 4:00 p.m. High temperature that day was 94^{o} F. Humidity was not recorded at the PMC, however, for the sake of comparison, relative humidity at the Tampa Airport on 7/8 was 68% at 1:00 p.m. The clipping treatment was done with a Grasshopper mower, which cut the stubble to a height of 1 to 2". Residue was left on the plots. For the burn treatment, plants were set on fire with a drip torch. Most plots were not dense enough to carry fire across the entire plot, so plants often had to be individually burned. Fertilizer was applied with a hand-held fertilizer spreader on July 20. Plots were harvested with the Flail-Vac Seed Stripper on December 8, 1999. Purity was estimated to be 42%. Seed samples were weighed and germination tests were conducted. Seed weight of both this and the burn frequency study averaged 2300 seeds/g or an average of 1,038,000 seed/lb.

Pounds of seed/acre obtained from the clip vs. burn study and percent viable seed are shown in Table 16. There was no significant difference in pounds of seed produced per residue or fertilizer treatment. This was especially true when calculated on a production per plant basis. Number of seed producing plants varied somewhat per plot, so plant numbers in each plot was used to more accurately determine actual production. Regarding seed viability, there were no differences between clipping and burning. Fertilization did not appear to affect fertility either.

Table 16. PMC Avon Park wiregrass clip vs. burn study, 1999 seed production per acre and per plant, and percent seed viability.

Treatment	Seed Produced lbs./ac.	Seed per Plant (g)	% Viable Seed
Burn/Fertilized	19.3	0.97	18
Burn/Unfertilized	24.3	1.21	21
Clip/Fertilized	21.7	1.05	21
Clip/Unfertilized	21.8	1.06	17
LSD (0.05)		0.51	

In 2000, plots were clipped and burned on July 12 between 1:00 and 3:00 p.m. Clipping height of the mowed treatment was again between 1 and 2 inches. Most plants had not produced enough dry matter in one year to carry the fire across the whole plot. Therefore, plants had to be ignited individually in the burn treatment plots. High temperature at the PMC on that date was 94^{o} F. Relative humidity at Brooksville was recorded at 65% at 3:53 p.m. Because no significant differences appeared in seed viability between fertilized and unfertilized treatments in 1999, fertilizer rates were tripled in 2000 in an effort to elicit a response. The fertilizer was applied in two applications, with 50 lbs./ac. of K (in the form of 0-10-20) applied on August 1 when plants had just begun to regrow. On August 23, after plants had put on a substantial amount of leaf tissue but had not yet begun to bloom, 100 lbs./ac. of K was applied.

Wiregrass Burn Frequency Study: This study is also a split-plot design. Main plots are burn frequency (annual, every 2 years or every 3 years). Subplots are fertilization treatment (none vs. 50 lbs/ac of 0-10-20 applied after canopy is removed or during the growing season on unburned plots). Soil samples were also taken from these plots in May of 1999, with results being very similar to those reported in Table 14. Plots were burned 7/8/99 as outlined above. Fertilizer was applied with a hand-held fertilizer spreader. Plot size is 10' x 40' with four replications. Study duration will be 3 to 6 years depending on results and funding.

Number of flowering plants was counted in each plot just prior to harvest in 1999. Since all treatments were burned in 1999, the only differences in treatments were fertilization of half the plots. Unfertilized plots averaged 15.35 lbs. seed/ac., fertilized averaged 15 lbs. seed/ac. Production per plant in 1999 of the unfertilized plants was 0.79 g, fertilized was 0.76 g. Fertilization did not appear to significantly affect seed viability, which was 25% and 26% for unfertilized and fertilized plots respectively.

In 2000, the annual treatment plots were burned at the same time as the canopy removal study plots were burned. Plants in the burn treatment plots were relatively small, and had to be individually ignited with the drip torch. Fertilizer treatments were tripled on this study also, and applied as outlined above in the canopy removal study. Fertilizer treatments were applied to all designated plots even if they were not burned. Although plots are not yet ready for harvest at the writing of this report, it has been observed that unburned plots are also flowering profusely. Plant size and density of dry matter covering the plant crown may be major factors in the stimulation of seed-producing culms.

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'Wekiwa Source' Wiregrass:

Ecotype compatibility is one of the issues native site reclamationists are struggling with. There is some thought in the scientific community that wiregrass seed collected from, for example, a xeric ecotype will establish better on xeric sites than will a mesic ecotype. To test the response of a xeric ecotype to cultural management practices, the FLPMC sought to obtain seed from a xeric habitat. However, it soon became apparent that this would not be a simple matter. Nearby state forests and parks had large acreage's of wiregrass dominated sites. However, despite summer burns, production of viable seed was low on these sites (0-13%). The State Department of Forestry had been successful in harvesting viable wiregrass seed (germination rate was 22%) from a xeric site in Wekiwa Springs State Park. Tim Pittman of the DOF Andrews Tubeling Nursery graciously sent enough seed to establish a production field.

Seed was planted into six-inch tubeling trays in the greenhouse in 1996. In October of 1997, 2000 tubelings were transplanted into an irrigated field at the FLPMC which had been kept clean tilled for two years. Within and between row spacing was two feet. Plot size is approximately 0.2 acres. The site is predominately Kendrick fine sand, which is well drained. Transplants in this production field established very well in 1998. The field was divided into subplots in 1999, to test the effects of various fertilizer treatments on viable seed production of this upland ecotype. As discussed in the 'Avon Park' wiregrass section, the effect of nitrogen and other plant nutrients on wiregrass seed production is not well understood. The objective of this study is to determine the effect of N, P and K on seed viability, with K hypothesized to be the most essential nutrient to seed viability.

Table 17. PMC Wekiwa wiregrass fertility study 1999 average soil sample analysis results, including pH, P, K and Mg at two depths.

Depth	pH	P	K	Mg
	---------Parts per million soil------			
0-6 inches	5.4	161	19	88
6-12 inches	5.3	88	12	30

The study is a randomized complete block design comparing fertilization treatments (none vs. 50 lbs. K/ac. of 0-10-20, vs. 50 lbs. N & K/ac. of 10-10-10) applied after canopy is removed. Plot size is 10' x 30', with 6 replications. Soil samples were taken from the field on May 26, 1999. Results of soil analysis tests are shown in Table 17. According to the bulletin put out by the Florida Cooperative Extension Service/IFAS (1990) the pH in these plots was slightly low, compared to the average recommended for bahiagrass (5.5). The level of P was considered to be "very high", the level of K "very low" and the level of Mg "high". Very little N was detected in the samples.

In 1999 the field was partially burned on 7/8 from 4:00 to 5:00 p.m., with the remainder being burned on 7/9/99 between 1:00 and 4:00 p.m. Temperature highs on both days were 94^{o} F. Relative humidity at the Tampa airport on 7/8 was 72%, although it was probably higher than that at the FLPMC because a thunderstorm was moving in. Humidity at the Tampa Airport on 7/9 between 1:00 and 4:00 p.m. was 74%. Plants were fired with a drip torch. The canopy was not dense enough to carry the fire over the entire field, so many plants were burned individually. Some plants were too green, and would not completely burn. Plant counts were made prior to burning and prior to harvest in each plot.

Plots were harvested with the Flail-Vac Seed Stripper on December 9, 1999. Seed purity was estimated to be 34%. Number of seed per gram averaged 2,500 with there being 1,135,000 seed/lb. There was no significant difference in seed production on a per plant basis (Table 18). There were very small differences in seed viability, with the K & N treatment having the highest average percent viability, and the unfertilized treatments having the lowest. However, these differences were not statistically significant.

In 2000, all plots were burned on July 12, with high temperature at the PMC reaching 94^{o} F, and relative humidity at Brooksville being reported as 65% at 3:53 p.m. The fertilizer amounts applied in 2000 were tripled in an effort to elicit a greater response in percent seed viability. Fertilizer was applied in two treatments in 2000, with K or K & N being applied on August 1at a rate of 50 lbs./ac., and K or K & N being applied on August 23 at a rate of 100 lbs./ac.

Table 18. PMC Wekiwa wiregrass fertilization study, 1999 seed production in lbs./ac. and grams per plant, and percent seed viability.

Treatment	Seed Produced lbs./ac.	Seed per Plant (g)	% Seed Viability
K	20.9	1.32	27
K & N	23.0	1.35	29
No treatment	21.8	1.21	26
LSD (0.05)		0.36	8.5

Literature Cited:

Florida Cooperative Ext. Service/Institute of Food and Agric. Sciences, Univ. of Florida. Notes in Soil Science. IFAS standardized fertilization recommendations for agronomic crops. No. 35 (revised). SS-SOS-002. Feb. 1990.

RECLAIMED MINEDLAND DIRECT SEEDING STUDIES

OBJECTIVE #4: Develop and test cultural practices for direct seeding native species on disturbed sites in monoculture and mixtures.

Reclaimed Upland Minedlands Planting Date - Seeding Methodology Trials:

The objectives of this project are to study the influence of seeding method, seeding rate and seeding date on the establishment of lopsided indiangrass and wiregrass on reclaimed minedlands overburden and sand tailings. Plantings were made in January and May in 1997 through 1999. The experiments (including establishment data collected through January 2000) were discussed in-depth in the paper "Seeding Two Native Grass Species on Reclaimed Phosphate Minedlands", which was presented by S. Pfaff at the American Society for Surface Mining and Reclamation annual national meeting at Tampa, FL June 12, 2000. Experimental plots will continue to be evaluated through 2001 for establishment and persistence.

Reclaimed Minedlands Lowland Native Species Direct Seeding Trials:

The FLPMC is working with several native grasses that are adapted to mesic environments. Site adaptation and establishment technology need to be developed for these species. In August of 1999, three grass species were direct seeded, and another was established with rhizomes on a newly reclaimed lake shoreline site provided by Cargill Fertilizer, Inc. The study plots began within one foot of the water line, and extended 25' up a relatively steep bank. Soils were sandtails and overburden topped with 6 to 12" of muck soils. Plot size was 8' x 25', with four replications. Two Florida accessions of eastern gamagrass (9059213 and 9059264) were hand seeded at a rate of 4 seeds per linear foot. Three rows of each accession were planted in each plot, with row spacing between plots being approx. 1.5'. Planting depth was 2 to 4". 'Alamo' switchgrass and the Florida switchgrass accession 9060500 ('Miami' x 'Stuart' parent stock) were seeded in 3 rows each per plot, at a rate of approx. 60 pls/ft^2. Planting depth was 1 to 2". Chalky bluestem seed (collected from several initial evaluation plots at the PMC in 1998 with a forage harvester) was hand broadcast over plots. Rhizomes of 'Halifax' maidencane (*Panicum hemitomon*) from Mississippi, and the FLPMC released Florida accession 'Citrus' maidencane, were hand planted in trenches. Maidencane planting depth was 2 to 6" with approx. 5 rows per accession.

In addition to monoculture treatments, 3 rows of 'Citrus' maidencane were established in plots that were then hand broadcast with a mixture of gamagrass (0.25 seed/ft^2), switchgrass and chalky bluestem at a rate 15 pls/ft^2 each. All plots were packed with a cultipacker before and after seeding.

Table 19. One-year percent canopy cover of native species on Cargill lake shoreline at three levels on the slope.

Accession	Lower Slope	Middle slope	Upper Slope
	Average % Canopy Cover		
Halifax Maidencane	10	7	5
Citrus Maidencane	29	15	13
Chalky Bluestem	10	7	9
Gama – 9059213	15	15	11
Gama – 9059264	22	16	11
Switchgrass – Alamo	27	23	28
Switchgrass – 9060500	30	34	39

One-year evaluations were conducted on August 29, 2000. Measurements were taken at the top of the slope, in the middle, and at the base of the slope next to the water line, to observe the effect of moisture on establishment. Despite extremely droughty conditions, all species established well in the first year. Dry conditions did inhibit establishment on the upper slopes. Average percent canopy cover for each accession is shown in Table 19. Numbers do not include the amount of canopy cover provided by weeds in the plots. Overall, switchgrass produced the densest canopy of the four species, due in part to a high seeding rate. Dense stands substantially suppressed weed competition in the switchgrass plots. 'Citrus' maidencane very aggressively colonized the area next to the water.

General planting recommendations for eastern gamagrass call for a dormant winter seeding in which seed is planted in the late fall. This allows seed to undergo a cold stratification period that stimulates seed germination in the spring. Eastern gamagrass is typically slower to establish because of seed dormancy, but germinated well at this site. A surprising number of eastern gamagrass seedlings emerged between August and December in 1999 (Table 20). Accession 9059213 showed little change in plant densities between the 5-month and 1-year evaluations, except near the waterline. Several small seedlings were seen emerging at the time of the 1-year evaluation. Accession 9059264, had relatively higher emergence shortly after planting than did 9059213.

Possibly due to the drought, plant densities had actually decreased in 9059264 plots after 1 year.

Table 20. Five month and one-year stand densities of 2 eastern gamagrass accessions at Cargill lake shoreline; measurements taken at three levels above the waterline.

Accession	Lower Slope	Middle slope	Upper Slope
	Average Plants/m^2		
Gama – 9059213 (5 months)	3	4	3
Gama – 9059213 (1 year)	7	4.3	3.5
Gama – 9059264 (5 months)	15	10	11
Gama – 9059264 (1 year)	11	7	7.3

Chalky bluestem plants were generally smaller at one year of age than the other species in the study (Table 21) and had less canopy closure. Although not as tall as switchgrass, the gamagrass plants grew surprisingly tall in the first year. Nutrient rich muck soils contributed greatly to the height of this nitrogen-loving species.

Table 21. One-year plant height of native species at Cargill lake shoreline; measurements taken at three levels above the waterline.

Accession	Lower Slope	Middle slope	Upper Slope
	Plant Height (cm)		
Halifax Maidencane	38	42	33
Citrus Maidencane	64	55	65
Chalky Bluestem	57	49	42
Gama – 9059213	61	65	66
Gama – 9059264	56	59	54
Switchgrass – Alamo	75	77	87
Switchgrass – 9060500	73	72	72

Gamagrass did not emerge from the mixture seedings (Table 22). Since mixture plots were broadcast instead of planted in a row, it appears that the seed was planted too shallowly to promote emergence. Switchgrass and maidencane tended to dominate the mixture plots. Chalky bluestem established only on the two lowest levels evaluated. Competition from the other species may have inhibited chalky bluestem establishment.

Based on the results of this study thus far, chalky bluestem has potential to add diversity to a native lowland mix. However, due to its slower growth, it is not as useful for controlling soil erosion as switchgrass and maidencane. Despite the late August seeding date, the other 3 species established well before being slowed by winter frosts. If gamagrass is to be used as the primary erosion control agent when planting on slopes, results from this study suggest that either the seeding rate needs to be increased, or the seed needs to be pretreated so that it is prepared to germinate at the time of planting. A nurse crop may also be helpful. Plots will continue to be evaluated for two more years.

Table 22. One-year percent canopy cover provided by native species planted as a mixture at Cargill lake shoreline at three levels above the waterline.

Accession	Lower Slope	Middle slope	Upper Slope
	Average % Canopy Cover		
Citrus Maidencane	12	11	12
Chalky Bluestem	6	6	
Gama – 9059213			
Switchgrass – 9060500	25	18	17
Total	43	35	29