DEVELOPMENT OF SEED SOURCES AND ESTABLISHMENT METHODS FOR NATIVE UPLAND RECLAMATION

1997 ANNUAL REPORT

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FLORIDA INSTITUTE OF PHOSPHATE RESEARCH
1855 West Main Street
Bartow, Florida 33830 USA

Contract Manager: Dr. Steven G. Richardson
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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 no 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 increased 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 targeted 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 new promising species will be collected, (in addition to those species targeted 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:

Several hand collections of a variety of species were collected from around the state in the fall of 1996. These are listed in the seed evaluation tables in the following section.

Collections of lopsided indiangrass (*Sorghastrum secundum*) and chalky bluestem (*Andropogon virginicus* var. *glaucus*) were assembled in the fall of 1996 for the purpose of cultivar development. These assemblies will be discussed more fully under the evaluation section of this report.

Sky Blue Lupine (*Lupinus diffusus*) was collected from two separate sites in May of 1997. This is a perennial legume which has fair seed production and good potential for use in a native seed mix. Conventional equipment can be used for harvest and direct seeding of lupine seed.

Collections of wiregrass (*Aristida stricta*) and hairawn muhly (*Muhlenbergia capillaris*) are currently being assembled from around the state. However, because wiregrass does not produce viable seed without a growing season fire, and muhly seed viability is often poor, these species are usually being collected vegetatively. It is expected that these assemblies will not be completed until 1998.

Native Site Flail-Vac Collections:

In Oct. of 1996, 36 pounds (bulk material) of lopsided indiangrass was collected from a Ft. Cooper State Park sandhill site. This site had been burned in April of 1995. The germination rate of unconditioned seed was 20%.

In Nov. of 1996, 36 pounds of wiregrass (bulk material) was collected from a flatwoods site at Avon Park A.F. Bombing Range. This site had been burned 7/2/96. The germination rate of unconditioned seed was 44%.

In Oct. of 1997, 66 pounds (bulk material) of lopsided indiangrass was collected from Ft. Cooper State Park. Part of the collection site was burned 4/95 and part burned 5/96. Germination test results are not yet available.

At the writing of this report, preparations are being made to collect wiregrass from Avon Park A.F.Bombing Range in late Nov. of 1997

SEED AND PLANT EVALUATIONS

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

Native Site Hand Collections:

Table 1. 1996 Native Site Collection Lab and Greenhouse Germination Results

Species	Acc. Number	Origin	Collect. Date	Lab Germ %	Hard Seed %	G.H. Germ %
Andropogon arctatus	9060084	Ft. Cooper	11/14/96	28	12	
A. gyrans	9060387	Osceola Co.	12/2/96	64	1	47
A. ternarius		Ft. Cooper	11/14/96	22	20	
Carphephorous corymbosus	9060291	Osceola Co.	11/6/96	15	0	15
	9060292	Osceola Co.	11/6/96	24	0	17
	9060385	Osceola Co.	12/2/96	50	0	35
Chasmathium laxium	9060364	Sumpter Co	12/3/96	17		
Ctenium aromaticum	9060369	Avon Park	11/96	19		
Elephantopus elatus	9060211	Citrus Co.	10/29/96	12	0	7
	9060367	Avon Park	11/19/96	15	1	
Eragrostis elliotii	9060374			31	0	72
Helianthus Radula	9060290	Osceola Co.	11/16/96	74	1	56
	9060386	Osceola Co.	12/3/96	73	1	56
Liatris elegans	9060222	Santa Rosa	10/10/96	29	2	12
Liatris elegans	9059730	Citrus Co.	11/96	37		
L. gracillis	9060217	Osceola Co.	10/13/96	40	0	23
	9060397	Osceola Co.	12/2/96	52	0	37
L. tenuifolia	9059731	Ft. Cooper	11/14/96	38	21	
	9060370	Avon Park	11/96	68		
Oplismenus setarius	9060225	Osceola Co.	11/1/96	1	69	0
Panicum anceps	9060212	Osceola Co.	10/10/96	0	50	7
	9060218	Brevard Co.	11/18/96	0.25	44	22
	9060366	Osceola Co.	11/22/96	0	51	3
	9060368	Highlands	11/20/96	0	53	0
	9060373	Brevard Co.	11/19/96	0	49	6
	9060398	Osceola Co.	12/2/96	0	33	5
	9060399	Osceola Co.	12/3/96	0	24	0
Panicum longifolium	9060365	Sumpter Co.	12/3/96	0	83	5
Panicum virgatum	9059784	St. Lucie Co	10/3/96	0		
	9060100	Osceola Co.	9/20/96	0	0.5	4
	9059616	Def. Springs	10/11/96	0.25	7	
Schizachyrium scoparium	9060083	Ft. Cooper	11/14/96	0.25	0	
Sorghastrum nutans	9060224	Union Co.	10/29/96	0	0	0
Tridens flavus	9059726	Hernando C.	11/14/96	90		
Triplasis americana	9060384	Osceola Co.	12/2/96	23	22	43

Native site seed germination results conducted in a laboratory germinator are listed above in Table 1. All tests were conducted according to the Association of Official Seed Analyst seed testing procedures, if they were available for the given species. If not, those procedures for similar species were used. Several of the forbs displayed very good

germination rates. The *Andropogon* species had fair germination. The *Panicm anceps* collections from native sites had very poor germination in the lab. However, there was a large percentage of hard seed, indicating seed dormancy.

Germination tests were also conducted on several species in the greenhouse. Seeds from each species were seeded into potting soil in multi-cell trays. Ten seeds were placed in each cell, six cells were seeded per species. Planting date was March 3, 1997. Emergence was recorded every 7 to 10 days for 60 days. Total emergence is shown in Table 1. This study provided initial seed viability and performance information on a broad spectrum of species.

It is interesting to note that greenhouse germination actually exceeded laboratory germination results for several species, especially the hard seeded *Panicum* species. This would indicate that there are indeed dormancy mechanisms involved. It was also noted that these hard seeded species germinated over a longer period of time than did other species in the study. For instance, *Panicum anceps* accessions germinated over a period of three months, while most other species germinated within the first month.

Minedland Field Plantings:

If adequate seed was available, those native collections with potential for use on reclaimed minedlands were put in field trials. In Jan. of 1997, seven species were each planted in an 18 foot row on both overburden and sand tailing reclaimed minedland soils. Spacing between rows was 3 feet. Planting depth was 1/2 to 3/4 inches. Debearded and unconditioned wiregrass and indiangrass seed were planted to determine if debearding affects seedling emergence. In May 1997, thirteen accessions of native species were established in 18 foot rows on both soil types. Planting depth was 1/2 to 3/4 inches, except in the gamagrass, which was planted approx. 1 inch deep. Germination and purity were obtained prior to planting to determine percent pure live seed (pls). Seeding rate was 40 pls/linear foot, except in gamagrass, for which the rate was approx. 3-4 pls/linear foot. Species planted are shown in Table 2.

Table 2. Native Seed Collections Planted on Overburden and Sand Tailing Soils in January and May of 1997

January 1997 Planting		**May 1997 Planting**	
Species	**Accession Number**	**Species**	**Accession Number**
'Alamo' Switchgrass		'Alamo' Switchgrass	
Purpletop	9059726	Purpletop	9059726
Chasmathium laxium	9060364	*Chasmathium laxium*	9060364
Chalky bluestem	9059754	Chalky bluestem	9059754
Toothachegrass	9060369	Toothachegrass	9060369
Liatris elegans	9059730	*Liatris elegans*	9059730
Liatris tenuifolia	9060370	*Liatris tenuifolia*	9060370
Wiregrass-uncondition.	9060362	*Andropogon arctatus*	9060084
Wiregrass-debearded	9060362	*Andropogon gyrans*	9060387
Lopsided indiangrass -	9059727	*Helianthus radula*	9060290

unconditioned			
Lopsided indiangrass - debearded	9059727	*Sporobolus junceus*	9060098
		Eastern gamagrass	9059213
		Eastern gamagrass	9059215

January plantings were evaluated six months after planting. The results are shown below in Table 3. 'Alamo' switchgrass was used as a standard of comparison. In overburden plots, *Liatris tenuifolia* and the unconditioned wiregrass were the only species which had similar vigor to 'Alamo'. Surprisingly, purpletop and chalky bluestem emerged in this upland environment. They are typically found in wetter areas. It also appears that debearding wiregrass seed may affect seedling establishment on overburden soils. However, this trend was not apparent on the sand tailing soils.

Wiregrass and indiangrass performed as well as 'Alamo' on sand tails, but the two species with the most surprising response were purpletop, and *Liatris elegans*. Both species had vigor equal to or greater than that of 'Alamo'. The purpletop was dark green in color and forage production was relatively abundant. It looked much healthier on the sand tails than it did on the overburden soils. The *Liatris elegans* was also much healthier on the sand tails than on the overburden. One plant in the row was even preparing to bloom. These responses are surprising because of the low fertility and droughty nature of the sand tailing soils. There was very little weed competition on sand tailing soils, so seedlings with the ability to search deeper into the soil profile may have been able to find adequate moisture for their needs.

Plots will continue to be monitored for persistence for two years, and the May plantings will also be evaluated at six months. It is too early yet to make any definite conclusions, however, purpletop and the *Liatris* species may be good candidates for use in a winter direct seeded mix.

Table 3. Six Month Evaluation Results of Native Seed Collections Planted on Overburden and Sand Tailing Soils in January of 1997

Species	Accession Number	Avg. Plants/ft	Plant Ht.	Plant Wd. Canopy	Plant Wd. Basal	Vigor (1 to 9)*
Overburden:						
Alamo		**26**	**20 cm**	**7 cm**	**2 cm**	**5**
Purpletop	9059726	6	6	9	1	7
Chasmanthium	9060364	0				
Chalky B.S.	9059754	2	6	4	1.5	6
Toothachegrass	9060369	0				
Liatris elegans	9059730	4	6	2	1	7
Liatris tenuifol.	9060370	**5**	**8**	**4**	**1**	**5**
Wiregrass (unc)	9060362	**6**	**20**	**18**	**3**	**5**
Wiregrass (db)	9060362	8	14	7	1	6
Indiangrass(unc)	9059727	6	12	4	1	6
Indiangrass(db)	9059727	7	9	3	1.5	6

Species	Accession Number	Avg. Plants/ft	Plant Ht.	Plant Wd. Canopy	Plant Wd. Basal	Vigor (1 to 9)*
Sand Tailings:						
Alamo		**12**	**10**	**7**	**1**	**5**
Purpletop	9059726	**8**	**11**	**9**	**1.5**	**4**
Chasmanthium	9060364	0				
Chalky B.S.	9059754	0				
Toothachegrass	9060369	0				
Liatris elegans	9059730	**11**	**6**	**3**	**1**	**5**
Liatris tenuifol.	9060370	2	7	3	0.5	7
Wiregrass (unc)	9060362	**7**	**10**	**10**	**1**	**5**
Wiregrass (db)	9060362	**6**	**12**	**7**	**1**	**5**
Indiangrass(unc)	9059727	**6**	**10**	**7**	**1**	**5**
Indiangrass(db)	9059727	**4**	**10**	**6**	**1**	**5**

* 1= greatest vigor, 9 = a dead plant; ** 1 = greatest resistance, 9 = a dead plant

Plant Materials Center Species Evaluation Plots:

Under the previous FIPR agreement, collections of several promising species were started in the greenhouse, and than transplanted into small plots at the FLPMC. Establishment dates vary from 1995 to 1997, depending on when the materials became available. Plot size is five feet by ten feet. Plots are irrigated, and weeds are controlled using chemical and mechanical methods. The purpose of these plantings is to study growth characteristics, seed production and viability under controlled conditions. Accessions under evaluation are listed in Table 4.

Table 4. Accessions currently being maintained at the Plant Materials Center

Species	Accession No.	Species	Accession No.
Andropogon arctatus	9060084	*Schizachyrium stoloniferum*	9060083
Andropogon tenarius	9060379	*S. stoloniferum*	9060403
Ceratiola ericoides	9060229	*S. stoloniferum*	9060404
Muhlenbergia capillaris	9059694	*S. stoloniferum*	9060405
M. capillaris	9059716	*S. stoloniferum*	9060406
M. capillaris	9059717	*S. stoloniferum*	9060407
M. capillaris	9059720	*S. stoloniferum*	9060408
Panicum anceps	9060087	*Sporobolus junceus*	9059564
P. anceps	9060088	*S. junceus*	9060098
P. anceps	9060089	*S. junceus*	9060099
P. anceps	9060090	*Tridens flavus*	9059726
P. anceps	9060091	*T. flavus*	9059732
P. anceps	9060092	*T. flavus*	9059735
P. anceps	9060093		

In the fall of 1996, seed was gathered from those accessions which flowered. This seed was then tested in the lab for percent germination. The results are listed below in Table 5. Seed from most accessions was collected on two different occasions. Despite prolific flowering, very little viable seed was produced by the Muhly accessions. One accession, 9059720, which originated in Levy Co., did have some viable seed. It also germinated in greenhouse tests.

Collection dates did not appear to affect germination rates in the *Panicum anceps* accessions either. All accessions produced fair quantities of hard seed, however, there appears to be dormancy problems, because actual germination rates were very low. Seed from this species will require further testing to find methods to break seed dormancy.

Table 5. 1996 PMC Plot Seed Collections and Laboratory Germination Results

Species	Accession Number	Collection Date	Lab Germ %	Hard Seed %	G.H. Germ %
Muhlenbergia capillaris	9059694	10/24/96	0	0	0
	9059715	11/12/96	0	0	
	9059716	11/12/96	1	0	
	9059720	11/12/96	1	1	5
	9059720	10/24/96	1	0	
Panicum anceps	9060087	9/25/96	0.25	55	
	9060088	9/25/96	0	46	
	9060088	10/25/96	0	53	
	9060089	9/24/96	0	53	
	9060089	10/25/96	0	56	
Panicum anceps	9060090	9/25/96	0	55	
	9060090	10/25/96	0	62	
	9060091	10/25/96	0.25	60	
	9060092	9/25/96	0	56	
	9060092	10/25/96	0	55	
	9060093	9/25/96	0	54	
	9060093	10/25/96	0	57	

Eastern Gamagrass Seed Viability Study:

In an effort to develop a seed source for eastern gamagrass, a collection of over 75 gamagrass accessions at the PMC were screened for seed production potential. Twelve accessions were selected for further study. In 1996, ripe seed was collected every 7-10 days, beginning 6/13 and ending 8/29. Collected seed was then weighed, counted and cut open to determine presence of viable seed. This method was employed rather than conducting germination tests, because gamagrass seed has been known to undergo dormancy. Percent viable seed verses collection date data for six selected accessions is

shown in Figure 1. From this data, it appears that the peak percentage of viable seed occurred between 7/24 and 8/2 in 1996 for most accessions.
The percent viable seed was multiplied by the number of seed collected, to obtain average number of pure live seed produced per rep. Results are shown in Figure 2. Accessions which produce highly viable seed may not necessarily produce large quantities of seed. A desirable cultivar would have both high seed production and high seed viability. Peak pure live seed occurred between 7/15 and 7/24 in 1996, for four of the six accessions shown here.

Results from 1996 gamagrass seed collections were used to identify candidates for seed collection in 1997. A field of thirteen candidates was selected (two of the accessions collected in 1996 were dropped, and three more added). The first collection was made on 6/16, and the last was made on 8/29. Seed was collected on nine occasions. Growth characteristics of each accession were also evaluated, to observe such things as quantity of seed stalks, seed stalk lodging, and seed stalk height. These factors will influence the success of collecting seed mechanically, on a large scale. Seed will be tested for viability in early 1998 as time permits.

In addition, seed was collected from 9055975, 9059213 and 9059215 germplasm increase blocks. These three accessions were selected in initial evaluation trials at the FLPMC, and increased for further testing. The latter two accessions had high seed viability and production in 1996 studies. This seed will be used for further direct seeding studies in the greenhouse and field.

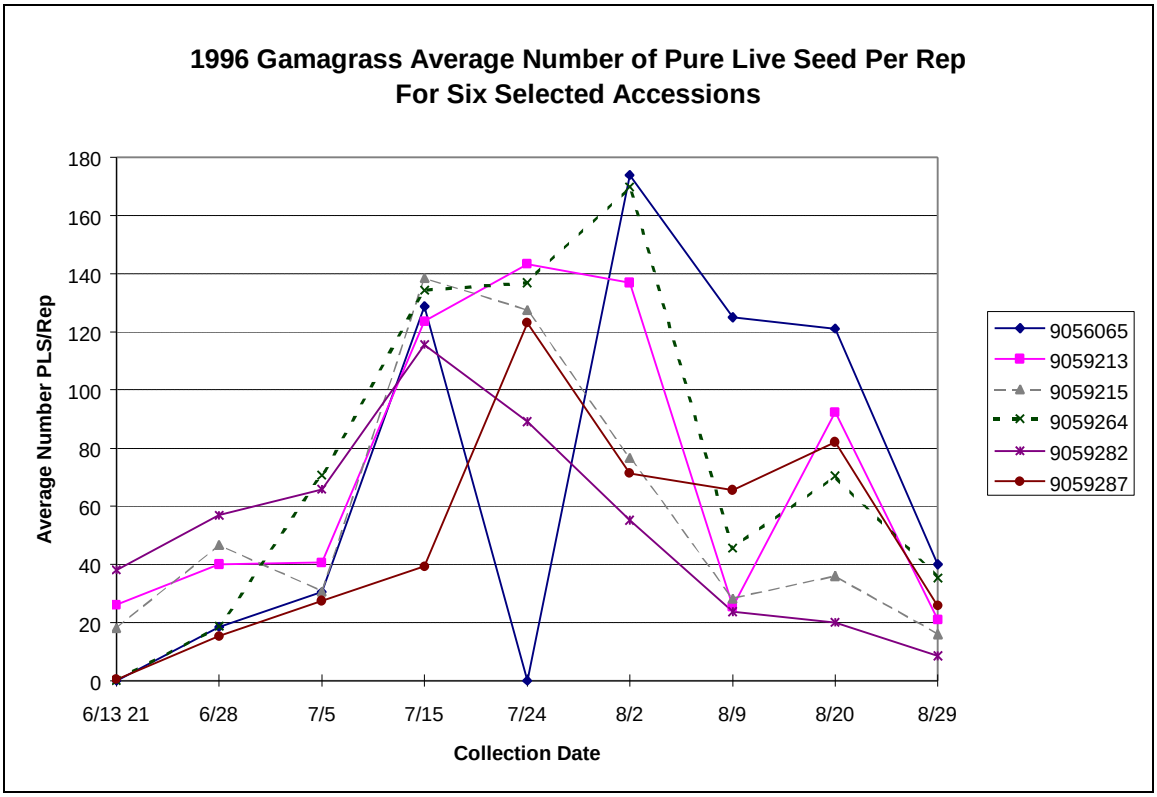

Figure 1. Viable Seed Verses Collection Date for Eastern Gamagrass in 1996

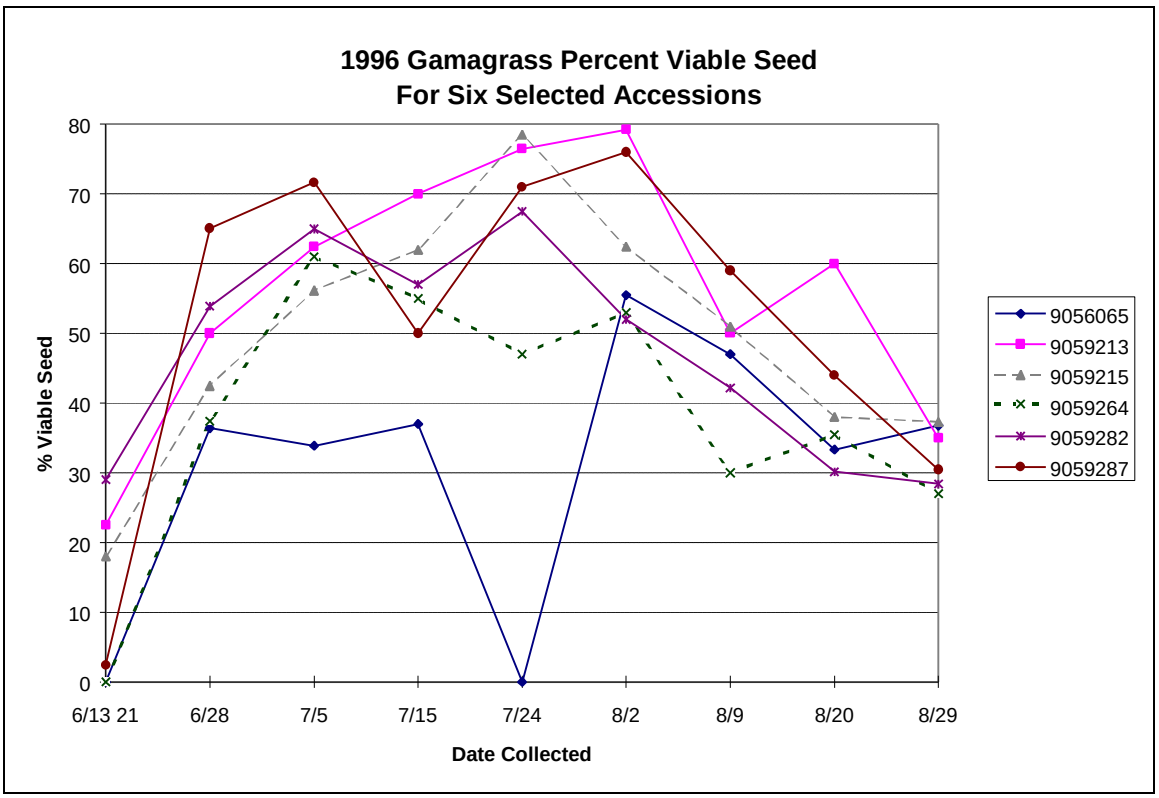

Figure 2. Pure Live Seed Verses Collection Date for Eastern Gamagrass in 1996 Initial Evaluations For Cultivar Selections:

Lopsided Indiangrass: Indiangrass was assembled in the form of seed from 48 of the 67 counties in FL, in the fall of 1996. When combined with the accessions collected under the previous FIPR agreement, the assembly totaled 138. These accessions were then planted in the greenhouse in January of 1997. Seedlings were established in the greenhouse rather than simply direct seeding for two reasons. First, it was not known how successful direct seeding would be. Prior direct seeding efforts at the PMC had not been entirely successful. Secondly, several accessions did not have adequate quantities of seed available for direct seeding. Greenhouse seedlings were transplanted to replicated field plots in early November of 1997. The planting site was an irrigated well drained field of predominately Kendrick fine sand.

Those accessions with adequate seed were direct seeded on two PMC sites in late January of 1997. The first site is an irrigated well drained field of predominately Kendrick fine sand. The second site is a non-irrigated well drained field of predominately Kendrick fine sand and Sparr find sand. Direct seeded plots were evaluated at 2 months and 9 months after planting for forage production, vigor, drought and disease resistance. At the 9 month evaluation, plots were also evaluated for seed production. Weeds were controlled by hand hoeing, tilling and with chemical herbicides.

'Lometa' yellow indiangrass was used as the standard of comparison. A large percentage of accessions in the direct seeded trials were able to perform as well or better than 'Lometa'. In fact, on the non-irrigated site, three accessions besides 'Lometa' were robust enough to produce seedheads. On the irrigated site, 27 accession produced

seedheads. Origin of these accessions ranged throughout the state. Initial evaluation trials will continue for another two to four years, in order to evaluate plant performance and persistence.

Chalky Bluestem Assembly: Chalky bluestem was assembled in the form of seed from 43 counties in FL, in the fall of 1996. A total of 91 accessions were collected. All accessions were established in the greenhouse in January of 1997. These seedlings were then transplanted into replicated field trials in September of 1997. The planting site is a poorly drained irrigated field of predominately Blichton loamy fine sand.

Those accessions with adequate seed were also direct seeded on two sites in early February of 1997. The first site is a well drained irrigated field of predominately Kendrick fine sand. The second site is a poorly drained irrigated field of predominately Blichton loamy fine sand. Direct seeded plots were evaluated at 2 months and 9 months after planting for forage production, vigor, drought and disease resistance. At the 9 month evaluation, plots were also evaluated for seed production. Weeds were controlled by hand hoeing, tilling and with chemical herbicides.

The direct seeding trials were tremendously successful. Many accessions emerged and were vigorous enough to produce seedheads. The poorly drained site is subject to severe weed competition. Many accessions were able to emerge and become established on this site. Initial evaluation trials will continue for another two to four years, in order to evaluate plant performance and persistence.

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. To date, production fields of one legume and four grasses have been established.

Croom Lopsided Indiangrass:

Lopsided indiangrass is one of the dominate grass species in healthy native upland ecosystems. It provides ground cover for erosion control and maintaining water quality. It is readily grazed by livestock, and provides cover and some food for wildlife. In minedland direct seeding studies conducted under the previous agreement, indiangrass had greater seedling emergence and vigor than any of the other Florida native species tested.

Lopsided indiangrass has good seed production. However, seed viability is relatively low. Samples collected from native sites under the original agreement had germination rates of 15 - 30%. Fire is not necessary to stimulate seed production in indiangrass. In fact, it has been observed that plants in native sites do not flower during the burn year, even after a winter burn. There is some thought however, that burning stimulates seed production and viability in the two to three years following a burn.

An irrigated field of lopsided indiangrass was established at the FLPMC in March of 1996. Soils on this site are predominately Kendrick fine sand, which is well drained, and Flemington fine sandy loam, which is somewhat poorly drained. The seed source was from a sandhill site in the Croom Wildlife Management Area in Hernando Co. Seedlings were grown in trays (cells were four inches wide and deep) in the greenhouse and then transplanted to the field, being placed on two foot centers. Despite planting into a field which had been kept clean tilled for a year, weed competition was severe. Crab grass (*Digitaria sanguainalis*) was especially a problem, as it could not be chemically controlled, and it choked out a large percentage of the transplants.

During the 1997 growing season, weeds were chemically controlled with glyphosate and 2,4-D (2,4-dichlorophenoxy) acetic acid. A backpack sprayer with a shielded nozzle was used to control drift of glyphosate around established plants. Other chemicals need to be tested which will control weedy grass species without harming the lopsided indiangrass seedlings.

More seedlings were established in the greenhouse in late 1996, to fill in vacant areas. These seedlings were grown in six-inch tubeling trays, to allow the transplants to have a deeper, more vigorous root system at the time of planting. Approximately 1500 seedlings were planted in the established plot to fill in vacant areas in late September of 1997. An additional 1500 seedlings were planted in an adjacent clean tilled plot, so that the entire field now measures 60' x 210' (0.28 acres). To date, almost all of these transplants have survived and look healthy and vigorous. Weed competition still exits. However, we hope that by planting in the fall instead of the spring, the indiangrass plants will be well established and able to compete with weedy species during the following growing season. After observing the success of the direct seeded lopsided indiangrass cultivar trials discussed in the previous section, it appears that a direct seeded winter planting may be more successful and more economical than attempting to establish a production field with transplants.

A few of the established plants from the 1996 planting produced a small quantity of seed. Germination rate was 11%. The 1996 transplants continued to increase in size during the 1997 growing season, some reaching a height of five feet. Almost all produced seed in 1997. Approximately 2.5 pounds of seed was collected by hand on 10/22/97. Seed viability data is not yet available.

New transplants in this production field will be given one more year to establish. If this is adequate, clipping, burning and fertilization treatments will be applied to subplots to test methods for increasing seed production and viability on this species.

Avon Park Wiregrass:

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, and it provides cover and nesting sites for wildlife.

A growing season fire is necessary to stimulate seed production. When burned, wiregrass produces a fair quantity of seed, however seed viability varies greatly. Seed collected under the previous agreement had germination rates of 0 to 48%. It appears that summer burns (May through July) produce higher seed viability than winter burns. A smut-type fungus has also been observed in the seed of this species. It is unknown how this fungus affects seed viability.

An irrigated field of wiregrass was established at the FLPMC in late February of 1996. 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. The seed source was from a flatwoods site on the Avon Park Air Force Bombing Range in Polk Co. Seedlings were grown in trays (cells were four inches wide and deep) in the greenhouse and then transplanted to the field, being placed on two foot centers. The field had been kept clean tilled for two years prior to planting, and weed competition was minimal. Survival of seedlings was fair, with some spots needing to be replanted. Weeds were controlled chemically and by hand hoeing. Chemical herbicides used to control broadleaf weeds and sedges were 2,4-D (2,4-dichlorophenoxy) acetic acid and bentazon respectively. If necessary, a backpack sprayer with a shielded nozzle to control drift was used to spray glyphosate between rows of established plants. Other chemicals which can be used to control weedy grasses in wiregrass fields need to be studied, to insure successful stand establishment.

More seedlings were established in the greenhouse in late 1996, to fill in vacant areas. These seedlings were grown in six-inch tubeling trays, to allow the transplants to have a deeper, more vigorous root system at the time of planting. Several hundred seedlings were planted in the established plot to fill in vacant areas in October of 1997. An additional 1500 seedlings were planted in an adjacent clean tilled plot, so that the entire field now measures 40’ x 390’ (0.35 acres). New transplants in this production field will be given one more year to establish. If this is adequate, clipping, burning and fertilization treatments will be applied to subplots to begin testing methods for increasing seed production and viability on this species.

Direct seeding studies conducted under the previous agreement have shown that wiregrass seedlings lack vigor, and are highly sensitive to any form of weed competition. Healthy plants, however, appear to be quite persistent once they are established. Direct seeding wiregrass efforts at the FLPMC have not been successful on a small scale, most likely because of the severity of weed competition in the irrigated fields. However, wiregrass has been successfully direct seeded on reclaimed minedland, as will be discussed later. The feasibility then, of successfully establishing a production field vegetatively verses direct seeding, would depend on the soils, expected weed competition, available moisture, etc.

Almost all of the original transplants flowered in the fall of 1996. Seed was collected using the Flail-Vac Seed Stripper. One pound of seed was obtained. Germination rate was 18%. Most of the plants flowered again in 1997. A harvest is not

planned this year, as the tractor tires will damage the recently transplanted seedlings. That the established plants continue to flower is unusual, as they have not undergone any form of clipping or burning since they have been established.

Wekiwa 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 this hypothesis, and also to determine if a xeric ecotype responds differently 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 acreages 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 us enough of this 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 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 will be given one year to establish. If this is adequate, burning and fertilization treatments will be applied to subplots to begin testing methods for increasing seed production and viability on this species.

'Miami' - 'Stuart' Switchgrass Crossing Block:

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.

The FLPMC has recently released (vegetatively) two strains of Florida native switchgrass, selected from an assembly which had undergone initial and advanced cultivar selection trials. Both strains have excellent forage production and persistence. Both flower prolifically every year. However, seed viability is very low because the caryopsis rarely fills. This has been a common problem in switchgrass throughout Florida. Even 'Alamo', a cultivar released from Texas, produces less viable seed when grown at the FLPMC, then when grown further north.

In 1991, vegetative material of three Florida accessions (including 'Miami' and 'Stuart') 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 factors are involved.

Both 'Miami' and 'Stuart' had been increased from a single plant. Since switchgrass plants are self-incompatible, it was thought that crossing these two accessions may stimulate seed production. After consulting with Ken Vogel, ARS Research Geneticist at University of Neb., a plan to develop a crossing block was developed. Root stalk of both accessions was established in the greenhouse. Tubelings were then transplanted to an irrigated field on 5/3/96. Soils on this site are predominately Kendrik fine sand, which is well drained. The two accessions were randomly mixed, and placed on three and one-half foot centers. Spacing was left this large, to allow the field to be tilled every year, to trim plants and keep them from growing together. Total plot size is 42' x 54' (0.05 ac.)

Most plants flowered in 1996. However, ripening was very uneven between strains and also between individual plants. 'Stuart' typically flowers and ripens several days before 'Miami'. A small amount of seed was gathered and tested for germination. There was a substantial percentage of hard seed, but less than 1% of the seed germinated in the laboratory germinator. Prechill treatments were not applied to this seed prior to testing. Seed dormancy is known to be a problem in switchgrass. The most common and economical method to overcome this is allowing the seed to age one to two years before planting. Seed gathered in 1996 will be tested again in 1997 for germination.

The crossing block was burned on 2/27/97, and tilled between rows in both directions. Half of the plot was fertilized on 7/18/97, with 10-10-10 at a rate of 100 pounds per acre. Fertilization was delayed until seed set with the hypothesis that the nutrients would be used for the development of viable seed rather than for foliage production. Two rows of plants were also clipped to 14 inches to determine if clipping would stress the plant and trigger it to develop viable seed.

The results were as follows: Clipping caused uneven tiller maturity. Some tillers contained ripe seed while others were just flowering. This does not appear to be a favorable practice for stimulating production of viable seed.

In the main block, it has not yet been determined whether fertilization increased viable seed production. However, in both fertilized and unfertilized plots, a substantial amount of hard seed was produced. Both plots were harvested using a Massey-Ferguson combine, model no. 940056Z1. However, 'Stuart' was ripe before 'Miami', so it was difficult to stage collection. Seed was also collected from the isolated germplasm blocks of both 'Miami' and 'Stuart', and it appeared that hard seed production in these blocks was extremely low. This would indicate that crossing these two species does indeed stimulate production of viable seed. Total seed harvested from both fertilized and unfertilized plots was approx. 3 pounds (66 lbs./ac.), however, some seed was lost by the full-sized combine used to harvest the plots. Results from laboratory germination tests are not yet available. The block will continue to be maintained and seed production monitored in 1998.

Pasco Purpletop:

Purpletop is a bunchgrass typically found in mesic flatwoods and hardwood hammocks. It is grazed by livestock and provides cover and food for wildlife. It provides ground cover in mesic areas, which limits erosion and increases water quality. It has good seed production. Viability often ranged between 80 and 90% in ripe seed in tests conducted under the previous agreement. Seed can be readily harvested and planted with conventional equipment, making this a good candidate for use in a mesic seed mix.

An irrigated production field of this species was established in 1996 to study cultural management methods for this species. Plot size is 30' x 40' (0.03 acres). Soils on this site are predominately Blichton loamy fine sand, which is poorly drained. The seed was originally collected in Pasco Co. in 1995. It had very high germination (85%) and a substantial amount of seed had been collected. Seedlings were established in tubeling trays in the greenhouse in 1995. On 9/6/96, 1,300 seedlings were transplanted to the field, which had been clean tilled for one year. Plants were placed on one foot centers. It was thought that the narrower spacing might allow for less weed competition on this site. Weed competition is much more severe in wet sites verses well drained sites.

No weed control was conducted on this field during 1997. The primary weed competition came from carpetgrass (*Axonopus* spp.), which is low growing, and could not smoother the purpletop plants. On 6/27/97 half of the field was fertilized with 10-10-10 at a rate of 100 pounds per acre. Increased foliage and seedhead production from this fertilizer treatment was strikingly obvious.

On 10/16/97 a 6' x 30' strip was harvested from the fertilized and unfertilized treatment. Harvesting was done by clipping seed stalks by hand. Seedheads were allowed to dry for several days, and then separated from the chaff using a hammermill, air-screen cleaner and an aspirator. Quantity of cleaned seed produced on the unfertilized treatment was 35 grams (19 pounds/acre). Quantity of cleaned seed produced on the fertilized treatment was 98 grams (53 pounds/acre). Addition fertilizer applications may increase seed production even more. This will be investigated in 1998.

Fort Cooper Partridge Pea:

Partridge pea seed is a robust reseeding annual. It readily colonizes disturbed sites, and is able to compete well with other species. It 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. Partridge pea can be harvested and planted with conventional equipment. It is a very good candidate for use in a native seed mix for xeric sites.

Cultivars of partridge pea are available commercially, however, there have been no cultivars released which are native to Florida. A 22' x 62' plot (0.03 ac.) of partridge pea was established on an irrigated site in May of 1996, to observe this species under cultivation. Seed was collected from Fort Cooper State Park in Citrus Co., in the fall of 1995, and direct seeded into the PMC field in 1996. Soils in this field are well drained Kendrick fine sands. The seed was not scarified. The seeding rate was 40 pls/linear ft., based on germination rates in the laboratory germinator. Row spacing was one foot.

A good stand of partridge pea was established and seed was collected in the fall of 1996. Seed production was rather poor, with seed being small and shrunken. A total of

0.25 lbs. of seed was collected in 1996. It was thought that the seeding date may have been too late to encourage greater seed production. Because of the hard seed coat, partridge pea may actually benefit from being seeded into the field in late fall or early winter. This is the time the seed would normally be incorporated into the soil in native situations.

In 1997, hard seed planted in 1996 once again emerged to produce a fair stand. This was allowed to produce seed, which was collected in September of 1997. Germination tests results and total seed yield are not yet available.

RECLAIMED MINEDLAND DIRECT SEEDING STUDIES

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

Reclaimed Minedlands Native Species Planting Date - Seeding Methodology Trials:

Introduction: In 1995, under the previous agreement with FIPR, the FLPMC established seeding methodology trials on two reclaimed minedland sites, using wiregrass and lopsided indiangrass. Plots were planted in the early summer, at the beginning of the rainy season. Despite problems with severe competition from introduced pasture species, much information was gathered from these studies. Indiangrass readily established, although plant densities were low. Wiregrass did not readily establish.

The cause of the low plant densities in these studies was thought to be primarily due to the following factors: Season of seeding, seeding rate and weed competition. Problems associated with the three seeding methods employed in this study also contributed to poor stand establishment. Drilling showed good potential for use in establishing indiangrass. However, the drill used in the initial study was not capable of handling light chaffy seed.

The objective of the current study is to research the effect of planting date and seeding method on the establishment of wiregrass and indiangrass in monoculture and mix.

Literature Review: Prior to the 1995 FLPMC study, the only recent research had been conducted by Bisset. She and her associates had successfully established several native species by broadcasting chopped native seed material on a reclaimed minedland site in December of 1994. (Bissett, 1995) Wiregrass established very well in this study. Season of seeding, seeding rate and less weed competition may have had the greatest influence on establishment success, since soils and seeding methods were similar in the 1995 FLPMC study.

In the FLPMC study, an indiangrass seeding rate of 20 pls/ft^2 produced about half of the desired plant density in the drill treatment, and one quarter in the broadcast treatment on overburden soils. Therefore, a seeding rate of 40 to 80 pls/ft^2 should be adequate to produce a successful stand. The wiregrass broadcast method used by Bisset produced an approximate seeding rate of 50 pls/ft^2 (personal conversation). Other published research will continue to be reviewed as it comes available.

Materials and Methods: In this study, two series of plantings of wiregrass and lopsided indiangrass were direct seeded in monoculture and mix. The first series was planted 1/28/97, the second 5/20/97. The planting site was reclaimed minedland provided by Cargill Fertilizer, Inc. It is composed of three acres of sand tailings, and an adjacent three acres of sand tailings capped with 6 or more inches of overburden soils. A cross section of soils were tested on each series of plots as they were established. Soils were tested for texture, pH, and macro and micro nutrients at 0-6, 6-12 and 12-24 inches. Testing was conducted by a private soils testing facility.

Lopsided indiangrass seed was collected from Ft. Cooper State Park in 1995 and 1996, using the Flail-Vac Seed Stripper. Wiregrass seed was collected from Avon Park A. F. Bombing Range in 1995 and 1996 with the Flail-Vac. The '95 wiregrass material contained a large percentage of *Liatris tenuifolia*.

Seed from both species was debearded using a Clipper debearder. Seed was then screened and asperated several times to remove chaff. Purity obtained on the indiangrass was 95%. Purity of the wiregrass was approx. 50%. Low purity in the wiregrass was due to broken seed. Wiregrass seed is very brittle, and the debearder caused a great deal of seed breakage. Although much of the chaff could be screened out of the wiregrass, the broken seed could not be removed. The hammermill appears to be a better instrument for debearding wiregrass seed. Although breakage also occurs in the hammermill, the seed is not processed as long as in the debearder, therefore breakage is reduced.

A clean weed-free seedbed was prepared prior to planting. All plots were freshly reclaimed in January of '97, so no further preparation was necessary. However, in order to prepare for the May seeding, the planting site was sprayed with chemical herbicides in April, and then again in May just prior to planting. The site was relatively clean except for the presence of crabgrass on the overburden site. All plots were packed before seeding with a cultipacker.

For the January planting, monocultures of both grass species were seeded using an air drill built by Pounds Motor Company of Winter Garden, FL. This drill was specifically designed to handle light chaffy seed. A Tye drill with a warm season grass attachment was used for the May drill treatments. The Tye drilled was loaned by the Quicksand, KY PMC. An indiangrass/wiregrass/*Liatris* mixture of debearded seed was also drilled at each planting date.

All monoculture broadcast treatments used debearded seed, and were planted using a hand held Cyclone seeder. A mixture of uncleaned wiregrass, debearded indiangrass and *Liatris* were broadcast at each planting date, using a seed blower to distribute the material over the plot. All broadcast plots were packed with a cultipacker after seeding.

Lopsided indiangrass and wiregrass seeding rate in drilled and broadcast monoculture treatments was 60 pls/ft^2, for both seeding dates. The exception to this was the January wiregrass drill treatment. It was seeded at a rate of 75 - 80 pls/ft^2, due to the aggressive brush system of the air drill. In broadcast mix treatments, wiregrass and indiangrass were planted at an approximate rate of 60 and 40 pls/ft^2 respectively. *Liatris* was also added to the January mix treatments at a rate of 12 pls/ft^2. Normally a mix

would be planted at a 50:50 ratio. However, wiregrass appears to be less aggressive than indiangrass, and more seed was planted to obtained the desired plant densities.

Plots are 10' x 50' in size. They are replicated 4 times on the overburden soils. Because sand tailing soils are very consistent, plots on these soils were only replicated 3 times.

Plots were checked within 30 to 60 days for emergence. Two m^2 quadrats were randomly established on the January seeded plots at six months. These were used to evaluated treatments for plant density, size, vigor, percent canopy cover, and percent weed cover. Six month evaluation data for May seeded treatments was not available at the writing of this report. All treatments will continue to be evaluated for the next two years.

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

Preliminary Results and Discussion: In the January planting, the air drill was able to handle the debearded indiangrass and wiregrass seed fairly well. It has an aggressive brush system, which pulls the seed to the drop tube openers. The seed is then sucked into the drop tubes and blown through to prevent bridging or clogging. However, the air pressure through the tubes was so great that it actually blew the seed out of the furrows. Seeding depth was increased to offset this problem, and the planting depth of the drilled mix was deeper than the planting depth for the monoculture treatments. The air pressure could be adjusted to some extent, however decreasing the air pressure decreased the amount of seed output. Depth placement using this drill was difficult to determine because seed was distributed throughout the upper two inches in the soil profile of the row. Six month plant density results are shown in Table 6, and Figures 3 and 4.

Table 6. Plant densities on January planted indiangrass and wiregrass on overburden and sand tailing soils, 6 months after planting.

Treatment	Overburden	Sand Tails
	Plants/m^2	
Indiangrass - Broadcast	177a*	47b
Indiangrass - Drilled	96bc	77a
Indiangrass in Mix - Broadcast	89bc	26bcd
Indiangrass in Mix -Drilled	79cd	86a
Wiregrass - Broadcast	65cde	15cd
Wiregrass - Drilled	36ef	5d
Wiregrass in Mix - Broadcast	39def	4d
Wiregrass in Mix - Drilled	17f	3d
Mix - Wiregrass & Indiangrass - Broadcast	130b	30bc
Mix - Wiregrass & Indiangrass - Drilled	95bc	90a

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

The Cyclone seeder and the seed blower both handled the seed well. However, the seed blower did not produce even distribution over the surface of the plots. Broadcasting

produced the greatest plant densities on overburden soils for both species. Only in the sand tailing indiangrass treatments did drilling show any advantage over broadcasting. This was most likely due to the larger indiangrass seed being placed closer to available moisture. The smaller wiregrass seed apparently needed to be closer to the soil surface to emerge. However, there was no statistically significant difference between any of the wiregrass treatments on either soil.

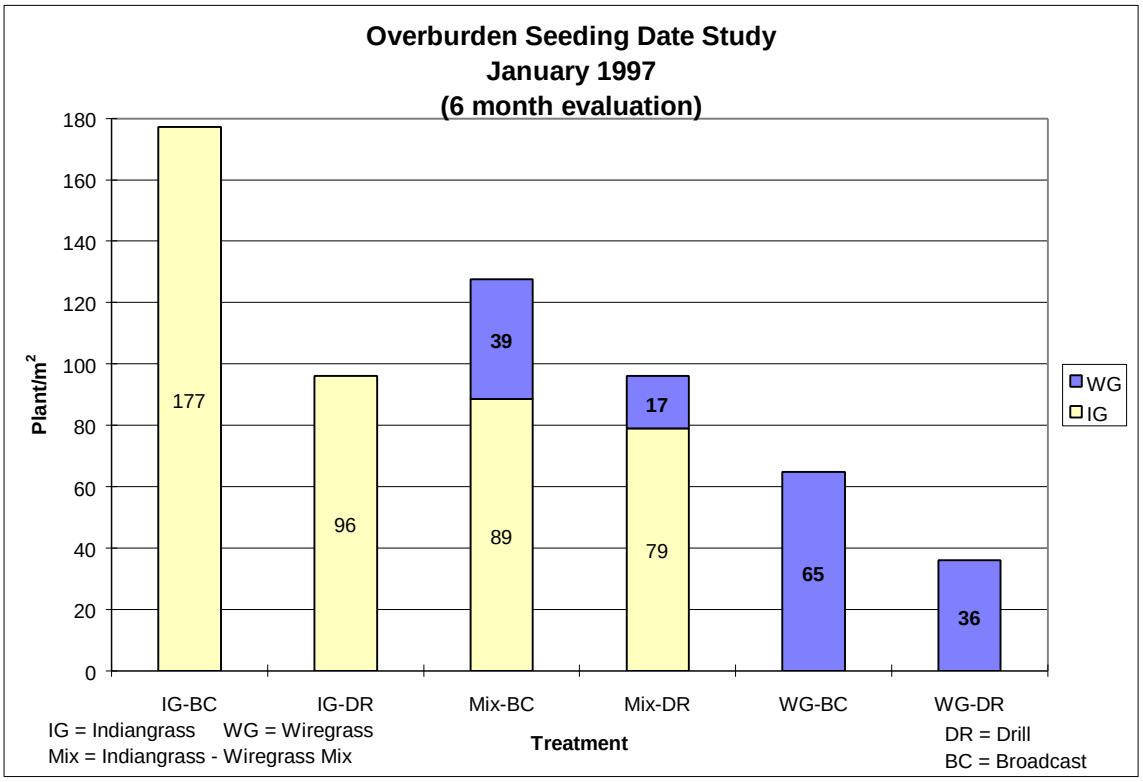

Figure 3. Plant densities on January planted indiangrass and wiregrass on overburden soils, 6 months after planting.

It is interesting to note that there is statistically no significant difference between the drilled indiangrass in monoculture and mix. The seeding rates for indiangrass in monoculture and mix were 60 pls/ft^2, and 40 pls/ft^2 respectively. Since the mixtures were drilled deeper than the monocultures, it appears that a deeper planting depth may be more advantageous for indiangrass on both soils types in the January planting.

Wiregrass broadcast in a monoculture produced greater plant densities than when planted in a mixture on both soil types. Although these differences were not statistically significant, plant densities were reduced by half or more, indicating that wiregrass is very susceptible to competition, even from other native grass species. Drilled wiregrass had only half the emergence of the broadcast treatments. Drilling may place the seed too deep, and lessen total emergence.

In its natural environment in Florida, wiregrass averages five plants per square meter (Clewell, 1989). Under this criteria, all of the wiregrass treatments were successful

on the overburden soil. The monoculture treatments on the sand tailing soils also successfully met this criteria.

Successful stand establishment criteria used in the West is four plants per square foot (approx. 43 plants/m^2) (Cook *et al*, 1974). All treatments except the drilled wiregrass met this criteria on the overburden soils. In fact, the monoculture indiangrass seeding rate could have been reduced on overburden soils. On the sand tailing soils, only indiangrass in monoculture and the drilled mix met this criteria. The droughty nature of these soils may inhibit higher plant densities, despite the seeding rate. Wiregrass seeding rates may be high for the monoculture overburden treatments. However, they were adequate or less than adequate for other treatments on both soil types according to the criteria discussed above.

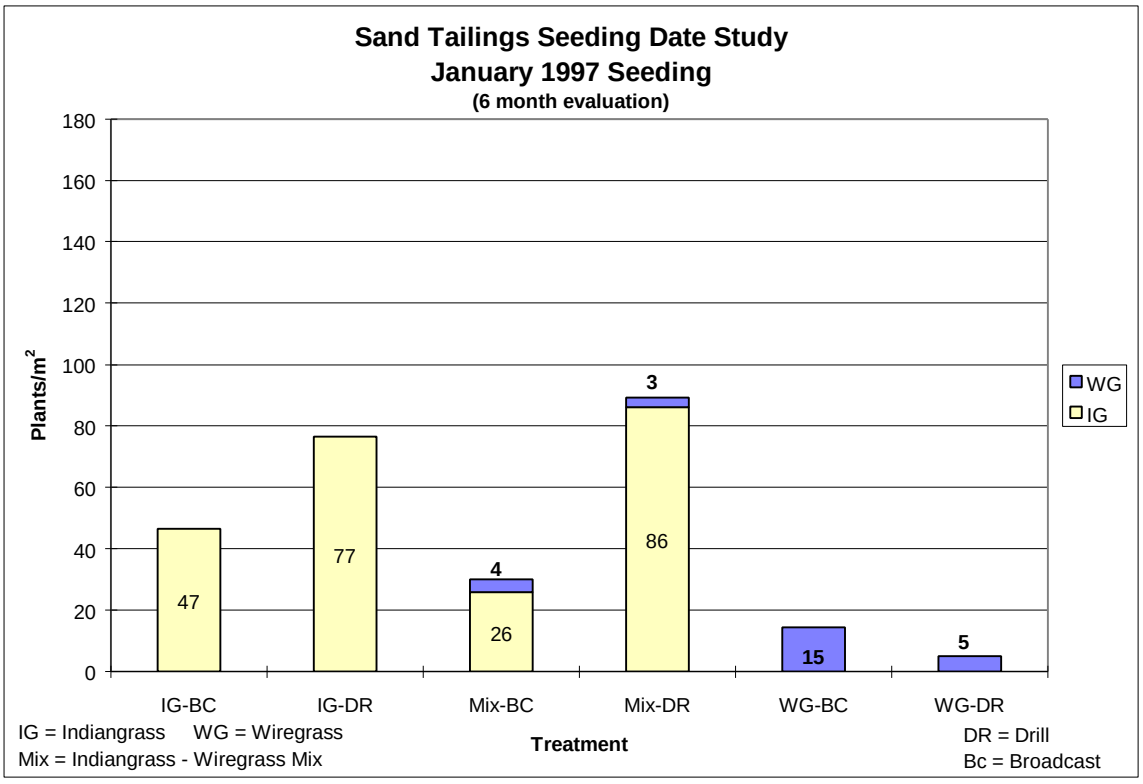

Figure 4. Plant densities on January planted indiangrass and wiregrass on sand tailing soils, 6 months after planting.

Regarding the May planting, six month evaluation data was not available at the writing of this report. However, emergence was not as great at 60 days as it had been in the January planting. Many of the treatments in the sand tailing soils had not emerged at that time. For the drill treatments, this may have partially been due to problems with the Tye drill used for this planting. This drill operated on a gravity flow system. It was able to meter out debearded indiangrass seed fairly efficiently. However, the drop tubes are placed behind the double disk openers. The furrow partially closed up before the seed could fall into it, causing a large percentage of the seed to be left on the surface. Planting

depth was increased to overcome this problem, however, placement was not precise. This system showed no advantages over broadcasting. In addition, debearded wiregrass seed was very light, and the hopper had to be over half full for it to meter out efficiently. Broadcast treatments were conducted identically to those in January, and should be a good standard of comparison for influence of seeding date.

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