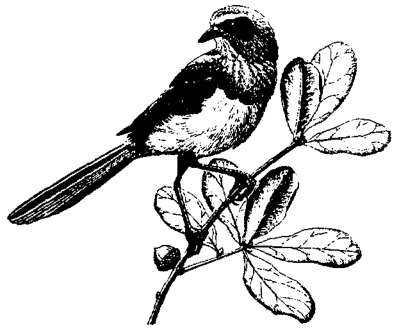

ECOSYSTEM RESTORATION WORKSHOP

PROCEEDINGS

April 25 and 26, 1996
Lakeland, Florida

Sponsored by

Florida Institute of Phosphate Research
and
Society for Ecological Restoration

FIPR
Florida Institute of Phosphate Research

1855 West Main Street, Bartow, Florida 33830

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This workshop was held as a follow-up to the 1994 Wiregrass Ecosystem Restoration Workshop held in Tallahassee and the 1995 Phosphate Reclamation Workshop held in Lakeland.

The purpose was to provide a forum for the exchange of up-to-date information and develop cooperative efforts that would advance the art and science of ecosystem restoration. The first day of the workshop emphasized upland topics, and the second day included wetland and landscape-scale topics. These proceedings were compiled to aid information exchange and serve as a networking tool.

Steven G. Richardson
Workshop Chairman
Florida Institute of Phosphate Research
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SANDHILL RESTORATION AT APALACHICOLA BLUFFS AND RAVINES PRESERVE

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The Nature Conservancy (TNC) at Apalachicola Bluffs and Ravines Preserve has been restoring a windrowed slash pine plantation back to sandhill community since 1985. TNC has cut most of the off-site slash pine plantation and used the proceeds to purchase longleaf seedlings to replant the site. To date close to 900,000 longleaf pine seedlings have been hand-planted on the preserve. We have been using fire to open the mid-story and invigorate the remaining intact ground cover in the community. We began a three-year cycle of burning our sites with intact ground cover during the growing season to encourage viable seed production. In 1989 we began collecting native ground cover seed by hand with volunteers and staff. Wiregrass (Aristida berychiana) has been collected and grown into containerized plugs in our nursery. We also have worked with Liatris sp., Sporobolus junceus, Andropogon virginicus, A. gyrans , Sorghastrum secundum, and Schizachyrium scoparium. We have had good success in growing and transplanting these plugs in the field.

Beginning in 1993, we began to collect native ground cover seed mechanically. Using a Woodward Flail-Vat seed stripper mounted on the front of an all-terrain vehicle (ATV), we have collected a mix of seed, stems and leaves together. We are specifically interested in wiregrass but have also collected various other species including but not limited to andropogons, solidagos, and liatrises. In February 1995, six 15m x 15m plots were sown with this seed mix using a leaf blower. The seed was fed into the air intake on the blower and dispersed through the outflow pipe. Approximately 4 pounds of seed mix was spread over each plot. Three of the plots were in a recently burned site, the other three were in a site recently cleared with a bulldozer. One burned and one cleared plot were seeded. Another pair of plots were seeded and then watered with 150 gallons of water. The third pair of plots were seeded and then watered with 150 gallons of water mixed with Terrasorb, a super absorbent. By early October no wiregrass seedlings were found in the burned plots but 718 to 1133 seedlings had been found in the cleared plots. This averages 3 to 5 plugs per square meter.

In February 1996, 24 five pound bags of mechanically harvested seed mix collected in late November/early December were direct seeded into six different 15m x 45m plots. Four bags of mix were spread over each plot with an AgriMetal hay blower that was placed in the back of a pick-up truck. The hay blower has a hose attachment allowing the seed to be dispersed across the whole plot. There are two cleared plots, two burned plots and two undisturbed plots. In one of each pair, a landscape roller was used to roll the seed into the soil. Fifteen .25 gram samples of the seed mix were taken to determine the percentage of the mix that was wiregrass by weight. Approximately 26% of each bag was wiregrass seed. Knowing that approximately one pound of wiregrass seed contains 1,000,000 seeds, it is estimated there were 5,200,000 wiregrass seeds sown within each plot. As of September, 1996, wiregrass seedlings have been found growing in each treatment. Monitoring of each treatment will be conducted in mid-October.

United States Department of Agriculture

Natural Resource Conservation Service

Plant Materials Center
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Clarence Maura, Jr.
Manager

Sharon Pfaff
Agronomist

Mary Anne Gonter
Biological Technician

DEVELOPMENT OF NATIVE PLANT SEED SOURCES AND SEEDING METHODS

The Brooksville PMC is working to develop a Florida native seed mix of upland grasses and forbs, which can be used to reclaim disturbed areas.

Seed from over 20 different native species have been collected. A Flail Vac Seed Stripper was used in large scale collections of lopsided indiangrass (*Sorghastrum secundum*), wiregrass *(Aristida stricta), Liatris,* and several *Andropogon* species. We greatly appreciate the Forest Service, Florida State Parks and Avon Park Air Force Range being open to mechanical seed collection. Collections are tested in the lab, greenhouse, and field for seed viability and vigor. Obtaining successful field plantings by direct seeding is difficult, primarily due to poor seed germination, vigor, and competitiveness with weed species. Also, native seeds often have beards which make seeding with conventional equipment difficult.

A seeding method study was planted on two reclaimed minedland sites in the summer of 1995. Three different methods (broadcast, drill and plug mix planter) were used to seed lopsided indiangrass at a rate of 20 pls/ft^2. Half of each plot was also mulched. Plots are still under evaluation but, thus far, unmulched plots generally have greater emergence than mulched plots. On sand tailing soils, unmulched plots averaged 5,6 and 9 plants/m^2 respectively. On unmulched clay overburden soils, averages are 18, 11 and 5 plants/m^2 respectively. From these preliminary results, we can already conclude indiangrass can be direct seeded successfully if the seedbed is clean and weed free, and planted just prior to the time of the most dependable moisture. A minimum seeding rate of 20-40pls/ft^2 appears to provide an adequate stand, but more studies are needed to verify this. Wiregrass was also seeded on the clay overburden site. To date, emergence has averaged less than 1 plant/m^2. Broadcasting produced slightly greater emergence than other treatments. This and other research results suggest wiregrass needs to be seeded at a much higher rate with very shallow placement of seed. More planting date, rate and depth studies are necessary to verify this.

We would like to coordinate our research efforts with those of other agencies and individuals, and develop good technology transfer. There are three major challenges we have encountered, which could be overcome more quickly through a cooperative effort. First, a coordinated effort to study burning and climatic regimes on desirable native species throughout the state would yield a great deal of useful information. Secondly, a cooperative effort to locate desirable species across a broad range of sites would insure the development and release of the most vigorous native seed stock. Thirdly, coordinated scientifically sound seeding studies need to be established at a broad range of sites to determine such things as seeding rates, dates, depths and methods for different species. The more studies put into place, the more quickly seeding method technology can be developed for monocultures and mixes of native species.

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REVIEW OF RECENT UPLAND RESTORATION PROJECTS

* 16 acre direct-seeded wiregrass and associated species

We harvested seed heads with a green-silage chopper from a native prairie site and claimed mine land to determine if direct seeding is a viable restoration technique. Half of the site was covered with a sterile bahia grass mulch. After nine monts, the 6.4 ha site contained approximately 1,300,000 wiregrass seedlings and 650,000 seedlings of other desirable native plants. The site also had about 2,500,000 invasive native or exotic seedlings, mostly in the mulched area (see below). In all, 36 native species and 25 exotic/native invader plant species were identified. Greenhouse trays seeded with this material had about 7 times the number of wiregrass seedlings than the field site, indicating that improved growing conditions in the field could make this technique more efficient. Estimated cost of this method was about $3,365 / ha, or about 1.2 cents per desirable germinated seedling.

At the end of the first growing season, mulched areas had significantly more wiregrass seedlings than unmulched ($7.4/0.5\ m^2 \pm 1.4$ SEM vs. $3.0/0.5\ m^2 \pm 1.3$ SEM, respectively). Mulched and unmulched plots did not have different numbers of other desirable native plants ($2.9/0.5m^2 \pm 0.5$ SEM vs. $2.3/0.5m^2 \pm 0.7$ SEM, respectively) but mulched plots had significantly more exotic and native invaders than unmulched plots ($16.7/0.5m^2 \pm 4.0$ SEM vs. $3.9/0.5m^2 \pm 1.2$ SEM, respectively). Mulched plots also had significantly more native plant species ($2.6/0.5m^2 \pm 0.3$ SEM vs. $1.7/0.5m^2 \pm 0.3$ SEM, respectively) and significantly more exotic and invasive native species ($3.4/0.5m^2 \pm 0.4$ SEM vs. $1.2/0.5m^2 \pm 0.2$ SEM, respectively). It is unclear whether the benefit of more native plants in mulched areas outweigh the detriment of more invaders.

Additional notes: In the two years after the seeding wiregrass, bluestems, and forbs have continued to bloom and set full seed. The silver-leaved aster, *Pityopsis tracyi*, has spread rhizomatously to form small colonies. Patches of bermuda and bahia grasses are also spreading, though the droughty conditions of 1996 seem to have reduced growth of other weedy species.

* 100 acre scrub and 65 acre sandhill restoration on sandtailings at Bald Mountain in 1993 with hydroseeding and potted plants in 1993.

Additional notes: The site is showing some natural regeneration, especially after this area lacked 20 inches of rainfall in 1996, which seemed to slow down weed growth and release the natives. Sandhill wireweed, *Polygonella fimbriata* var.*robusta*, is reseeding itself in large drifts across overburden topped sand tailings and pure sandtailings areas. A scrub wiregrass, *Aristida gyrans*, that was only planted in small numbers as tubelings is also spreading by reseeding. Both seem to be good candidates for direct-seeding, even on sand tailings. Also regenerating by seed were blazing star *(Liatris sp.)*, lopsided indiangrass *(Sorgastrum secundum)*, and Elliot's lovegrass *(Eragrostis elliottii)*. Some saw palmetto that was direct seeded 3 years ago had full hand-shaped fronds, though most still had strap-shaped leaves. The overall survival still seems to be high and was more evident with weed suppression caused by this year's droughty conditions. Wiregrass and the other planted grasses bloomed and seeded this year again. At least some of the wiregrass bloom developed into full seeds.

* 200+ acre bayhead, flatwoods, and scrubby flatwoods is under restoration, using planting and direct seeding techniques on land reclaimed with sand tailings and 6 inches of topsoil, in process.

* 20 acre wiregrass were direct-seeded on former bahia grass pasture on natural flatwoods soil, in November 1996. A green silage cutter was used to harvest the seed which was immediately transported to the seeding site where it was spread with a mulch blower. A cultipacker and roller were used to work the seed firmly into the soil.

* Three 1/2 acres plots on sand tailings were seeded with a mix of 8 upland grasses and forbs, including *Aristida gyrans*, *Polygonella fimbriata var. robusta*, and *Pityopsis graminifolia* in January 1997. These species have been reseeding well on Bald Mountain and disturbed natural scrub sites. The seeding was done with an ATV pulled field drag and a pipe to cover the seeds.

* We are participating in a FIPR research project, Uplands Reclamation Study which will study the relationships between reclaimed mine soils and native and weedy plant growth and will incorporate work on several of the projects mentioned above.

* We are participating in a study of the use of imazameth (Plateau) in wiregrass system restoration.

* The Natives are presently growing 12 native grasses and many forbs for upland systems.

Wiregrass Seed Collection Efforts
(A Water Management District Perspective)

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Introduction

After the first wiregrass restoration workshop, the Northwest Florida Water Management District (District) began to evaluate, establish and manage several donor sites for native plant seed collection efforts by the public and private sectors. One site, in particular, had merit because it had not been disturbed by fire in at least 15 or more years. The District and others were curious as to what would be the extent of flowering and seed production of wiregrass after a growing-season burn was conducted on the site. In addition, the District had intentions of using this seed, through Division of Forestry's (DOF) Andrews Nursery, to grow wiregrass plugs for groundcover restoration efforts on our lands. On May 16, 1996, the donor site was burned and a significant amount of viable seed was produced on the site in the Fall with a germination rate of approximately 80 percent.

Seed Collection Efforts

Public Sector

As stated above, the District, in cooperation with DOF, scheduled initial seed collection efforts to test for seed germination in November of 1996. In late November, it was determined that viable seed was produced on the site and collection efforts were to begin immediately. Since the District does not have to enter into any formal agreement with other public agencies for seed collection activities, it was believed that seed collection operations for this site would proceed smoothly with few, if any, administrative and/or logistical problems. It soon became apparent that seed collection activities would not be taking place as anticipated. Several factors prohibited DOF from successfully collecting any seed. These factors include: lack of available personnel to collect seed, travel distance to and from the site by DOF nursery personnel, ongoing DOF nursery operations, and to a minor extent, the weather. Based on this experience, I believe that the following recommendations and/or suggestions should be implemented by other agencies before any cooperative native seed collection activities are initiated on their lands:

Recommendations and/or Suggestions

- Send a donor site list to all prospective agencies. At a minimum, a donor site listing should contain the following information:

  A prescribed fire history and a proposed growing-season burn schedule for each site.

A detailed floristic survey of all groundcover species that occupy each site.

A detailed map of each site with delineated areas containing threatened rare and endangered species and species of collection importance.

- Make sure that sufficient manpower exists for seed collection activities.

- Plan well in advance with your cooperating agency(s) before you begin seed collection activities. For example, with wiregrass: 1) Attempt to conduct your growing-season burn between mid-May and mid-June; 2) Begin planning for seed collection efforts in September; 3) Start in early to mid-November to collect seed for germination tests; 4) As soon as possible after germination testing, begin to collect seed in mid-November and watch for strong cold fronts with accompanying high winds which may disperse seed prematurely; 5) Properly store collected seed; and 6) Utilize seed by planting plugs and/or by broadcasting.

Private Sector

In early November 1996, the District was also approached by A. F. Clewell, Inc. concerning the possibility of conducting wiregrass seed collection activities on District lands. Since the District had never had a request of this nature in the past, we immediately began to assess what contractual, administrative and/or legal requirements might be needed to enter into a proposed agreement with a private business concern. Other factors that also arose included: monetary consideration (price of seed), liability concerns (habitat impacts, injury to personnel, etc.), competing firm(s), and agency approval. Due to the experimental nature of the project, the lack of other competing firms involved in this type of restoration science and the proposed project's undeterminable economic impact, the District asked Dr. Clewell what, if any, goods or services his company might provide to the District in lieu of payment for seed. Dr. Clewell proposed that his company would be willing to collect seed and to prepare a report to document and establish baseline information regarding pounds of seed collected per acre, seed viability, seed collection economics, etc. for use in developing future native plant seed collection agreements with other firms. Dr. Clewell also stated that he would be willing to prepare and submit to the District an additional report. This second report would provide the District with a complete floristic list of all plant species found on the donor site which could be used by District land managers to determine the level of site disturbance to aid in longleaf pine/wiregrass habitat restoration efforts on adjacent District lands. I have attached a copy of this agreement for your information.

On November 30, 1995, the District's Governing Board approved the project. In early December, representatives of A. F. Clewell, Inc. traveled to the site to assess seed quantity and discovered that strong northwest winds associated with a passing cold front had dispersed most of the seed to the ground. As such, the experimental wiregrass seed collection agreement was not executed.

Based on the above experience, I have another set of recommendations and/or suggestions for any public agency that may be contemplating establishing donor sites for native plant seed collection by private firms.

Recommendations and/or Suggestions

- Establish a donor site list (as presented above under recommendations for cooperative seed collection efforts with public agencies).

- Begin a vendor list of interested seed collection firms.

- Begin to collect baseline information for native plant seed collection efforts. Critical baseline information is needed in the following areas:

  Average number of ounces or pounds of seed collected per acre.

  1) By specific species, e.g. wiregrass

  2) Composed of seed mixtures

  3) By percentage of species per mixture

  Price per ounce or pound of seed on the open market.

  Economics of mechanical versus hand seed collection efforts.

- If possible, begin to explore, initiate and execute experimental seed collection agreements with private firms to obtain critical baseline information concerning native plant seed collection.

- Network any information you may obtain with other donor site agencies or entities.

- Establish your own research site(s) for collecting baseline information.

- Look for creative sources of funding, e.g. mitigation projects, to fund seed collection efforts and/or research.

The recommendations and/or suggestions that I have presented above are just a few of the many issues that concern native plant seed collection. I hope that the District's experience with seed collection efforts this past year has enlightened many of you to the possible pitfalls associated with this type of endeavor and I believe that the information presented above will be of some benefit to future restoration projects.

Synopsis of Wiregrass Ecosystem Restoration Efforts by the Northwest Florida Water Management District
(From May 1994 to Present)

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Since May of 1994, the Northwest Florida Water Management District (District) has been concentrating most of its ecosystem restoration efforts on cut-over or disturbed natural longleaf pine/wiregrass habitat. Over the past two planting seasons, the District has initiated longleaf pine habitat restoration efforts on over 2,000 acres of public land by planting in excess of 1.7M tubelings. Most of our restoration efforts focus on restoring the habitat's "missing" overstory component. Some ground cover restoration projects, i.e. wiregrass plantings, are being conducted on highly disturbed sites using 6 x 6 feet spacing or at a stocking rate of 1,210 plugs per acre. From May of 1994 to January of 1996 the District planted over 100,000 wiregrass plugs at two sites, totaling 90 acres. In December of 1996, the District will be planting an additional 100,000 wiregrass plugs at two sites totaling 83 acres. After an initial grow-in period of three to five years, the District will begin to reestablish and mimic each site's natural fire regime; and hopefully after the first growing-season fire, wiregrass and other species occurring on these sites will flower, produce viable seed and begin to fill in the gaps in the understory.

In addition to planting wiregrass on disturbed sites, the District is attempting to establish and manage a number of suitable donor sites for ground cover species seed collection efforts. At present, two sites have been established and are being managed with prescribed fire. Site One, the Kammer tract, was burned on May 16, 1996, to attempt to produce viable wiregrass seed for use on adjacent District lands. Sample wiregrass seed was collected in late November, and germination tests conducted by Florida Division of Forestry (DOF) personnel indicated an 80-percent germination rate which was the highest rate for any site in northwest Florida. It is unfortunate that logistical problems prevented any large-scale seed collection efforts by either the public or private sector. Site Two, Garcon Point, was burned using aerial ignition on June 15, 1995. This 2,000-acre mosaic of wet prairie, estuarine marsh and longleaf pine upland habitat has unlimited potential for use as a donor site, but demand for various species of seed was non-existent. This was partly due to lack of interest by the private sector, no viable donor site network and the lack of a listing of available ground cover species for the site. During the spring of 1996, the District will designate and manage another donor site of approximately 100 acres. This proposed donor site will be broken up into at least five blocks in an attempt to maintain a consistent set of areas that can be managed for annual seed production and collection efforts. It is hoped that this large donor site will provide the public and private sector with at least 15 to 25 acres of suitable longleaf pine/wiregrass habitat which will allow for continuous, annual seed collection of important ground cover species.

Summary of Discussion on Donor Sites of Native Plant Propagules for Restoration Projects

A major theme identified at the 1994 Wiregrass Ecosystem Restoration Workshop was the urgent need for large-scale and reliable seed sources for restoration projects. As a follow-up, this forum was organized in order to continue the discussion and facilitation of statewide and regional donor sites as seed sources.

The assembled panel was **a** diverse group whose members represented the views and experiences of land managers (private and public lands), restoration project managers, native plant nursery operators, and researchers. The discussion by the panel was supplemented by participants from the audience as well. The discussion covered a wide range of issues concerning the collection of propagules at donor sites. Highlights of the discussion included the following topics:

<u>Identification of Donor Sites</u>

Public lands are available now as donor sites with the completion of the proper permitting process. For example, collections are permitted at Florida State Forests/ Parks, Florida Water Management Districts, and National Forests. For more information on permit applications call the following contact personnel at these different agencies:

1) Mark Latch, Lands Coordinator
Florida Division of Recreation and Parks
Bureau of Natural and Cultural Resources Mail Station 530
3900 Commonwealth Blvd.
Tallahassee, FL 32399
(904) 488-8666, FAX (904) 922-6215

2) Dennis Hardin, Forest Ecologist
Florida Division of Forestry
3125 Connor Blvd.
Tallahassee, FL 32399-1650
(904) 414-8293
FAX (904) 921-6724

3) William Cleckley, Lands Coordinator
Northwest FL Water Management District
Route 1, Box 3100
Havana, FL 32333-9700
(904) 539-5999
FAX (904) 539-4380

4) Steve Miller
Land Management Dept.
St. Johns River Water Management District
Highway 100 West/P.O. Box 1429
Palatka, FL 32177
(904) 329-4399, FAX (904) 329-4848

5) Robert Hekee
Land Management Dept.
Suwannee River Water Management District
9225 County Road 49
Live Oak, FL 32060
(800) 226-1066
FAX (904) 362-1056

6) Kevin Love
Land Resources and Management Dept.
Southwest FL Water Management District
2379 Broad Street
Brooksville, FL, 34609-6899
(800) 423-1476 extension 4465
FAX (352) 754-6877

7) Fred Davis, Director
Land Management Dept.
South Florida Water Management District
P.O. Box 24680
West Palm Beach, FL 33416-4680
(407) 687-6636

Private lands are also becoming more available as donor sites. Large corporate landholders, for example, have granted permission when it is viewed as excellent public relations, On the other hand, corporations may be limited due to liability concerns of permitting land access to the public. Smaller landowners also have a very good potential due to their increased flexibility in land use. For instance, ranchers today are very interested in new forms of revenue from their land due to the deflated meat market prices. Unimproved pasture lands represent a large potential source of donor sites. It was estimated by a representative of the Florida Cattlemen's Association that $2000 per 1/2 section of unimproved pasture would constitute a fair price for seed collection.

Donor Site Management

Concerns for responsible management and collection procedures of donor sites were repeatedly stated in the discussion. For example, site degradation is very possible with excessive harvests due to naturally low levels in seed germination of a number of native plant species. The use of large machinery is not allowed at Florida State Parks in order to prevent any negative impacts to the habitats. Growing-season prescribed burning is recommended in order to optimize viable seed production. Changing the burning regime on ranches for donor site use will be necessary. The research program at the U.S. Air Force Avon Park Bombing Range has demonstrated the compatibility of summer bums to meeting the needs of cattle ranching, wildlife hunting (e.g.,quail) and ecological restoration.

Donor Site Certification

There is a critical need for documentation of the donor sites. For example, collection dates need to be recorded because germination rates have been demonstrated to be a function of season for a number of native plant species. The introduction of noxious weeds from collections can be avoided by documenting their absence on donor sites. Addressing issues of ecotypes and diversity can be accomplished by matching identified donor sites of similar, local plant communities to restoration sites. Prevention of degradation of donor sites can be assured only by certifying the management and collection practices. The panel agreed that a good first step is to evaluate the certification procedures in California and Michigan for native plant propagation as models for use in our region.

Formation of a Donor Site Committee

The topics relating to donor sites continued on the following day of the Workshop in the discussions at the meeting for the formation of the SE Coastal Plains Chapter of the Society for Ecological Restoration. The proposal for a donor site network was approved by its members as an initial project for the Chapter. To this end, a committee was formed with Dr. Robert Kluson (BioDept., USF, Tampa, FL, (813) 974-3226) as the contact person. This committee agreed to act on the further clarification of the needs, ethics, and standards of certification that are appropriate for the establishment of a donor site network.

STRATEGY FOR RESTORING WIREGRASS ECOSYSTEMS

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"Sandhills," "pine flatwoods," "palmetto prairies," "herb bogs," and other named plant communities belong to an ecosystem that remains unnamed. "Wiregrass Ecosystem" is not fully inclusive, nor is "Longleaf Pine Ecosystem." "Firelands Ecosystem" (Clewell 1986) is more appropriate but lacks currency. This ecosystem, by whatever name, is dominated by a dense, species-rich and largely herbaceous ground cover which under natural conditions carries near-annual surface fires. Grasses and, in wetter sites, sedges provide much of the fuel. When present, wiregrass *(Aristida stricta, A. beyrichiana)* is frequently the principal fuel. Pines may or may not be present. The ecosystem occupies sites that range from xeric sandhills to pitcher-plant wetlands. Species composition is restricted by fire and soil infertility. The dearth of available nutrients induces fiber production in grasses which increases their flammability. Anthropogenic fire suppression has allowed the proliferation of turkey oaks, saw palmettos, gallberries, and other indigenous woody elements at the expenses of herbs. Soil disturbance has attracted undesirable exotic, woody, and generalist species that a&ordinarily absent from the ecosystem.

This description of the wiregrass ecosystem contains the three keys to its restoration:

1. ***Establish flammability quickly and begin prescribed burning as soon as possible.***
2. ***Maintain soil infertility and minimize soil disturbance.***
3. ***Augment species diversity until the full indigenous species composition is achieved***

Wiregrass ecosystem restoration should not even be attempted unless the potential for fire management exists into the indefinite future. Prescribed fire should commence as soon as possible to discourage the establishment of competitive shrubs, exotic species, and undesirable generalist species. Burning too soon, though, can kill young grass plants. To protect these grasses, the first bum could be a fast moving dormant season head fire..

In wiregrass regions, the establishment of flammability is accomplished by planting wiregrass, alone or in combination with associated grass and sedge species (Table 1). If wiregrass is unavailable, or if the restoration site lies beyond the geographic range of wiregrass, then other grasses must be used. Grass density should be sufficient to carry a fire within a year or two of being planted. Natural stocking of grasses may substitute for intentional planting, if an effective seed source exists nearby.

Site preparation may be necessary prior to grass establishment. Any erosion problems should be resolved prior to planting grasses. Annual ryegrass or another temporary cover crop can be planted but only to stabilize eroding surfaces or to pre-empt space that would very likely be colonized by competitive unwanted species. Fire can be prescribed to remove excessive vegetation and detritus that could interfere with the propagation of grasses. Reclaimed mine land should not be compacted, and soil within the root zone should have a sandy consistency.

Removal of competitive vegetation may also be prerequisite to grass establishment. Turkey oaks should be cut or killed with herbicide until only a few trees per acre remain. Any row-planted slash pines should be thinned considerably but not entirely cleared all at once, because their needle-drape will enhance initial flammability. Aerial stems of saw palmettos can be roller-chopped with drums empty, so that drum blades do not damage persisting herbaceous cover. Dense gallberry can be treated with Garlon®. Any cogongrass must be entirely removed quickly. Bahiagrass can be treated with glyphosate, then harrowed in autumn and heavily seeded with native grasses. *Andropogon* spp. are appropriate for seeding, even though some are semi-weedy, because they provide rapid cover and fuel until additional grass species can be established.

Amendments of fertilizer and organic matter are discouraged, because they increase soil fertility and attract woody and weedy species. The establishment of too many legumes is also discouraged for the same reason. Off-site seed sources of undesirable species should be removed.

The augmentation of plant species diversity can begin at any time during the restoration program. However, the early establishment of flammability should not be sacrificed on account of a desire for instant diversity. Numerous kinds of herbs and several low-growing shrubs (e.g., *Vaccinium myrsinites, GayIussacia dumosa, Licania michauxii)* should be the focus of diversity plantings. If direct seeding is not feasible, then pocket plantings will suffice. These are small clusters of a few plants each of one or more species. The clusters are widely spaced. Pocket plantings later become seed sources for the colonization of intervening spaces.

The temptation should be squelched to plant more than a few token turkey oaks, saw palmettos, gallberries, and other common indigenous woody species. If these proliferate, they will overtake a restoration program, just as they have overtaken vast areas of the original wiregrass ecosystem following fire suppression. Likewise, the urge to plant pines during the first few years should be subdued. Pine needle-drape sometimes rivals grasses in its importance as a fuel. Nonetheless, young pines inhibit grass establishment with shade and competition. Once the grasses are well established, pines may be planted with impunity. If necessary, supplemental fuel can be spread, such as pine straw or seed-free hay, in lieu of planting pines too early.

Reference

Clewell, A. F. 1986. Natural Setting and Vegetation of the Florida Panhandle. COESAM/PDEI-86/001 U.S. Army Corps of Engineers, Mobile (AL) District. 773 pages.

Table 1. Some mostly xeric and mesic grasses and sedges of wiregrass ecosystems.

Andropogon	*patula*	*Eragrostis*	*monostachyum*	*secundum*
arctatus	*purpurescens*	*spectabilis*	*plicatulum*	*Sphenopholis*
brachystachyus	*spiciformis*	*Eustachys*	*praecox*	*filiformis*
floridanus	*stricta*	*floridana*	*setaceum*	*Sporobolus*
gerardii	*Ctenium*	*glauca*	*Rhynchospora*	*curtissii*
glomeratus	*aromaticum*	*neglecta*	*plumosa*	*floridanus*
gyrans	*Dichanthelium*	*petraea*	*Schizachyrium*	*junceus*
longiberbis	*acuminatum*	*Gymnopogon*	*hirtiflorum*	*Stipa*
ternarius	*dichotomum*	*ambiguus*	*scoparium*	*avenacea*
tracyi	*erectifolium*	*brevifolius*	*tenerum*	*Tridens*
virginicus	*oligosanthes*	*chapmanianus*	*Scleria*	*carolinianus*
Anthaenantia	*ovale*	*Muhlenbergia*	*baldwinii*	*flavus*
villosa	*sabulorum*	*capillaris*	*ciliata*	*Triplasis*
Aristida	*scabriusculum*	*Panicum*	*hirtella*	*americana*
beyrichiana	*scoparium*	*hians*	*Setaria*	*purpurea*
condensata	*strigosum*	*virgatum*	*corrugata*	*Tripsacum*
gyrans	*Dichromena*	*Paspalum*	*geniculata*	*dactyloides*
lanosa	*colorata*	*bifidum*	*Sorghastrum*	
longespica	*latififolia*	*floridanum*	*elliottii*	
palustris		*laeve*	*nutans*	

EFFECTS OF FIRE REGIME AND HABITAT ON SURVIVAL AND GROWTH OF OUTPLANTED WIREGRASS AND TOOTHACHE GRASS PLUGS IN THE FRANCIS MARION NATIONAL FOREST, SC

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Wiregrass *(Aristida beyrichiana* and *Aristida stricta)* and toothache grass *(Ctenium aromaticum)* are dominant grasses of longleaf pine savannas and woodlands throughout much of the Southeastern Coastal Plain. In many areas, however, these grasses have declined precipitously as a consequence of fire exclusion and soil disturbance (e.g., site preparation for pine plantations). Reestablishing, or enhancing, populations of these species is thus an important goal of restoration ecology in the southeast USA.

Outplanting of nursery grown "plugs" is one popular method for re-establishing populations of grasses or other species. This method is commonly employed for seedlings of longleaf pine and wiregrass and it has been tested on other species as well.

A restorationist using plugs to re-establish or enhance grass populations faces a number of questions, including the following:

1) Is site preparation necessary before planting the grasses? Is fire sufficient, or are more extreme methods required? These are important questions if one wishes to minimize site preparation impacts on surrounding vegetation or simply hopes to save money by avoiding site preparation expenses.
2) If fire is the desired method of site preparation, how far in advance of planting can a site be burned while still obtaining reasonable growth and survival of the outplanted plugs? In other words, is it necessary to plant plugs immediately after a fire or is some delay acceptable?
3) How soon after planting is it possible to bum without killing the plugs?
4) How long after planting can one expect to wait before competition increases mortality and reduces growth of the outplanted plugs? In other words, how soon after planting is it necessary to reburn?
5) How do site factors (e.g., soils, topography etc.) influence plug survival? Do site factors influence the answers to questions 1-4?

We are using an experimental approach to try to answer these and other questions pertaining to interactive effects of fire and site on the success of species introductions in longleaf pine groundcover vegetation. The experiment is a randomized block design with three blocks (habitat types) and seven treatments replicated three times within each block. Treatments include the following: (1) no burn, (2) dormant season bum every 2 yrs, (3) dormant season burn every 4 yrs, (4) growing season burn every 2 yrs, (5) growing season burn every 4 yrs, (6) growing season burns at average 2 yr intervals, but with random variation around the mean, (7) similar to no. 6, but with 4 yr mean burn intervals. Replicates (referred to for convenience as A, B, and C) were initiated in different years: A in 1993, B in 1994, C in 1995. Habitats (blocks) are located in three different types of longleaf pine woodlands which we will refer to as the wet, mesic, and dry sites. All sites are located in the Francis Marion National Forest (FMNF).

In January 1994, three subplots of planted grass plugs [wiregrass *(Aristida beyrichiana)* and toothache grass] were established in all replicate A main plots. Grass plugs were grown in 6" deep groove tube trays (Growing Systems. Inc.; Milwaukee WI) and were approximately 6 months old at the time of planting. Subplots are 1.5 m x 4.0 m subdivided into 25 cm x 25 cm cells. Grass plugs were planted into every other cell within the center 50 cm x 4.0 m strip of each subplot. Plugs of the two species were alternated when planting, so that each species was surrounded by plugs of the other species. Plugs were planted by hand using a small bulb planter, and no site preparation was employed, other than the various burn treatments. Prior to planting, no wiregrass was present in any of the three sites. Toothache grass occurs sparsely in the mesic and wet sites.

Planted grass plugs of both species were checked for survival in March 1995 and again in March 1996. Also, we counted tiller numbers at the latter date. During the interval between these censuses, 4 plots (3 growing, one dormant) were reburned. Thus, the treatments actually experienced to date by the planted grasses can be summarized as follows: 1) burned 3 yrs pre-planting, no post-bum, 2) burned .5-1 yr pre-planting, no post-burn, 3) burned .5-1 yr pre-planting, reburned 1-1.5 yrs post-planting.

After one yr, approximately 90% of wiregrass plugs were still alive. Two yrs after planting, over 80% of outplanted wiregrasses were alive except in the reburned dry site plots where survival was reduced to approximately 60 % .

For the most part, outplanted wiregrass plants grew slowly (mean size of 10 tillers/plant after 2 yrs, averaged across all treatments). At the wet and dry sites, tiller numbers of surviving plants were greatest in the plots burned shortly before planting and then not reburned (treatment 2 above). At the mesic site, tiller numbers were highest in the no bum plots (i.e., burned 3 yrs previously and not since). The largest plants, on average, occurred in the treatment 2 dry site plots (mean of 19 tillers/plant, with some plants exceeding 50 tillers).

The most obvious effect on toothache grass growth and survival was that of habitat. Even prior to reburning, toothache grass survival was distinctly lower in the dry and mesic sites. This is perhaps not surprising since this species typically is found most abundantly in wet savannas. Two yrs after planting, the effect of habitat on toothache grass survival was even more pronounced, especially in reburned plots (e.g., only 40% of toothache grass plugs were alive in reburned dry site plots). There was also a similar habitat effect on tiller numbers. Within habitats, treatment effects on toothache grass tiller numbers resembled those for wiregrass.

The conclusions at this stage are as follows: 1) Six month old wiregrass and toothache grass plugs outplanted into undisturbed groundcover vegetation experience high initial survival, but low early growth. 2) These plugs can be safely burned within 1 yr after planting, except perhaps on well drained soils. 3) Competitive effects on grass survival may become evident within 3 yrs after the previous fire. Consequently, it is probably best to reburn within 2-3 yrs after planting.

LARGE-SCALE PINE FLATWOODS RESTORATION EFFORT ON LAND CONVERTED TO IMPROVED PASTURE

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As part of a holistic ecological improvement program, CF Industries, Inc. (CFI) has proposed to restore approximately 925 acres of improved pasture to pine flatwoods in northeastern Hillsborough County. This area was converted from flatwoods to pasture during the 1920's or 30's and has been heavily grazed in recent decades. The overall program also includes enhancement, restoration and creation of wetland habitats (swamp, marsh and wet prairie) and the enhancement and management of an additional ±320 acres of existing native uplands. The restoration effort is proposed to offset impacts from the construction of an expansion of the phosphogypsum stack at the CFI Plant City facility.

As part of the preliminary planning and regulatory approval process, Biological Research Associates, Inc. (BRA) prepared a *Conceptual Restoration Plan* in 1995. Incorporating technical information and recommendations from upland restoration practitioners in Florida and the southeastern United States, BRA prepared a *Detailed Restoration Plan* in 1996 to guide the upland and wetland habitat improvement efforts. Both documents have been incorporated into permit application materials for the stack expansion and accompanying restoration. The goal of the restoration effort has been to produce an program which is adaptive in nature and will thus enable adjustments to be made to allow for the most successful, cost-effective restoration.

Initiation of the CFI restoration program will take place following the receipt of all required permits. Flatwoods restoration will be implemented using a series of six upland restoration units ranging from approximately 100 to 175 acres. One unit will be started each year. This is sequential approach is expected to facilitate the management of the effort and ensure that sufficient donor material will be available each year.

The proposed flatwoods restoration portion of this effort consists of the following steps:

- <u>Eradication of bahiagrass and other pasture grasses</u> by (1) a combination of herbiciding and disking and (2) sod cutting in areas where turf quality is suitable with supplemental herbiciding as necessary. This eradication will take place between the end of the wet season and the time at which direct seeding will begin.

- <u>Direct seeding of wiregrass and other groundcover species</u>. Donor sites of high quality pine flatwoods or palmetto prairie in the region will be burned in late spring (April - June). Initially, approximately two acres of donor area will be burned for each acre of area restored; this ratio may be adjusted in subsequent years as necessary. Seed will be mechanically harvested from donor sites during late November and will be mechanically distributed over the restoration area as soon as possible thereafter (i.e. late November - early December). If necessary, supplemental seeding may be utilized in the spring to provide propagules of other native herbaceous species.

- Planting of pine trees. Young pine trees and several shrub species will be planted, rather than seeded, to increase survivorship. Tubeling longleaf pine will be planted in higher, dryer areas and tubeling slash pine will be installed in wetter areas. *Dichanthelium* spp., *Ilex glabra*, *Lyonia lucida* and *Vaccinium myrsinites* will also be installed since these species typically show better survivorship when planted than when seeded. Trees and shrubs will generally be planted in a random configuration and, in many portions of the site, a clumped distribution will be used to simulate natural plant distributions and increase habitat diversity.

- Monitoring and maintenance. The restoration area will be closely monitored for the first several years to detect recruitment of nuisance vegetation and to track the development of the native plant community. Herbicide treatment and manual removal of undesirable vegetation will be implemented as necessary. Ultimately, prescribed growing season burns are expected to be the predominant management tool. Additional monitoring likely will include wildlife surveys to evaluate utilization of the restored habitat by animals.

Planning of this effort has benefitted from substantial input by restoration experts, agency staff and interested third parties, especially the Hillsborough River Greenways Task Force which participated in the development of the overall concept for this particular plan. Upon its completion, the program is expected to provide additional native habitat and a wildlife corridor link within the upper Hillsborough River basin.

The following list has been prepared by BRA to indicate selected research activities which we see as key to improving the technology of upland restoration.

- Assessment of the role of physical and chemical properties of soils in reclamation/restoration areas
- Assessment of the role of hydrology (i.e., rainfall patterns, water table elevation and fluctuation, percolation rate) on reclaimed/restored vegetational community
- Investigation of the optimal method(s) for removing and controlling unwanted vegetation in areas being reclaimed/restored
- Assessment of optimal species combinations to utilize in direct seeding and planting (i.e., development of a "seed mix" to obtain better establishment
- Investigation of the effects of varying seeding/planting densities of both groundcover and woody plant species on success of re-vegetation efforts
- Evaluation of various post-planting techniques in controlling successional trends and invasion/spread of undesirable species
- Evaluation of management techniques in donor areas to optimize seed number and quality.

RESTORATION OF IMPROVED PASTURES IN CENTRAL FLORIDA PINE FLATWOODS COMMUNITIES. Beth Wertschnig*, Michael Duever. The Nature Conservancy, Disney Wilderness Preserve, 6075 Scrub Jay Trail, Kissimmee, FL 34759, (407)935-0002.

ABSTRACT

In 1995 The Nature Conservancy (TNC) initiated a pilot project in upland pasture restoration aimed at determining cost effective methods for restoring 1500 acres of pasture to pine flatwoods at the Disney Wilderness Preserve (DWP). The preserve is located in central Florida in Osceola and Polk Counties and totals 11,500 acres. The pilot project will examine methods for removal of exotic pasture grasses, primarily bahia *(Paspalum notatum),* and methods for re-introducing native plants to the site. Methods to be tested for removing bahia grass include multiple disking and herbiciding, single herbiciding and disking, and combination treatments. It is anticipated that revegetation of the restoration sites will be accomplished by direct seeding native seed collected on DWP.

INTRODUCTION

As more land is set aside for conservation in Florida, more land is being acquired by private, state, and federal agencies that is currently or was previously agricultural land. Land managers are challenged with the possibility of restoring these agricultural lands, or allowing natural succession to occur. It is becoming apparent that in Central Florida succession of old fields does not follow the predictable stages to a wooded climax community in the classical manner (KBN Engineering, 1988). Instead, succession in Central Florida agricultural lands may follow one of many paths depending on hydrology and fire frequency (Cattelino, 1979). Other important factors to consider are degree of disturbance and persistence (or competitive ability) of the introduced species.

Land managers and researchers throughout Florida have experienced problems with leaving improved pastures to natural succession. There are documented instances where pastures improved to bahia grass *(Paspalum notatum)* have been abandoned for 20 to 30 years yet are not being colonized by herbaceous native plants. For example, the abandoned pastures at San Felasco State Preserve have had no management of any kind for 21 years, and the only species present with the bahia are blackberry *(Rubus* spp.) and loblolly pine *(Pinus taeda)* (V. Doig, pers. comm.). Neither of these species is a dominant in the desired or anticipated community. Other abandoned pastures at the same state park have been completely colonized by woody species, but bahia grass persists as the herbaceous layer. The lack of pyrogenic fuels in the bahia dominated understory prevents naturally occurring fires from burning through, and allows woody species to become dominant in a system traditionally dominated by the herbs (V. Doig, pers. comm.). Other documented sites that continue to persist with bahia grass remaining dominant include Audubon's Kissimmee Prairie Sanctuary, Archbold Biological Research Station, and Apalachicola Bluffs and Ravines Preserve.

Because natural succession does not appear to proceed to a desired or recognized community type even in long abandoned pastures, many land managers and researchers in Florida and the Southeast are experimenting with options for restoring the herbaceous groundcover. The most common habitats converted to pasture were sandhills and flatwoods (KBN, 1988). These vegetation types are dominated by fire adapted species, predominately wiregrass *(Aristida beyrichiana,* formerly *A.*

stricta). Much of the research has focused on how to re-introduce this species into abandoned agricultural lands. Seeding wiregrass into bahia pastures is difficult, since bahia grass is more competitive and wiregrass grows more slowly and has low seed viability. The alternative, planting seedling wiregrass, is very labor intensive.

To date, most of the research in bahia grass pasture restoration has focused on planting plugs of wiregrass and other native species, and eliminating the bahia grass through herbicides and/or disking (Seamon, 1992; Hatcher, 1994; Uridel, 1994). These methods have proved effective on a small scale. Uridel's (1994) herbicide, disking, and planting in $10m^2$ plots was successful but costly to undertake on a larger scale. A current project on South Florida Water Management District land on the Kissimmee River north of Lake Okeechobee focuses on removing the bahia grass, but not planting or seeding any native plants. Preliminary results are showing bahia grass re-invades or other exotic species quickly gain dominance (C. Hatcher, pers. comm.). Direct seeding of wiregrass has been tried with limited success, but this treatment is very new (Bissett, 1994; Seamon, 1994).

STUDY SITES

Pasture restoration at The Disney Wilderness Preserve began in the fall of 1995 with the establishment of a pilot project. Six sites were randomly chosen in pastures that are currently classified as improved bahia pastures. Each site contains 5 plots 30x30 meters in size. There is an 8 meter buffer between plots, and the actual area of treatment is 32x32 meters to minimize edge effects. The pastures are currently grazed, although the treatment areas have been fenced from cows with hog fencing and barbed wire. The sites are aligned perpendicular to any elevational gradient to include representative elevations within the pastures.

MATERIALS AND METHODS

The pilot project will test 5 options for removal of bahia grass:

1. Disking
2. Herbiciding
3. Disking and herbiciding
4. Multiple disking
5. Multiple herbiciding

Single disking and herbiciding treatments are incorporated to provide comparative information regarding the additional benefits of multiple efforts to remove bahia grass. Multiple treatments are anticipated to provide better weed control, although the additional costs may be substantial. The combination treatment of disk and herbicide was included to see if combining the treatments reduced cost or provided better bahia control for the same cost as one of the other treatments.

Following the treatments for removal of bahia grass, the sites will be both direct seeded with native plant species and also planted with a small number of potted plants of native species. (Native species will be naturally occurring plants in Florida communities). Pre-treatment monitoring began prior to any weed treatment to quantify the current condition of the pastures based on cover and plant composition. Following the monitoring, bahia removal treatments will begin in the spring of 1996, and continue until fall 1996. Seed will be collected in the fall of 1995 for the potted plant portion of the pilot project, to be planted in the treatments in September 1996. Seed will be collected in the spring, summer, and fall of 1996, to be spread on the plots in late November 1996. All seed for direct seeding and potted plants will be collected from DWP.

The pre-treatment monitoring used the point-intercept method. For each 30x30 meter plot a point intercept transect was randomly located within each of six 5x30 meter belts. Then measurements were made at 30 equidistant points along the transect. The initial point was randomly selected within the first meter of the transect. A camera tripod with a level attachment allowed the pin to be dropped vertically at each point. A botanist identified plants touched by the tip of the pin as it descended. Data were recorded on a Hewlett Packard palm-top computer in Lotus format. The transects are not permanent. These data will permit us to evaluate whether we have been able to reduce exotic vegetation to a percent cover of less than 10%. The sites will be monitored annually for a period of three years following completion of treatments to determine which bahia removal method is most effective at diminishing the bahia cover and facilitating establishment of the native groundcover. Photo-points were established to track changes on the sites.

RESULTS

The results of the pilot study will not be known. for a few years. What information is learned about pasture restoration from the pilot study will be applied to large scale pasture restoration on DWP in the coming years.

ECOSYSTEM RESTORATION OF LONGLEAF PINE WIREGRASS: CHALLENGES AND OPPORTUNITIES

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Longleaf wiregrass ecosystems are among the most threatened, and important ecosystem restorations challenges in the southeastern United States. They provide habitat for many of the endangered or threatened flora and fauna in the region and are an important economic resources as well. The remnant stands, now less than 5% of the original extant of this type, are found across a wide ecological amplitude and range of ownership's, and thus, landowner objectives. Managing these sites profitably, and restoration of new sites economically, while enhancing ecological value is one of the most formidable tasks facing conservation biology of this region.

Recent concepts of ecological restoration suggest that establishing primary structure of communities can be done in a way that will allow for development of secondary structural features and establishment of ecosystem function. Conceptually, the success of restoration can be measured by determining the degree to which secondary structures and natural rates of ecosystem functions are restored. However, applying this concept to the longleaf pine wiregrass ecosystems is fraught with uncertainty. Firstly, the definition of primary structure, the types and abundance of structure that needs to be established, the timing of establishment, and the operational procedures that can be used to establish structure are not axiomatic. Wiregrass and longleaf pine certainly are important to establish to maintain fire regimes, but the extent that abundance of each varies throughout the landscape is not well defined. The need for other important functional guilds, i.e. legumes, is also not clear at the present time. Mechanistic controls on succession trajectories and the rate at which succession proceeds on throughout landscape is not known; thus, determining the types and rates of development secondary structural features in a properly restored ecosystem is ambiguous. Guidance in fauna establishment, and changes through time are even less well documented. Lastly, the use of ecosystem function as a metric of successful restoration, although conceptually attractive, is particularly perplexing in this community in that one may expect wide ranges in rates of functions (nutrient cycling productivity) across wide environmental gradients that longleaf systems span yet the literature provides little guidance as to the range that would be expected. Furthermore, determining where a site fits in the continuum of sites is problematic.

The objective of this presentation is to give some ideas that we have been debating as to restoration efforts at the Jones Center, and use examples of ongoing work that we feel will provide data to help reduce some of the uncertainty by which we might define restoration efforts and the metrics used to judge the success.

INTEGRATED MANAGEMENT OF COGONGRASS FOR NATIVE HABITAT RESTORATION *(IMPERATA CYLINDRICA)*

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Cogongrass *(Imperata cylindrica)*, a perennial grass native to southeast Asia, has become a serious problem in the southeastern United States. It spreads by both seed and rhizomes and has the ability to displace other vegetation in forests, rangelands, pastures, roadsides, reclaimed phosphate mines and natural areas. Short-term suppression has been achieved, but long-term control has not due to large rhizome reserves and quick regrowth following burning, tillage, mowing or herbicide treatment. Repeatedly treating cogongrass enhances control, but in many areas this is not feasible. Regardless of which control method is used, bare soil results; consequently, regrowth or recolonization occurs. To avoid the continued reoccurrence of invasion by non-native plants, methods must be developed for the practical establishment of desirable plants in effected areas. Our experience indicates that a combination of techniques, applied in an integrated strategy, is needed to effectively manage cogongrass.

Mowing and tillage have been used to manage many perennial species and may be effective in suppressing cogongrass. Mowing cogongrass, however, must be done consistently over two or more years to deplete the starch reserves that support the growth of new shoots. We suspect that most managers will find that such a strategy causes budgetary or logistical problems. Tillage on the other hand, both knocks down new shoots, and cuts and helps dry out the rhizomes. Deep tillage is important since cogongrass rhizomes rarely re-sprout from depths greater than 15 cm. Complete control of cogongrass requires repeated tillage until there is no regrowth. However, in most natural areas, tillage is not a viable option because of the ecological impact. With either mechanical approach, re-vegetation with desirable species is key to prevent re-colonization.

Only a few herbicides have proven effective in controlling cogongrass. We found that an application of imazapyr *(Arsenal)* at 0.84 kg/ha or glyphosate *(Roundup)* at 2.24 kg/ha provided 70-80 percent control up to one year after a single treatment. However, both of these herbicides have some drawbacks. Both herbicides are non-selective and kill all plants in the treated area. Arsenal can remain active in the soil for long periods of time, where it inhibits the establishment of desirable species. Roundup is not soil active so establishment of other plants can begin immediately, but Roundup is sensitive to rain and needs at least one dry day for maximum activity. With both herbicides, complete control is difficult to achieve even with repeated applications. Regardless of the duration of control, bare soil is the result of using either of these herbicides. Therefore, if these treated areas are not re-vegetated immediately, recolonization with occur.

The key to long-term control of cogongrass is replacing it with a competitive plant community capable of closing ranks and resisting re-invasion. Establishing new species in cogongrass-infested areas is difficult because cogongrass secretes allelophathic chemicals, has an extensive system of rhizomes, and creates a dense canopy. However, we have found several exotic species that show promise in competing with cogongrass, following treatment with a combination of control methods, including hairy indigo *(Indigofera hirsuta)*, Bermudagrass *(Cynodin dactylon)*, and bahiagrass *(Paspalum notatium)*. These species seemed to grow best when we added 22.5 kg ha of 10-10-10 fertilizer and mowed once a month. This work has established the potential utility of replacing invasive plants with other species. However, most restorationists would prefer the use of native species. We have therefore begun studies to evaluate whether similar practices will encourage the establishment and growth of native species. We expect, however, that native plants will be more difficult and costly to work with and be less effective at competing with cogongrass.

Ultimately the best way to control cogongrass is by following an integrated approach that employs a variety of management techniques. For example, burning followed by tilling and herbicide applications should contain cogongrass long enough to give restorationists a chance to establish species chosen to compete successfully with cogongrass over the long-term. Regardless of its potential for success, we suspect that this strategy may be somewhat expensive with replacements using horticulturally-altered exotics costing hundreds of dollars per acre, and restorations with native species costing even more--perhaps thousands of dollars per acre. In many areas the cost of this integrated approach is justified. In areas where it cannot be justified for financial or other reasons, some form of classical biological control that would include introduced insects or pathogens will be necessary. Several indigenous fungi that cause disease in cogongrass have been isolated. Methods for practical utilization are presently being evaluated.

DADE COUNTY FLORIDA'S POST-HURRICANE ROCKLAND HAMMOCK RESTORATION PROGRAM, A MULTI-SPECIES EXOTIC CONTROL STRATEGY.

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After Hurricane Andrew in August 1992, the rapid growth of over 50 different species of exotic plants, especially vines, inhibited the natural post-hurricane recovery processes of South Florida's rockland hammocks. Dade County Park's Department in cooperation with Fairchild Tropical Garden EcoHorizons and The Nature Conservancy developed, obtained funding and implemented the Post-Hurricane Rockland Hammock Restoration Program, for the restoration of 385 acres of hammock. Restoration of the first 125 acres of hammock occurred between July 1993 and February 1996 at a cost of $1,000,000. Restoration cost per acre varies from $4,000 to $20,000 depending on the species and density of exotic plants. Controlling invasive exotic plants allows hammocks to undergo natural post-hurricane successional processes. Upon completion of restoration, hammocks will be able to recover naturally from the next hurricane, with minimal assistance from resource managers. Biologists create site specific restoration plans by performing pre-management qualitative hammock assessments that include estimates of invasive plant cover, species present, and canopy and understory condition recorded at 50 meter intervals along transects running throughout the hammock. Management begins by dividing hammocks into 0.25h quadrats. Crews cut access transects through quadrats and treat large exotic plant stems with 10% Garlon4 and a basal oil. Six weeks later crews upright small trees, prune native vegetation, place debris in piles, cut dead vines within 6' of the ground and hand pull or chemically treat persisting exotics. This step encourages canopy formation and growth of native species, increases crew access and visibility, and discourages vines from trellising into the canopy. Two months later, crews pull or treat any remaining exotics. Crews repeat exotic plant treatments as necessary; usually in 3 months, then at 6-month intervals for the next year and yearly thereafter. This protocol varies with the presence and density of exotic species. Biologists document the progress of the restoration process through the use of GIS/GPS and color infrared aerials.

UPLAND HABITAT RECLAMATION ON PHOSPHATE MINED LANDS
RESEARCH TOPICS

Compiled by
Steven G. Richardson, Florida Institute of Phosphate Research
John Kiefer, CF Industries

Soil Structure and Hydrology

What soil characteristics are necessary (or desirable, tolerable, undesirable) for various upland habitats?

How thick should the layer of sand tailings on top of the graded overburden be? How thin can it be? Could perching of water in sand tailings on top of an overburden layer be advantageous to scrub oaks, pines and other deeper-rooted plants?

Can sandy overburden be used alone? How much clay and silt is tolerable? Compaction, crusting, fertility effects.

Topsoiling may have benefits or problems. Topsoil may contain propagules of desirable plant species plus some nutrients. It may also contain propagules of weedy plants and the added nutrients may promote weed growth.

What soil characteristics tend to promote or retard invasion by exotics? (moisture, fertility, pH, etc.)

Vegetation Management

Natalgrass is a common invader on sand tailings. It may serve the purpose of stabilizing the sand and may even provide forage for gopher tortoises, but how competitive is it to native plants? If it is a significant weed problem, how can it be controlled or managed to promote establishment and eventual dominance of native plants? (herbicides, tillage, temporary cover crops, etc.)

How can cogongrass, bermudagrass and bahiagrass best be prevented from invading and dominating an upland site reclaimed to native habitat? If they do invade, how can these exotic species be effectively and economically controlled?

What temporary cover crops might be used effectively to inhibit or retard competitive exotics, but which are short-lived in Florida or could be easily controlled with selective herbicides or fire, etc.? For example, alfalfa is a temperate perennial legume that could be planted in the fall but usually does not persist more than a couple years in subtropical Florida. If necessary, it might be selectively controlled in a stand of wiregrass by spraying with a broadleaf herbicide. Browntop millet is a warm season annual grass commonly used on mined lands that usually does not reseed itself to any great extent. However, what effects might the additional nitrogen fixed by the alfalfa or from the fertilizer that might be added to enhance browntop millet establishment, have on the site? Might the added fertility promote other weedy species? Fertility would have to be managed carefully.

Could planting of fire-carrying plant species as a cover or nurse crops, coupled with burning, help in establishing a wiregrass community or other native fire-adapted community? One caution: cogongrass seems well-adapted to fire on reclaimed lands. It produces lots of fuel, which results in a hot fire, and its deep rhizomes are well protected from the fire.

How should fertility levels be managed to provide enough nutrients for desirable plant species but not so much as to promote weed growth.

Establishment Techniques

Stabilizing sand tailings - polymer sprays, mulches, cover crops

Optimizing soil moisture and minimizing surface crusting for direct seeding

Seeding methods - broadcasting, hydroseeding, drilling, spreading hay

What about species that produce little or no seed? Vegetative propagation, micropropogation, somatic embryos and artificial seeds

Topsoiling, the application of propagule laden soil, will only be advantageous if the soil comes from a high quality donor site. This will require proper management of the donor site. One innovative approach for a flatwoods donor site is to burn the site early in the growing season to promote seed production of several fire tolerant species. The topsoil would then be moved to the reclamation site after the seeds mature. How thick or thin should the topsoil be spread on the reclamation site, and how thick of a layer should be removed from the donor site? Can techniques be improved to better cover vegetative propagules with soil during the spreading process?

Tubeling transplants may be too expensive to use on large acreages, unless they are only used to augment seeding, or unless the cost of tubelings can be drastically reduced.

Time of planting/seeding

"Planned succession" - short-lived cover crops, fire carrying species

Seed Harvesting and Handling Methods

Preharvest management, time of harvest

Flail-vac, IMCA harvester, hay cutter

Seed storage life

Additional Reclamation Questions

a) How much donor area is necessary to supply enough seed to adequately cover an acre of reclaimed land? What management practices maximize seed production? What management practices produce acceptable seed harvests without compromising the biological integrity of the donor site?

b) What native or exotic species are most suitable as a temporary groundcover that will retard cogon grass establishment without significantly retarding the growth of the desired climax species? Does an overburden cap necessarily increase nuisance species invasion? Will a diverse, dense groundcover develop on a sandtailings cap? Under what hydrologic ranges should tailings (or overburden) not be used as a surface soil?

c) How many seed crops can I remove from a donor site without upsetting the nutrient balance of the site? Is this even an issue?

d) Will flatwoods wiregrass do better than sandhill varieties on overburden? Which one should be used on tailings? Over what hydrologic regimes? North Florida wiregrass grows on richer soils than south Florida. Would it be better to use northern varieties on overburden even though the southern genotypes are located closer? Are the differences in performance even worth considering?

e) What types of mechanical seed harvesters and planters give the most cost effective results? What are the economies of scale for mechanized work?

f) Does topsoiling help or hinder? How does the plant composition, fire history and hydrology of the donor site and timing of application affect the establishment of desired plants and aggressive weeds on the recipient site? How thick should the topsoil blanket be? Does the reclaimed hydrology, topography and underlying substrate play a significant role, or are the donor site materials and management typically the major controlling factors? What interactive effects are there? Can topsoil be stockpiled without significantly losing viability? For how long and under what conditions?

g) What plants grow best on the higher pH soils created by mining companies (pH 5.5-7.5)? Should we be looking to species that thrive on limey soils (e.g., on south Florida rocklands)? Can we find varieties of typically acidophilic species that are competitive on circumneutral soils?

h) Are soil mycorrhizal or Rhizobial inoculations beneficial? Is the benefit justified by the cost? Would the use of municipal or agricultural compost help or hinder plant establishment on tailings? Is there an inexpensive source(s) of this material available?

i) Does irrigation really matter? What is the optimum time to plant? To seed?

j) What will it cost me per acre to establish an analogue to a wiregrass-longleaf pine community? What planting techniques will reduce my management risks (e.g., cogon grass control)? What is the optimum combination of treatments? How can I get the biggest bang for my buck?

ESTABLISHING, DESCRIBING, EXPLAINING, AND TESTING THE DIFFERENCES BETWEEN VERTEBRATE ASSEMBLAGES OF DISTURBED AND UNDISTURBED UPLAND FRAGMENTS IN CENTRAL FLORIDA

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During the past several decades, a large portion of the upland habitats of central Florida has been heavily disturbed by phosphate strip mining. To establish lists of the terrestrial vertebrate species present in patches of unmined upland habitats -- sandhill, scrub, scrubby flatwoods -- but absent or under-represented at mined lands ("focal species"), we surveyed vertebrates at 30 unmined and 30 previously-mined sites. The 60 sites were distributed within an area encompassing about 1500mi^2, in Hillsborough, Manatee, and Polk Counties. Amphibians, reptiles, and mammals (quadrupeds) were collected primarily with drift fence/pitfall trap arrays; and birds were surveyed visually. Size, isolation, vegetation structure and composition, and soil characteristics were measured for each site. When available, management histories of sites were obtained.

We used a variety of sources to establish a list of potential resident species. We captured and/or observed 90% of potentially resident amphibians (9 of 10 species), 69% of reptiles (24 of 35 species), 100% of trappable small mammals (7 species), and 57% of birds (39 of 69 species). From the list of resident species, we established that 5 amphibian, 5 lizard/turtle, 3 snake, 1 mammal, and 14 bird species should be considered focal species. These focal species contribute most of the differences between the vertebrate species compositions of unmined and mined sites. The list of focal species includes several listed species, as well as species that are relatively abundant and/or have a broad distribution.

We compared the vegetation and soil components of the 60 sites. The mined sites represented different kinds of substrate types -- overburden, sand tailings -- and revegetation types -- woody, herbaceous, topsoil from upland habitats. We found that aboveground habitat structure at mined sites was greatly simplified, compared to unmined sites. Important differences included missing canopy layers and reduced woody ground cover at mined sites. Certain sites reclaimed with topsoil had aboveground habitat structure most similar to unmined sites, but they were still substantially different. We found that belowground habitat structure also was very different at unmined and mined sites. Important differences included increased soil compaction at relatively-shallow depths; reduced percent sand; coarser sand particle sizes; and elevated pH, phosphorus, and potassium levels at mined sites. These differences in habitat structure were used to explain differences in vertebrate species compositions of unmined and mined sites.

The 60 sites were ranked on the basis of their representation of focal species. For quadrupeds, 27 unmined sites and 3 mined sites comprised the upper half of the rankings, indicating that few mined sites support very many focal quadruped species. The same conclusion. holds for birds: 29 unmined and 1 mined site comprised the upper half of the rankings. Examination of the natural histories of the focal species revealed that many are dependent on the presence of a complex vegetational structure, especially including low and mid-level shrub and tree canopy layers. Other focal species are dependent on the presence of deep sandy soils and temporary ponds, typical of upland habitats in Florida. Mined sites typically lack a well-developed canopy structure; and the soils usually are compacted near the surface, relatively-impervious to water percolation, and rich in available phosphorus. Mined sites lack the vertical stratification or layering of vegetation which is typical of unmined sites. Vegetation structure, rather than a specific plant association appears to be a major determinant of habitat quality for many vertebrate species. Among the mined sites, those possessing significant vertical stratification have the highest representation of focal species, even if the stratification is not provided by native plant species. To increase the representation of upland vertebrate species on former phosphate mines, our data indicate that development of mid- and upper-story canopy layers should be incorporated into early rehabilitation efforts, with the goal of obtaining significant structure in the shortest amount of time. We suggest that this structure will serve to enhance the regional pool of vertebrate species and, thereby, enhance the chances of success of additional rehabilitation projects.

Our results indicated that knowledge of specific microhabitat requirements for the species resident in upland habitats may promote effective conservation and successful translocations. This conclusion may be particularly true for biotope specialists, because they are the most vulnerable to environmental change, particularly catastrophic habitat destruction. The endemic Florida mouse, *Podomys floridanus,* a Species of Special Concern, is restricted to xeric upland habitats where it is typically found living commensally in the burrows of the gopher tortoise, *Gopherus polyphemus.* Monte Carlo simulations using capture patterns from structurally heterogeneous scrubby flatwoods and oak hammock habitat show Florida mice were not randomly distributed with respect to both habitat structure (e.g. bare ground, shrub and high canopy) and gopher tortoise burrows. Florida mice were captured more frequently than expected by chance in areas with xeric edge or mid-successional habitat structure and higher densities of burrows. We translocated 134 Florida mice from four scrub habitat islands (South Fort Green, Hardee County) to reclaimed phosphate-mined land (Best of the N-West, Noralyn Mine, Polk County) and a scrub control site (Refuge, Noralyn Mine). Translocations during the winter with releases directly at the mouths of recipient burrows were successful at establishing Florida mice on both sites at a reduced density (relative to the donor areas). Spatial distribution of gopher tortoise burrows and xeric edge vegetation structure (e.g. presence of shrubby oaks greater than lm height) successfully predicted distribution of surviving relocated mice and their offspring. Our results suggest that specific microhabitat requirements for the Florida mouse can be quantified and used to assess the suitability of reclaimed sites for translocations. We recommend additional research to assess the probability of long term persistence at the recipient sites given the isolated nature of the suitable habitat patches and the inherent stochasticity of population processes.

THE MALLORY SWAMP RESTORATION PROJECT

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"...sound partnerships may prove our best and surest vehicle yet to carry forth a full and rich biological community into the 21st Century."

- John Turner, Director U.S. Fish & Wildlife Service 3/25/91

The Mallory Swamp Restoration Project (MSRP), located in southwest Lafayette County, Florida, is a 9,850-acre privately owned demonstration of forested wetland restoration. The landowner, in partnership with Florida's Legacy, Inc., a non-profit organization, is working to make the MSRP a model in the effort to preserve Florida's unique biological diversity for future generations through conservation and education.

Fifty percent of the 728 species currently listed as federally threatened or endangered are found exclusively on private lands. Private landowners dissatisfaction with the Endangered Species Act has escalated. In addition landowners increasingly feel burdened by regulations. In fact, conflict is often a part of conservation efforts. Repeatedly, with regard to endangered species, adversarial situations develop that polarize communities or regions and more resources and energy are expended to battle an opposing view than to resolve the issue. The MSRP strives to move us away from conflict towards our goal by taking a proactive, cooperative approach to habitat restoration and conservation. The MSRP has engaged the interest and participation of local community leaders, citizens, regional civic organizations, surrounding land owners, the forest industry, Florida's academic community and entrepreneurial businessmen and women.

Over 100 junior environmental science and senior biology students from Lafayette High School have participated in on-site restoration and monitoring activities - conducting wildlife surveys, testing water quality and evaluating areas prior to a prescribe bum. The goal is to instill in future community leaders a sense of place and understanding of their environment. Our hope is by using the MSRP area as an outdoor laboratory, that students will have that critical environmental experience that will make them better stewards of the land and wildlife.

Established in 1995, the MSRP has also invited the participation by members of the scientific community. Dr.'s Reed Noss and Andre Clewel are to be thanked for their roles as advisors and promoters of the project. The MSRP has been equally successful in competing for funding. A grant from the U.S. Fish & Wildlife Service, Partners For Wildlife program will fund two hydrologic projects at a cost of $13,000 for restoration of approximately 4,000 acres.

Conservation theory teaches that a high priority is to preserve large land areas. The MSRP area is intended as a regional core reserve, providing high quality habitat for a variety of species such as the bobcat, wild turkey, black bear and swallow-tailed kite. Corridor and reserve design research is on-going. Twelve adult and juvenile bobcats are being tracked to discern the use of the property and neighboring lands to help prioritize future land acquisition.

The Mallory Swamp is part of a vast swamp system in Florida's northwest Gulf Coast region. The Mallory Swamp, San Pedro Bay and California Swamp supports some of Florida's most significant rivers: the Suwannee, Steinhatchee, Ecofina and Fenholloway. Wildlife occurring on the MSRP area, including the American Alligator and Florida spotted turtle, are representative of the region's biological diversity. The project area is a complex of forested wetland types - basin swamps, cypress domes and strands, gum swamps, mesic pine flatwoods and a system of depressional and herbaceous marshes and sogs that support a variety of resident birds. White ibis, great egret and anhinga breed, roost and feed on the property and the property is a winter retreat for duck. The state threatened Florida black bear is also an occasionally visitor.

Priorities for restoring the project area include ensuring that natural processes such as fire, nutrient cycling, water flow and animal migration can continue. An 115-acre fuel reducing burn was successfully completed in May 1996. Hydrologic restoration is needed. A ditch drainage system was created when roads were constructed for the removal of pine and cypress. Over decades the land area has repeatedly been cleared and planted in pine. Today, some pine plantation still persists.

In order to halt or reverse species loss and the degradation of Florida's natural lands it is critical that individuals from landowners, businessmen and women to Florida's children become involved in conservation. Engaging citizens can be a role for conservation scientist and restorations by including them in all aspects of projects. The approach to restore the MSPR area reflects a g-rowing trend to acknowledge the importance of integrating humans into the conservation equation. To consider *all* species in a system. In so doing, science fosters " biophilia" an understanding and devotion for nature, that some believe to be an innate human character. For more information about this project contact Florida's Legacy, Inc. at the above address.

UPPER ST. JOHNS RIVER BASIN
SUMMARY OF WETLAND RESTORATION ACTIVITIES

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History of Wetland Alteration

Alteration of the St. Johns River floodplain began with the construction of a road and levee between 1910 and 1914, which cut off Blue Cypress Lake and the St. Johns River from their headwater marshes (Kushlan, 1990). More than 70 percent of the St. Johns River basin is now used for cattle production, and the marshes and swamps feeding the river have been reduced by 65 percent (Brooks and Lowe, 1984 as in Kushlan, 1990). The marsh is a segmented version of its original expanse with a complex system of levees and canals separating it from surrounding agriculture and cattle operations.

Restoration in the Upper St. Johns River Basin

The St. Johns Water River Management District conducted research under a U.S. EPA Clean Lakes Diagnostic/Feasibility grant to the Department of Environmental Regulation. In this study, Brooks and Lowe (1984) determined that the ecological degradation of the Upper Basin apparently stemmed from the dramatic loss and hydrologic alteration of floodplain wetlands. The restoration of these wetlands in terms of their areal extent and hydrology is the primary restoration goal. Because of the magnitude of land acquisition and construction required to satisfy these goals, the restoration efforts were incorporated into the federally funded Upper Basin Project (UBP). The UBP is designed as a semi-structural approach to water management in which the flood control and water supply objectives of the project are met to the extent practicable through wetland acquisition and restoration (Brooks and Lowe, 1984). Approximately 56,600 acres of developed floodplain were designated for purchase and restoration under the proposed project. This acquisition included over 21,000 acres of land located in the Three Forks Marsh Conservation Area (14,100 acres), Sartori West (2,703 acres), Tucker (2,035 acres) and S.N. Knight (2,526 acres) properties.

Restoration Through the Re-establishment of Natural Hydrologic Regimes

Conceptual restoration plans for the Sartori West, Tucker, S.N. Knight and Mary A (TFMCA) properties have been completed. Generally, the restoration of these properties will be achieved by restoring the natural hydrologic regime. By re-establishing the appropriate hydrologic regime on a property, we have only taken the first step in restoration. Although this method is cost effective, there are several complications that, depending on the level of alteration (1-3) and previous land-use practices, may prohibit successful restoration if further steps are not taken.

1) <u>Level of Alteration - drainage only</u>

In some cases, agricultural properties in the Upper Basin were drained but native vegetation was not eradicated; for example when farmers provide native pasture for cattle grazing. For restoration on this type of property, the re-establishment of a more natural hydrologic regime may be all that is required. Maintenance and establishment of vegetation communities can be by both vegetative and sexual reproduction.

2) <u>Level of Alteration - drainage and vegetation removal</u>

In most cases, restoration is needed on properties that have been drained, native vegetation has been removed and the land has experienced a small amount of subsidence. Restoration on these properties relies on the remnant seed bank to provide propagules for new emergent plant growth, as well as the dispersal of seeds and vegetative expansion from remnant depressional wetlands on-site. However, some "undesirable" species such as cattail may be over-represented in the seed bank and existing wetlands. These early colonizers of disturbed conditions may invade the new wetland areas and become the dominant species or even create a monoculture given the right conditions. In contrast, other desirable species, such as the native dominant sawgrass, are conspicuously absent from seed banks.

Active restoration may be advisable in an area that is devoid of "desirable" vegetation in the seed bank and remnant wetlands. This may involve either planting or seeding of desirable species. In addition, these areas may benefit from experimentation with innovative restoration techniques. Techniques aimed at expediting the restoration process may include non-wetland vegetation removal by burning, discing or herbicide application and subsequent wetland vegetation establishment by seed bank contribution, planting or direct seed distribution. However, in some properties where pasture grasses are the dominant cover, passive restoration may produce the desired results. To determine whether active restoration is warranted, preliminary studies should be conducted to characterize the efficacy of each restoration technique.

Example: Mary A Restoration Property in the Three Forks MCA (Brevard County)

Before restoration: Prior to District purchase, the property was in row crop production. Later, when the property was used as a flood abatement area, it became deeply flooded and the vegetation was dominated by water hyacinth, water lettuce, *Hydrilla* and a small percentage of cattail.

During restoration process: The property was subsequently drained in order to establish emergent plants and to kill existing aquatic weeds. We are now conducting an experiment to determine if establishment of sawgrass is possible by direct seeding. Sawgrass germination, of at least 32% percent, occurred in the experimental plots. However, the survivability of the sawgrass seedlings was low and by September 1996 only 6 seedlings per $1m^2$ were found. Other emergent species (desirable and undesirable) have become established in the property and the distribution of aquatic weeds such as water hyacinth, water lettuce and *Hydrilla* has been drastically reduced.

3) <u>Level of Alteration - drainage and vegetation removal with associated subsidence</u>

In a few cases, restoration is needed on properties that have been drained, native vegetation has been removed and the land has greatly subsided due to long-texm production of row crops. Restoration to shallow marsh on these properties becomes logistically impossible without a commitment to long-term active management (ie. constant pump operation). In extreme cases like these, the decision may be to "restore" deep-water habitat in that area. In situations such as this, the control of aquatic weeds is critical. Herbicides should be applied before and after reflooding to ensure low populations of aquatic weeds.

Brooks, J. E. and E.F. Lowe. 1984. U.S. EPA Clean Lakes Program, Phase I, Diagnostic-Feasibility Study of the Upper St. Johns River Chain of Lakes, Volume II - Feasibility Study. St. Johns River Water Mgt. Dist. Tech. Pub. SJ 84-15. Palatka, Florida.

Kushlan, J.A. 1990. Freshwater Marshes, p. 324-363. In R.L. Myers and J.J. Ewe1 (Eds.), Ecosystems of Florida. University of Central Florida Press, Orlando, Florida.

CREATING WETLANDS FROM FARM LANDS IN CENTRAL FLORIDA

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During late 1980s the St. Johns River Water Management District acquired about 8,000 acres of muck farms adjacent to the Ocklawaha River, Haines Creek, Lake Griffin, and Lake Harris in Central Florida for the purpose of restoring wetland habitat. Prior to the 1940s the area consisted of shallow marshes dominated by sawgrass and wet prairie communities, with cypress and hardwood swamps located along the river and creek. In the early 1900s development of water control structures and land clearing for farming were initiated, but extensive agricultural expansion did not occur until after WW II. The peat soils of the farms were ideal for growing vegetables. Other areas were converted to pasture for grazing cattle. After several years of intensive farming the peat soils lost most of their initial fertility. Large “quantities of fertilizers, as well as pesticides, were applied to the farms from the 1950s-1980s. During the interim between property acquisition and initiation of restoration in 1991, farming operations were terminated.

The restoration sites include two areas: the Emeralda Marsh Conservation Area(EMCA) and the Lake Harris Conservation Area (LHCA). Restoration involves limited re-creation of the floodplain ecosystems in both areas by allowing water to reflood the properties through rainfall and from the adjacent lakes through the existing water control structures. Due to the extended hydroperiod, subsidence and oxidation of the peat soils, and nutrient flux from the sediments into the water column as a result of flooding, the areas are unlikely to develop historic wetland communities. About 53% of the EMCA will be deep marsh habitat; 47% will support shallow marsh and wet prairie communities. A variety of wetland and aquatic plant species have established from the existing seed bank and from wind and animal dispersal. Invasive species such as water hyacinth *(Eichhornia crassipes)*, hydrilla *(Hydrilla verticellata)*, and cattail *(Typha* spp.) have rapidly colonized and become monocultures in some areas, particularly in the more disturbed areas of the former muck farms. Bird surveys conducted since 1995 indicate that at least 145 species of birds are utilzing the areas.

The restoration goals for the sites are 1) to eliminate nutrient loading from the former muck farms to the lakes; 2) to reduce the equilibrium nutrient concentrations in the lake by utilizing certain properties as wetland treatment systems; 3) to establish diverse aquatic and wetland habitats for wildlife and fish; and 4) to provide recreational benefits such as fishing, waterfowl hunting, hiking and wildlife observation. The properties will be hydrologically reconnected internally through levee breaching within the next five years. External reconnection of the areas with the surrounding water bodies will occur within 10 years. The long-term restoration schedule will allow monitoring of biological changes and the levels of water quality improvement in the ecosystems that develop prior to reconnection with the lakes, streams, and rivers.

To increase biodiversity of habitat in one flooded property of the EMCA, we planted 32 vegetative propagules of giant bulrush *(Scirpus californicus)* and white water lily (*Nymphaea odorata*) on one-meter centers in six 10x10 m plots. Three of the plots were fenced with plastic mesh; the other three were unfenced. The purpose of the fencing was to exclude water hyacinth *(Eicchornia crassipes)* from three of the six planted plots to determine if fencing was beneficial to native plant establishment. The fencing succeeded in excluding the water hyacinth during the first five months of growth. After two years the bulrush colonies expanded 2.0-2.5 times their original coverage. The colonies were dense and formed an effective wall against further hyacinth invasion. The water lilies became established in the fenced plots, but not the unfenced plots. They did not persist because of herbivory. No native vegetation established in the unfenced plots.

We are applying limited hydrological control in the restoration of the LHCA. Water levels fluctuate between established minimum and maximum levels to prevent offsite flooding and promote fish and wildlife habitat. Hydrology is primarily rainfall driven, but when water level reaches the allowable maximum, it is drawn down by pumping to a mean level. Water levels may reach the minimum by evapotranspiration. When the minimum level has been reached, water is allowed to passively flow into the property until the mean stage is reached. We are monitoring the habitat development, water quality, fish, and wildlife to determine the effectiveness of the restoration approach.

FORESTED WETLAND RESTORATION AND "NUISANCE" PLANT SPECIES MANAGEMENT ON PHOSPHATE MINED LANDS IN FLORIDA

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Primrose willow *(Ludwigia peruviana)* and cattail *(Typha spp.)* are two wetland plant species listed by the Florida Department of Environmental Protection (FDEP) as "nuisance" species. This designation is legally important in the restoration of forested wetlands on phosphate mined lands, because one success criterion on many permits limits "nuisance? species to less than 10% of the total cover. Controlling primrose willow and cattail with herbicides, by mechanical means, or manually can be expensive and can even harm the desirable trees and understory species. It is hypothesized that shade-tolerant trees can grow through, overtop, and shade out these sun-requiring "nuisance" species. If so, rather than battling nature, a reclamationist could save money by working with nature by planting a sufficient number of trees and being patient. This study, conducted on reclaimed phosphate mined lands in central Florida, compared tree growth in primrose willow stands and in cattail stands, versus with the nuisance species removed (cut or herbicided). Through three growing seasons on a seepage wetland, primrose willow had little or no effect on baldcypress *(Taxcodium distichum)* height growth. Although baldcypress was 25 percent taller by the sixth growing season with primrose willow removed, baldcypress growth was, nevertheless, substantial in the presence of primrose willow. After three growing seasons 50 percent of the baldcypress trees had grown through and overtopped the primrose willow, and that figure had increased to 85 percent after the sixth growing season. Popash *(Fraxinus caroliniana),* baldcypress, and red maple *(Acer rubrum)* heights were only slightly affected by primrose willow competition at a wet floodplain site after three years, although some trees were bent by the primrose willow. Red maple grew taller in the presence of the primrose willow. At a drier floodplain site, average heights of baldcypress, popash and water hickory *(Carya aquatica)* exceeded the height of the primrose willow in the third growing season. Cattail at the two study sites had little or no effect on heights of baldcypress or popash after two years. The modest effect of primrose willow on baldcypress indicates control measures, which are expensive, are not necessary. The presence of primrose willow may even have a temporary beneficial effect on understory development. We observed an abundance of ferns and begonias beneath the shade of the primrose willow at one site and volunteer red maples beneath the primrose willow canopy at another site, but in the plots where primrose willow was removed, the result was a ground cover of weedy species. If trees are planted at a sufficient density, they will eventually develop a canopy cover that will probably shade out the primrose willow. This has been casually observed at older wetland sites on reclaimed phosphate mined lands. Fieldwork using structures covered with shadecloth rated at 30% and 70% shade indicates that the primrose willow is adversely affected by shade, Elderberry is being studied as a potential forested wetland nurse crop that will suppress weedy species, yet permit shade tolerant forest trees and desirable understory plants to thrive.

INTEGRATED HABITAT NETWORK and the UPPER PEACE RIVER ECOSYSTEM PROJECT

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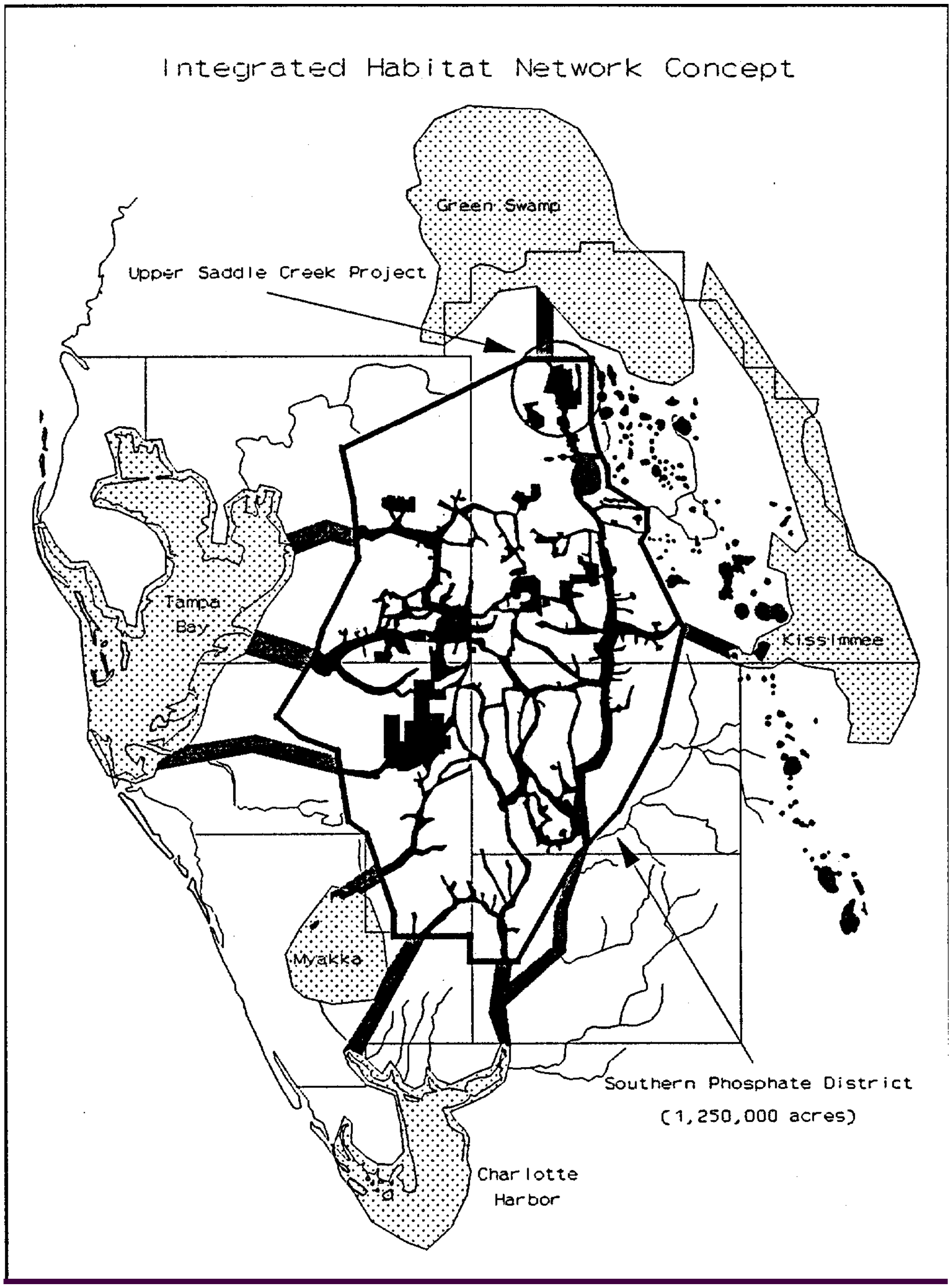
The Florida Department of Environmental Protection (DEP), the Florida Game and Fresh Water Fish Commission (GFC), and the phosphate industry are creating an Integrated Habitat Network (IHN) that will eventually span the entire southern phosphate district. The resulting inter-connected system of protected environmental lands is intended to provide mitigation for mining-related impacts to fish and wildlife, and function as the key component of reclaimed ecosystems capable of restoring the region's hydrology and fauna1 characteristics. The IHN has three parts: 1) a core reserve of protected, unmined land composed largely of riverine floodplains, 2) surrounding complementary reclamation planned as individual ecosystems or land management units, and 3) upland habitat connections between the mining region's rivers and significant environmental features outside the planning area. The plan is being implemented both through mine permitting and through the post-mining development planning of existing and former mines. A key demonstration of the potential for IHN implementation in the post-mining arena is the Upper Saddle Creek restoration project overseen by the Upper Peace River Ecosystem Planning Committee (UPREPC). The project area is a 29-square mile basin that forms the northern-most reach of Peace River. It was largely mined-over during the 1960's and 70's. The state-owned, 6,040-acre Tenoroc Fish Management Area occupies the lower portion of the basin, while privately-owned former mines occupy most of the remainder. Plans for the area include three Developments of Regional Impact, two major road construction projects, and a dozen or so Nonmandatory Reclamation Program projects. The strategy is to orchestrate the impact mitigation needs of these developments into a single, basin-wide reconstruction project. The Department of Transportation's (DOT) Turnpike Authority provided the first funding commitment for the project to cover mitigation of wetland impacts from construction of the Polk Parkway. That resulted in formation of the UPREPC consisting of representatives from DEP, GFC, DOT, the Southwest Florida Water Management District, and the U.S. Army Corps of Engineers. In cooperation with the area's various land owners, they will oversee development and implementation of a final overall plan. The effort is being assisted by a DOT and FIPR-funded hydrological research project carried out by the University of South Florida. The planning and research phase of the Upper Saddle Creek project should be completed in 1998, and should meet the IHN goals of providing: 1) a core reserve of protected floodplain habitat in the upper Peace River, 2) a complementary functional stream ecosystem, and 3) a key habitat connection between Peace River and the nearby Green Swamp Area of Critical State Concern. It should also serve as a precedent for other remedial projects in the extensive portion of the phosphate district that was formerly planned and permitted without a modern ecosystem perspective.



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